One Health approaches to different problems:
Work at the International Livestock Research Institute

Johanna Lindahl
One Health Sweden
8 April 2015, Uppsala, Sweden
Today’s talk

1. What is ILRI?
2. Why an international livestock research institute?
3. One health, Ecohealth and health
4. One health projects at ILRI
A history of international livestock research

- International Laboratory for Research on Animal Diseases
- International Livestock Center in Africa
- Merged in 1994 - ILRI
ILRI and where it works

Headquarters in Nairobi

ILRI outposts in SE Asia: Hanoi, Vientiane, ChiangMai (Bangkok)

ILRI outposts

No. per Km²

- 0
- 1 - 2
- 3 - 5
- 6 - 20
- > 20
• Consultative Group for International Agricultural Research- 1971
• CGIAR Consortium of International Agricultural Research Centers- 2011
• Today 15 centers
<table>
<thead>
<tr>
<th>Active CGIAR Centers</th>
<th>Headquarters location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Africa Rice Center</strong> <em>(West Africa Rice Development Association, WARDA)</em></td>
<td>Bouaké, Côte d'Ivoire / Cotonou, Benin</td>
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<tr>
<td><strong>Bioversity International</strong></td>
<td>Maccarese, Rome, Italy</td>
</tr>
<tr>
<td><strong>Center for International Forestry Research</strong> <em>(CIFOR)</em></td>
<td>Bogor, Indonesia</td>
</tr>
<tr>
<td><strong>International Center for Tropical Agriculture</strong> <em>(CIAT)</em></td>
<td>Cali, Colombia</td>
</tr>
<tr>
<td><strong>International Center for Agricultural Research in the Dry Areas</strong> <em>(ICARDA)</em></td>
<td>Beirut, Lebanon</td>
</tr>
<tr>
<td><strong>International Crops Research Institute for the Semi-Arid Tropics</strong> <em>(ICRISAT)</em></td>
<td>Hyderabad (Patancheru), India</td>
</tr>
<tr>
<td><strong>International Food Policy Research Institute</strong> <em>(IFPRI)</em></td>
<td>Washington, D.C., United States</td>
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<tr>
<td><strong>International Institute of Tropical Agriculture</strong> <em>(IITA)</em></td>
<td>Ibadan, Nigeria</td>
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<td><strong>International Livestock Research Institute</strong> <em>(ILRI)</em></td>
<td>Nairobi, Kenya</td>
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<tr>
<td><strong>International Maize and Wheat Improvement Center</strong> <em>(CIMMYT)</em></td>
<td>El Batán, Mexico State, Mexico</td>
</tr>
<tr>
<td><strong>International Potato Center</strong> <em>(CIP)</em></td>
<td>Lima, Peru</td>
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<tr>
<td><strong>International Rice Research Institute</strong> <em>(IRRI)</em></td>
<td>Los Baños, Laguna, Philippines</td>
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<tr>
<td><strong>International Water Management Institute</strong> <em>(IWMI)</em></td>
<td>Battaramulla, Sri Lanka</td>
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<tr>
<td><strong>World Agroforestry Centre</strong> <em>(International Centre for Research in Agroforestry, ICRAF)</em></td>
<td>Nairobi, Kenya</td>
</tr>
<tr>
<td><strong>WorldFish Center</strong> <em>(International Center for Living Aquatic Resources Management, ICLARM)</em></td>
<td>Penang, Malaysia</td>
</tr>
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</table>
CGIAR research programs

Climate Change, Agriculture and Food Security (CIAT)

Forests, Trees, and Agroforestry (CIFOR)

GRiSP - A Global Rice Science Partnership (IRRI)

Aquatic Agricultural Systems (WorldFish)

Maize (CIMMYT)

Roots, Tubers and Bananas (CIP)

WHEAT (CIMMYT)

More Meat, Milk and Fish by and for the poor (ILRI)

Water, Land and Ecosystems

Agriculture for Nutrition and Health (IFPRI)

Dryland Cereals (ICARDA)

Dryland Systems (ICARDA)

Humidtropics (IITA)

