Livestock and food security
An ILRI perspective

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015
Why are livestock important?

• Increasing recognition of role in achieving an adequate and balanced diet, and especially strategic for women and young children
• Extended rapid growth in demand for animal-source foods
• Reaching limits of expansion – pressure on feed resources
• Pressure/incentives to intensify
• Upward pressure on prices

OVER-ARCHING ISSUES

• How to achieve sustainable diets globally?
  ✓ Safe and appropriate consumption
  ✓ Acceptable environmental trade-offs

• Livestock as a tool for development
  ✓ Ensuring adequate, safe animal-source food to nourish the poor in 2050
  ✓ As an asset for generating income and smoothing the transition out of agriculture
Pathways to improved Food Security

A. Livestock-keeping households (nearly 1 billion people!)
   - Direct: consumption of household’s own livestock products
   - Indirect #1: Income from livestock buys food
   - Indirect #2: Better crop production for food/income; financial instruments
   - Dynamic – facilitating transition to professional agriculture / out of agriculture

B. Consumer households
   - Rely mostly on local small-scale production & marketing systems
   - Protecting/enhancing (sustainably) availability, accessibility, affordability

Varying contexts & trajectories

- Indirect #2: Other benefits
  - Crop production
  - Financial / insurance role

- Improve diet quality at individual & household level (esp. animal-source food content)

- Smallholder livestock keeping
  - Direct: Own consumption
  - Indirect #1: Income-mediated

- Local Markets

- Industrial systems

Indirect #2: Other benefits
- Crop production
- Financial / insurance role
Working toward improved Food Security: Our Agenda

- **#1 Increase livestock productivity**
- **#2 Improve livelihoods equitably**
- **#3 Understand trajectories**
- **#4 Increase farm productivity**
- **#5 Manage environmental trade-offs**
- **#6 Manage human health trade-offs**
- **#7 Enhance nutritional benefits**

**Smallholder livestock keeping**

- **Direct: Own consumption**
- **Indirect #1: Income-mediated**
  - Local Markets
  - Industrial systems

**Other benefits**
- Crop production
- Financial / insurance role

**Indirect #2**

- **#1 Increase livestock productivity**
- **#2 Improve livelihoods equitably**
- **#4 Increase farm productivity**
- **#3 Understand trajectories**
- **#5 Manage environmental trade-offs**
- **#6 Manage human health trade-offs**
- **#7 Enhance nutritional benefits**

**Improve diet quality at individual & household level (esp. animal-source food content)**
Why is it critical for food security?
- To increase supply from smallholder systems -- the main source of animal-source foods for low-income households
  - Protect and enhance availability, affordability
  - Address increasing resource pressures and trade-offs
  - Transition from expansion to intensification
- To avoid missing window of opportunity to reduce rural poverty and smooth transition out of agriculture

Key challenge: Understanding the ‘yield gap’
- Need for a conceptual and methodological framework for prioritizing
Complex interplay of factors

\[ P = G + E(\text{health, feed, management}) + GE \]

- **P** is the phenotype: The animal we see, its production etc.
- **G** is the genotype: The genetic make up of the animal
- **E** is the environment: All factors (ambient conditions, health, nutrition, husbandry) except the genes of the animal
- **GE** is the interaction: Between the genes and the environment
Genetics as the game changer
Estimates of potential versus realized dairy productivity

A. Indigenous Cattle

- Southern Africa: 170.1%
- West and Central Africa: 236.8%
- East Africa: 199.1%

B. Crossbred Cattle

- Southern Africa: 132.0%
- West and Central Africa: 65.1%
- East Africa: 312.6%

C. Exotic Cattle

- Southern Africa: 208.5%
- West and Central Africa: 90.2%
- East Africa: 157.0%
One take on opportunities to increase smallholder productivity

Animal genetics provides the largest opportunity across all geographies.

There is also opportunity in animal health, particularly in SSA.