Policies, Institutions, & Markets (IFPRI)

Grain Legumes for Health & Prosperity
7 billion reasons for more agricultural research

- More and more people to feed
- More and more are not producing food
  - The rest need to produce more

1.7 billion overweight/obese

2 billion hidden hunger

One billion hungry
• 37 billion livestock
  ➢ 31 billion in developing countries
  ➢ 1 billion poor people depend on livestock
    ✔ 600 million in South Asia
    ✔ 300 million in Sub-Saharan Africa
    ✔ 25% urban

*Update: March 2012*
Bridging the gaps between demand and supply – global level

- 60% more food than is produced now will be needed
- 75% of this must come from producing more food from the same amount of land
- The higher production must be achieved while reducing poverty and addressing environmental, social and health concerns
- This greater production will have to be achieved with temperatures that may be 2–4 degrees warmer than today’s
Why increasing demands?

- Increased demands for animal-source food
- More and more people
- Growing middle classes
- Continued urbanization
- Globalization
- Changing preferences

Increased demands for animal-source food
The livestock revolution

- 1970-Mid 1990s
- Demand-driven, unlike the green revolution

Figure 2: Increase in per capita consumption of perishables and pulses in developing countries with 1963 as index year (FAO, 2009).
Gains in meat consumption in developing countries are outpacing those of developed
Change in global and regional demand for food: Livestock and other commodities

% change 2005/07 to 2050

-50 0 50 100 150 200 250 300 350

cereals
root/tuber
meat
dairy

developed  developing

Modified from Alexandratos and Bruinsma 2012
Big productivity gaps
-largely due to poor animal health, inadequate feed and low genetic potential

Some developing country regions have gaps of up to 430% in milk

Steinfeld et al. 2006
Example: Green house gases

GHG per kg of animal protein produced

Herrero et al 2013
Mortality: global projection, 2004-2030

Deaths (millions)

- Intentional injuries
- Other unintentional
- Road traffic accidents

Other NCD

- Cardiovascular diseases
- Mat//peri/nutritional
- Other infectious
- HIV, TB, malaria

High-income countries

Middle-income countries

Low-income countries
Infectious diseases

- Neglected
- Mainly affecting poor communities
- Chronic morbidity

Source: WHO
Endemic disease (neglected zoonoses)

Source: WHO
Costs of zoonotic disease

- Zoonoses sicken 2.4 billion people, kill 2.2 million people and affect more than 1 in 7 livestock each year.
- Cost $9 billion in lost productivity; $25 billion in animal mortality; and $50 billion in human health.
Top Zoonoses (multiple burdens)

- Assessed 56 zoonoses from 6 listings: responsible 2.7 billion cases, 2.5 million deaths
- Top 13 responsible for 2.2 billion illnesses and most deaths
  - Wildlife interface
  - 9 have a major impact on livestock- affect 1 out of 7
  - All 13 amenable to on-farm intervention
Deaths - annual

- Leptospirosis
- TB (zoo)
- Rabies
- Cysticercosis
- Leishmaniasis
- Brucellosis
- Echinococcosis
- Toxoplasmosis
- Q fever
- Sleeping sickness
- Anthrax
Timely detection and response

Adapted from IQM (2009)
Benefits of controlling zoonoses in animals and along the value chain

• Credible economic cost benefit studies (n=13)
  – Average benefit cost ratio 6:1
  – Median 4:1
  – Range 1.1-19.8

<table>
<thead>
<tr>
<th></th>
<th>Developing countries</th>
<th>Developed countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.7</td>
<td>7.4</td>
</tr>
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</table>

• Implies $85 billion losses could be averted by $21 billion expenditure
The business case for One Health

This article outlines a pathway to develop the business case for One Health. It describes the origin and development of One Health and then identifies five potential areas where One Health can add value and reduce costs. These are: (1) sharing health resources between the medical and veterinary sectors; (2) controlling zoonoses in animal reservoirs; (3) early detection and response to emerging diseases; (4) prevention of pandemics; and (5) generating insights and adding value to health research and development. Examples are given for each category along with preliminary estimates of the potential savings from adopting the One Health approach. The literature reviewed suggests that one dollar invested in One Health can generate five dollars worth of benefits and a global investment of US$25 billion over 10 years could generate benefits worth at least US$125 billion. Conservation implications: the time has come to make the bigger case for massive investment in One Health in order to transform the management of neglected and emerging zoonoses and to save the lives of millions of people and hundreds of millions of animals whose production supports and nourishes billions of impoverished people per annum.