Sources: estimates based on BMGF analytical models referencing multiple data sources including: Oct 4-5 Livestock Landscape Analysis Expert Panel Workshop; Oct 27 Livestock Foundation Genetics Workshop; Expert Interviews; FAOSTAT; OIE Technical Disease Cards; the Center for Food Security and Public Health Animal Disease Information; OIE-WAHID database; Merck Veterinary Manual; 2011 Market Probe market research for Kenya, Ghana, Nigeria, Ethiopia
But it isn’t just genetics

Milk production by % dairyness

- High grade cattle only showed substantially better milk yields than other grades in the highest production environment
Entry points: technical drivers

- **Genetics**
  - Incentives and innovative recording systems for genetic selection programs
  - Optimizing indigenous-exotic crossbreeding: matching breed to environment
  - Genetic modification for disease resistance vs reliance on vaccines

- **Animal Health**
  - Novel vaccine development for neglected diseases
  - Managing disease where surveillance and veterinary services are weak
  - Adapting new technologies to increase access and use of diagnostics

- **Animal Nutrition**
  - Better use of existing feed biomass through reservation/conservation options
  - Improving voluntary intake and reducing feed wastages
  - Matching better key feed nutrients with animal production level – balanced rations
Entry points: socio-economic

❖ Institutional arrangements to support uptake of technologies and access to market
  ○ Business groups to create economies-of-scale
  ○ Business development services to stimulate supporting services
  ○ Innovation platforms to facilitate coordination and develop adaptive capacity
  ○ Appropriate, enabling policies and regulation to ‘formalize’ informal markets
Key Messages

❖ Good opportunities for science to improve productivity of animal-source food production if appropriately oriented to developing country context

❖ Work to be done on figuring how to prioritize what will give biggest return in addressing yield gap

❖ Genetics can be game changer, but isn’t a silver bullet
Intensification and the future of livestock and food security

Timothy Robinson

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015
Overview

• The global livestock sector - trends and drivers
• Mapping livestock distributions and production systems
• Forecasting intensification
• Examples: Avian Influenza and antimicrobial resistance
• Conclusions
The changing livestock sector

• Demographic and social drivers
  • Population: + 32% or 9.6 billion people by 2050
  • Income growth: + 2% per year by 2050
  • Urbanization: 70% will live in cities by 2050

→ Growth in demand for animal source foods
  • + 70% by 2050
  • + 200 million tonnes of meat

→ Structural changes in the livestock sector
  • Shift from ruminant to monogastric
  • Intensification of production

→ Impinges on global public goods
  • Poverty and growth
  • Health and nutrition
  • Climate and natural resources

• Integrated approach to socially desirable livestock sector development

• Need reliable data and information to guide policy
Livestock distribution and production

Sub-national Livestock data

Global livestock maps

Livestock maps by production system

Livestock production estimates

Data collection, cleaning and geo-registration

Livestock distribution modelling

Production systems modelling

Herd / production modelling

Applications

- Equity and growth
- Climate and natural resource use
- Health and nutrition
Global distribution of pigs

Pigs per square kilometre (2006)

Source: Robinson et al. (2014)
Livestock production systems

Ruminant systems:
• Based on land use and agro-ecological potential
• No actual livestock data

Monogastric systems:
• Based on scale and intensification
• Use livestock densities

Robinson et al. (2011)
Monogastric production systems

% backyard → Extensive production

Mapped based on rural population

Livestock distribution

% intensive → Intensive production

Difference (total – extensive)
Chicken systems

Output / input ratio (log kg$^{-1}$ stock$^{-1}$ year$^{-1}$)

Log per-capita GDP (US$/person/year)

From World Bank data

Source: Gilbert et al. (under review)
Chicken systems

From World Bank data

Log per-capita GDP (US$/person/year)

Proportion of extensively raised chickens

Source: Gilbert et al. (under review)
Chicken systems

Extensive chicken production

Intensive chicken production

Source: Gilbert et al. (under review)
Intensification trajectories

Data mining extensive and intensive chicken production

Source: Gilbert et al. (under review)
Intensification trajectories

Creating bootstrapped models

Source: Gilbert et al. (under review)
Intensification trajectories

Applying models to all countries

Source: Gilbert et al. (under review)
Intensification trajectories

Here is China...

Source: Gilbert et al. (under review)
Intensification trajectories

... and several other important countries for AI in human
Intensification trajectories

Focus on these countries, standardized to 2010 data

The diagram shows the proportion of extensively raised chicken on the y-axis and GDP per capita (PPP; log10(x)) on the x-axis. The countries BGD, PAK, MND, IDN, EGY, and CHN are highlighted with different sizes indicating population size: 1 billion, 0.5 billion, 0.2 billion, and 50 million. The data is standardized to 2010.
Intensification trajectories

Focus on these countries, standardized to 2030 FAO projections
Intensification trajectories