Introduction

This article is based on an invited keynote presentation given at the Southern African Centre for
Livestock
Wildlife
Humans

Ecosystem

LH
WL
WH
X

Disease transmission
Spillover event
## Ecosystem services – and disease emergence

<table>
<thead>
<tr>
<th>Ecosystem service</th>
<th>Importance</th>
<th>Effect of decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisioning</td>
<td>Economics, livelihoods</td>
<td>Increased poverty</td>
</tr>
<tr>
<td>Regulating</td>
<td>Health, environment</td>
<td>Increased disease</td>
</tr>
<tr>
<td>Cultural</td>
<td>Well-being, recreation</td>
<td>Increased stress?</td>
</tr>
<tr>
<td>Supporting</td>
<td>Basis for the other services</td>
<td>Increase in all above</td>
</tr>
</tbody>
</table>
Hierarchy of needs according to Maslow.

- Physiological needs: food, rest, water
- Safety and security
- Love and sense of belonging
- Self-esteem and respect
- Self-actualization

Provisioning
Example: Mycotoxins in the food

An example of trade-offs between food security and food safety
Never heard about aflatoxins?

- Acute outbreaks can claim 100s of lives (Kenya outbreak 2004-2005 150 known fatal cases)
- 4.5 billion people chronically exposed (estimate by US CDC)
  - Cancer
  - Immunosupression
  - Stunting
Dairy products and levels of aflatoxin

Pilot study show association with stunting!
What are aflatoxins?

- Aflatoxin “discovered” as the cause of Turkey X disease, 1960s
- Toxin produced by *Aspergillus* spp, mainly *Aspergillus flavus* and *Aspergillus parasiticus*
- *Aspergillus flavus* toxin

![Aflatoxin structures](http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/ucm070664.htm)
What promotes the fungal growth?

- Pre-harvest: damage by insects, draughts
  - Insects cause damage and are mechanical vectors
- Post-harvest: Poor storage conditions

Improper drying of grains - Different grains being dried on roadside with rains looming in the horizon. Photo by IITA
Major effects on trade

When EU harmonized the limits:

- Decrease to 4 ppb: saves 2 lives per billion
- Europe receives 57% of African and Middle eastern exports
- Estimated to decrease African exports by 64% (670 million USD)
- Peanuts one of Africa’s few export commodities (Gambia, Senegal, South Africa)
The consequences of export barriers

- The best products are exported
- The bad products are left to the national markets
Aflatoxins are a global issue

Figure 1. Areas and Populations at Risk of Chronic Exposure to Uncontrolled Aflatoxin Contamination

Source: Williams et al., 2008
Kebs tests showed Unimix was bad

Photo/FILE Families queue to receive relief food from the Kenya Red Cross Society at Lokichar in Turkana South District in the recent past.
NAIROBI, Kenya, Nov 3 – The number of school going children feared to have consumed the aflatoxin contaminated Unimix during the Kenyans4Kenya initiative is more than 270,000 and not 60,000 as earlier thought.

Public Health Minister Beth Mugo said on Thursday that 726 schools had been supplied with the contaminated food at the time of the recall.

“My ministry in collaboration with the Kenya Red Cross Society and manufacturers are still recalling the consignment which was distributed irrespective of whether it is suspected to be contaminated or not,” the Public Health Minister said.

While issuing a ministerial statement in Parliament, Mugo blamed the Kenya Red Cross Society for failing to immediately inform the ministry about the contamination.

She said the ministry was notified of the contamination on October 6 by one of the manufacturers, Proctor & Allan.
Aflatoxins are a political issue
How is ILRI working with this problem?