Focus on these countries, standardized to 2030 FAO projections

Source: Gilbert et al. (under review)
Intensification trajectories

Focus on these countries, standardized to 2050 FAO projections

Source: Gilbert et al. (under review)
Emerging diseases – Avian Influenza

H7N9 risk prediction

Source: Gilbert et al. (2014)
Antimicrobial resistance

- USA: at least 2 million people get drug-resistant infections each year, and at least 23,000 die from them
- USA: 80% of antimicrobial sales are in the agricultural sector
- Total consumption in the livestock sector in 2010 estimated at 63,151 tons
- Global antimicrobial consumption will rise by 67% by 2030
- It will nearly double in BRICS (Brazil, Russia, India, China, and South Africa) countries
- China’s livestock industry by itself could soon be consuming almost one third of world’s available antibiotics.
Antimicrobial resistance

Global antimicrobial use in food animals
(mg per 10km pixel)

Source: Van Boeckel et al. 2015
Antimicrobial resistance

- The European Union banned the use of antibiotics to boost animals' growth in 2006
- There is a ‘voluntary’ ban in the USA
- Chick-fil-A, McDonalds and Costco stopping antimicrobial use in the production chain

➔ Concerted action – multi-stakeholder platforms
➔ Strengthen the evidence base linking agricultural use to AMR in the medical sector
➔ Appropriate approaches in different settings – poor countries may not have the ‘resilience’ or ‘capacity’ of Europe in withstanding a blanket ban, for example
➔ This is a global issue and calls for a coordinated, global response
In conclusion

• Rapid demand growth for Animal Source Foods – particularly in developing and emerging economies
• The response of the livestock sector to this growth has major implications for global, interconnected, public goods
• This calls for integrated solutions to guide sector development along a sustainable pathway
• These are global issues and require global responses
Livestock, livelihoods, gender and food security

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015

Isabelle Baltenweck & Alessandra Galie
Livestock & livelihood options, key issues

- 70% of the world’s rural poor rely on livestock for important parts of their livelihoods.
- Nearly 1 billion poor livestock keepers in the world, around two-thirds are rural women.
- Over 100 million landless people keep livestock.
- Livestock is a direct source of food (milk/eggs/meat) and provides income.
- Livestock as an asset to protect against shocks.
- In the poorest countries, livestock manure comprises over 70% of soil fertility amendments.
- Rural income multipliers are higher for livestock than for other commodities.
- Many employed in local informal livestock product markets, as well as input markets and services.
Livestock & livelihood options, research questions

- Role of livestock in household resilience
- Role of large versus S&MSE in livestock markets
- What are the trade-offs between commercialization and ‘poor’ farmers participation? E.g. Inclusive value chain
- What market to target? Export versus domestic markets
- What are the factors affecting smallholders’ uptake of productivity-enhancing technologies?
- What’s the balance between promoting formal markets versus upgrading local and informal markets?
- How to bring business models into collective organisations?
Gender and livestock

• Gender in livestock is key for food security & livelihoods:
  - Livestock is key for gender equity:
    - women can often own animals (more than e.g. land)
    - women can often control the milk and its revenues
    - livestock is accessible food, livelihoods, collateral, living bank, status
References, contact Isabelle Baltenweck
(i.baltenweck@cgiar.org)


- Elizabeth Waithanji, Jemimah Njuki, Samuel Mburu, Juliet Kariuki & Fredrick Njeru 2015. A gendered analysis of goat ownership and marketing in Meru, Kenya. Development in Practice Vol. 25 (2) pg. 188 - 203


Crop livestock interactions and mixed farm evolution

*Alan Duncan, Nils Teufel*

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015
Typical evolution of mixed farms

Production diversity -> Intensity (land use, input use etc.) ->

Opportunities for increasing
- Land productivity
- Labour productivity
- Resilience

Opportunities for benefiting from
- Specialisation
- Economies of scale
- Market demand

Forage production
Market feeds competitive
Sale of livestock products
Decreasing feeding of crop residues
Crop-only farms keep subsistence livestock
Dung as fertiliser
Feeding of crop residues
Pastoralists -> agro-pastoralists
Investment in technologies
Industrialisation of monogastrics

Sale of livestock products
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Industrialisation of monogastrics
Implications for food security & nutrition

• Major assumption: Intensification increases food production & diet diversity

• More **efficient resource** use increases food production

• Increasing **production diversity & intensity** improves nutrition through more diverse subsistence consumption

• Greater market integration changes crop-livestock **interactions** and food sources
ILRI research – efficient resource use