• Exposure of aflatoxin
  • Levels of aflatoxin
  • Consumption of contaminated products

• Who are the consumers?
  • Children
  • Pregnant and nursing mothers
  • The first 1000 days.

• Where is the problems?
  • Risk mapping
How is ILRI working with this problem?

- Can we prevent aflatoxins?
  - Dryers, new technologies etc
- What can we do with contaminated products
  - Biodegradation
  - Binders
  - Policy and regulations
- What will happen in the future?
  - Predictive forecasting
  - Climate change
What can we do with the results – Do no harm!
Example- Milk production in India

*Is there always a trade-off between food safety and food security?*
Milk consumption in India

• Milk consumption 46 kg per capita in 1983; 62 kg per capita in 1997; and, 106 kg in 2011-12

• Estimated total annual consumption of 60 million megatons

• India consumed 13% of the milk in the world
Food-borne diseases

- Food-borne diseases are very important
- 1.4 million children die every year of diarrhea
- The majority is food and water-associated
- Animal-source food over-represented as a cause
Risks and benefits with dairy

Pathogens from the cow and from the milk

- *Mycobacterium bovis*
- *Brucella spp.*
- *Bacillus anthracis*
- *Salmonella*
- *EHEC*
- *Streptococcus spp*
- *Staphylococcus aureus*
- *Clostridium spp*
- *Listeria spp*
The importance of dairy production in Assam

- One of the poorest states
- Over 30 million people, 27% rural
- Agriculture accounts for ¼ of the state domestic product
- 8.5 million cattle, >90% indigenous
- 97% marketed in the informal traditional market
- Most initiatives focus on the organized sector
Pathways

- Adulteration!
- Trader
- Hotels
- Restaurants
Adulteration- a problem?

1. Producers in 2009: 0-66% water added
2. Traders in 2009: 2-55% water added
3. Producers in 2012: between 0-28 % water added
4. Traders in 2012: 0-31 % water added

Adulteration occurs at every step!
Consumers can not tell the difference!
No clear association with bacterial count
Can diseases be transmitted from dung?

<table>
<thead>
<tr>
<th></th>
<th>Believe diseases can be transmitted from dung</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producers</strong></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>2.7% (11/404)</td>
</tr>
<tr>
<td>2012</td>
<td>37.2% (60/161)***</td>
</tr>
<tr>
<td>Trained (2012)</td>
<td>69.8% (37/53)***</td>
</tr>
<tr>
<td>Untrained (2012)</td>
<td>21.3% (23/108)</td>
</tr>
<tr>
<td><strong>Traders</strong></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1.1% (2/175)</td>
</tr>
<tr>
<td>2012</td>
<td>47.1% (106/225)***</td>
</tr>
<tr>
<td>Trained (2012)</td>
<td>63.9% (78/122)***</td>
</tr>
<tr>
<td>Untrained (2012)</td>
<td>27.2% (28/103)</td>
</tr>
</tbody>
</table>

Comparison between 2009 and 2012 survey
Comparison between trained and untrained 2012
Comparison between 2009 and untrained 2012
Can diseases be transmitted by milk?

<table>
<thead>
<tr>
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<th>Believe diseases can be transmitted from milk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producers</strong></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>13.0% (52/401)</td>
</tr>
<tr>
<td>2012</td>
<td>35.4% (57/161)***</td>
</tr>
<tr>
<td>Trained (2012)</td>
<td>64.2% (34/53)***</td>
</tr>
<tr>
<td>Untrained (2012)</td>
<td>21.3% (23/108)</td>
</tr>
<tr>
<td><strong>Traders</strong></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>9.1% (16/175)</td>
</tr>
<tr>
<td>2012</td>
<td>41.5% (93/224)***</td>
</tr>
<tr>
<td>Trained (2012)</td>
<td>64.8% (79/122)***</td>
</tr>
<tr>
<td>Untrained (2012)</td>
<td>13.7% (14/102)</td>
</tr>
</tbody>
</table>

Comparison between 2009 and 2012 survey
Comparison between trained and untrained 2012
Comparison between 2009 and untrained 2012
Which diseases can be transmitted?

<table>
<thead>
<tr>
<th></th>
<th>Tuberculosis</th>
<th>Food poisoning/gastrointestinal disease</th>
<th>General disease symptoms (fever, cough, cold)</th>
<th>Worms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>3.5% (14/405)</td>
<td>18.3% (74/405)</td>
<td>0.3% (1/405)</td>
<td>4.7% (19/405)</td>
</tr>
<tr>
<td>2012</td>
<td>8.7% (14/161)**</td>
<td>36.0% (58/161)***</td>
<td>11.2% (18/161)***</td>
<td>9.3% (15/161)*</td>
</tr>
<tr>
<td>Trained (2012)</td>
<td>18.9% (10/53)***</td>
<td>64.2% (34/53) ***</td>
<td>20.8% (11/53) **</td>
<td>9.4% (5/53)</td>
</tr>
<tr>
<td>Untrained (2012)</td>
<td>3.7% (4/108)</td>
<td>22.2% (24/108)</td>
<td>6.5% (7/108) ***</td>
<td>9.3% (10/108)</td>
</tr>
<tr>
<td><strong>Traders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>4.0% (7/175)</td>
<td>9.7% (17/175)</td>
<td>0% (0/175)</td>
<td>2.9% (5/175)</td>
</tr>
<tr>
<td>2012</td>
<td>13.7% (31/226)***</td>
<td>42.9% (97/226)***</td>
<td>11.5% (26/226)***</td>
<td>4.0% (9/226)</td>
</tr>
<tr>
<td>Trained (2012)</td>
<td>23.8% (29/122)***</td>
<td>61.5% (75/122)***</td>
<td>20.5% (25/122)***</td>
<td>6.6% (8/122)*</td>
</tr>
<tr>
<td>Untrained (2012)</td>
<td>1.9% (2/104)</td>
<td>21.2% (22/104) **</td>
<td>1.0% (1/104)</td>
<td>1.0% (1/104)</td>
</tr>
</tbody>
</table>

Comparison between 2009 and 2012 survey
Comparison between trained and untrained 2012
Comparison between 2009 and untrained 2012
What was the food security effect?

- Farmers reported healthier animals, less mastitis, better production

<table>
<thead>
<tr>
<th></th>
<th>Average milk production in liters per cow and day 2 years ago/before ILRI training</th>
<th>Average milk production in liters per cow and day now</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trained farmers</td>
<td>7.0 (range 2.5-10)</td>
<td>7.8 (range 3-15)</td>
</tr>
<tr>
<td>Untrained farmers</td>
<td>7.3 (range 2.5-14)</td>
<td>6.8 (range 2.5-14)</td>
</tr>
</tbody>
</table>
Why a veterinary public health question?

What is necessary for health?

Food security + Food safety = Health
Example: Dynamic drivers of disease in Africa

One action- different outcomes
Livestock and the risk of diseases

ZOONOSES and livestock disease

- Endemic disease (diseases of poverty)
  - Neglected tropical diseases
- "Endemic epidemics"
- Emerging disease
  - 75% zoonotic

58% of human pathogens are zoonotic
(Woolhouse et al, 2005)
Emerging Zoonotic Disease Events, 1940-2012

Potential Hotspots in US, Western Europe, Brazil, Southeast Asia

Most emerging human diseases come from animals. This map locates zoonotic events over the past 72 years, with recent events (identified by an ILRI-led study in 2012) in blue. Like earlier analyses, the study shows western Europe and western USA are hotspots; recent events, however, show an increasingly higher representation of developing countries.

Top Zoonoses (multiple burdens)

• Assessed 56 zoonoses from 6 listings: responsible 2.7 billion cases, 2.5 million deaths
• Top 13 responsible for 2.2 billion illnesses and most deaths
  – Wildlife interface
  – 9 have a major impact on livestock - affect 1 out of 7
  – All 13 amenable to on-farm intervention

World bank (2010) estimates for last century:
• direct costs of zoonotic outbreaks >20 billion USD
• indirect costs 200 billion USD
Zoonoses

Deaths - annual

- Leptospirosis
- TB (zoo)
- Rabies
- Cysticercosis
- Leishmaniasis
- Brucellosis
- Echinococcosis
- Toxoplasmosis
- Q fever
- Sleeping sickness
- Anthrax
Anthropogenic action:
Increased irrigation

Effect on ecosystem:
Creates more larval habitats

Vector consequence:
More infected vectors

Epidemiologic consequence:
More individuals exposed

Increased disease
Case study: Kenya

- Rift valley fever/ mosquitoes
- Land use changes
  - Protected area vs irrigated area
  - Pastoralist areas
Case study: Kenya

• Making changes in a highly diverse landscape
• Increased number of scavengers
• Increased numbers of mosquitoes
Case study: Kenya

- Participatory rural appraisals indicated a concern about rodents
Case study: Kenya

• What to study:
  – Can we trust hospital data?
  – Screen all febrile patients
  – Too many differentials: Malaria, RVF, Dengue, YF, Brucella, Leptospira, Chikungunya, CCHF
Case study: Kenya

• Who to study:
  – Humans and livestock
  – Mosquitoes
  – Rodents
  – Bats
  – Ticks
Cross-cutting issues

- Participatory rural appraisals
- The economic burden of disease
- The association between poverty and zoonoses - the vicious circle
- Climate change and predictive modelling
Irrigation- preliminary results

![Graph showing disease seroprevalence in irrigated and non-irrigated areas for RVF, WNV, and Dengue.]

Disease Seroprevalence

- RVF
- WNV
- Dengue

Legend:
- Irrigated area
- Non-irrigated area
Results

Mosquitoes trapped – relative abundance and species distribution

(a) Results from surveys done when irrigation was active

(b) Results from surveys done at the inactive phase of irrigation
Intervention points

Communities’ perceptions on diseases that manifest similar signs as malaria – limited knowledge on arboviruses
Health-seeking behaviour

Ways in which the local communities respond to febrile illnesses such as malaria

- Use herbal concoctions
- Do nothing
- Self medication
- Visit local hospitals
## Unwillingness to pay for prevention

How much did you spend last year on the following health protection (Kenyan shilling)?

<table>
<thead>
<tr>
<th></th>
<th>Mosquito nets</th>
<th>Vaccines &amp; routine clinic visits for kids</th>
<th>Boiling or other water treatment</th>
<th>Insurance (annual fee)</th>
<th>Other health prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>762</td>
<td>254</td>
<td>6.8</td>
<td>0.9</td>
<td>586</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>0-3150</td>
<td>0-5000</td>
<td>4 households paid between 150-600</td>
<td>220 households paid nothing, one household paid 200</td>
<td>0-6000</td>
</tr>
</tbody>
</table>

How much did you spend last year on the following health prevention for animals?

<table>
<thead>
<tr>
<th></th>
<th>Deworming</th>
<th>Vaccinations (to prevent not to treat)</th>
<th>Tick and fly treatments</th>
<th>Insurance (annual fee)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>928</td>
<td>437</td>
<td>599</td>
<td>0</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>0-11000</td>
<td>0-5000</td>
<td>0-5000</td>
<td>Not existing</td>
</tr>
</tbody>
</table>
More material than we can manage to analyze...

- Multiple diseases
- Still mosquitoes and ticks to identify and screen for virus
- Rodents and bats?
- The association between poverty and zoonoses - the vicious circle
- Climate change and predictive modelling
Kenya attack: 147 dead in Garissa University assault

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Conclusions 1

• We need a one health approach and increasing understanding of drivers
• The livestock revolution has benefitted poor farmers both by increased incomes and improved nutrition
• More people, more insecurity and more disease
Conclusions 2

- Not the livestock revolution predicted by Orwell
- But still not a situation where all people are equally equal regarding a secured access to safe food
Acknowledgements

CGIAR Research Program on Agriculture for nutrition and health

Thanks to:
Ram Deka and students in Assam
Bernard Bett and DDDAC team
better lives through livestock

ilri.org