- Crop breeding for improving quality & quantity of residues (e.g. sorghum, millet, maize, rice, groundnut) (Blümmel 2010; Nigam 2010; Bidinger 2010; Homann-Ke Tui 2013; Blümmel 2013a)
- Identification of innovative & appropriate forage species & varieties (gene-bank, e.g. napier varieties, stylosanthes, brachiaria, desmodium, gliricidia) (Jorge 2012; Baltenweck 2014; ILRI 2014)
- Knowledge dissemination on processing and utilisation of crop residues (cereals, legumes, tubers) (Anandan 2013; Lukuyu 2013; Katjiuongua 2015)
- Quantification of livestock contributions to household livelihoods and opportunity costs of feed (Klapwijk 2014a; Valbuena 2015; Henderson 2015)
ILRI research – production diversity

- Nutrition impact of production diversification (Korir 2015)
- Distribution of food security amongst households (Silvestri 2015; van Wijk 2014; Ritzema 2015)
- Evolution of food sources (Douxchamps 2014)
- Farm typologies, food security and diet diversity (Hengsdijk 2014; Teufel 2015)
Example: Distribution of food security

Tanzania: Food Security Ratio
Van Wijk et al., in prep

- 61% are food-insecure

- Market options, further production intensification, diversification, crop-livestock integration

- Food crop production intensification, opening of market options

- Problem alleviation through more production, off-farm opportunities
ILRI research – production diversity

• Nutrition impact of production diversification (Korir 2015)
• Distribution of food security amongst households (Silvestri 2015; van Wijk 2014; Ritzema 2015)
• Evolution of food sources (Douxchamps 2014)
• Farm typologies, food security and diet diversity (Hengsdijk 2014; Teufel 2015)
Clustered by diet diversity score [max=1]

Example: Farm typologies by diet diversity
Increasing and decreasing demand for crop residues as feed

**livestock density ↑** - **draft power ↓** - **crop productivity ↑**

(Valbuena 2014; Mekasha 2014; Blümmel 2013b)

Contribution and market value of crop residues
(Klapwijk 2014b; Wright 2010; Teufel 2011)

More market integration leads to changes in food sources

- More resources to acquire food (ETC/Heifer 2013; Kidoido 2014)
- Higher opportunity costs of subsistence consumption (Duncan 2013)

Limits of intensification

- Resource limitations to food security; focus on off-farm income (Frelat 2015)
- Intensification may threaten sustainability (Duncan 2015)
References – efficient resource use


B. Henderson, M. van Wijk, C. Godde, S. Silvestri, S. Douxchamps, B. Power, C. Rigolot and M. Herrero (2015): Closing system-wide yield gaps to increase food supply and mitigate GHGs among mixed crop-livestock smallholders in Sub-Saharan Africa. On-going study at CSIRO.


References – production diversity


ETC/Heifer, 2013: EADD final evaluation report. Nairobi


Livestock and Environment

Mats Lannerstad

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015
Environmental scale of livestock

Land
30 percent global terrestrial biomes
33% all croplands

(Foley et al 2005)  
(Steinfeld et al 2006)

Water
~ 4,000 km$^3$ evapotranspiration - feeds, fodder & grazing
~ 3,200 km$^3$ evapotranspiration - food crops

(Heinke et al manuscript)

Feed biomass
~4.7 billion tons - feed biomass
- grasses 48 %
- grains 28 %
- occasional feed & stover 24 %

(Herrero et al 2013)

GHGs
14.5 % anthropogenic GHG emissions, 65% cattle (meat/milk/manure/draft power)
- feed production & processing 45 %
- enteric fermentation 39 %
- manure storage & processing 10 %

(FAO 2013)
Livestock & Environment – multiple dimensions impacting nutrition

Natural Resources Use

- Local degradation and scarcity
- "Carrying capacity"
- Planetary Boundaries
- Natural resource use footprints

Emissions / Pollution

- GHGs
- Nutrient leakage
- Antibiotics, etc.
- Pollution/emission footprints
Livestock & Environment – multiple dimensions impacting nutrition

Natural Resources Use
- Local degradation and scarcity
- "Carrying capacity"
- Planetary Boundaries
- Natural resource use footprints

Global Environmental Change
- Livestock contribute to CC
- CC impact livestock production

Emissions / Pollution
- GHGs
- Nutrient leakage
- Antibiotics, etc.
- Pollution/emission footprints

Vertical chain perspective
- Impacts along the Value Chains

System perspective
- Across scales, local → landscape → etc.
- Resource competition, land, water, etc.
- Environmental "multi-currency" analyses
- Ecosystem services & resilience
Environment and Climate Smart Livestock Production

Natural resource use and Environmental footprints

- Developing country figures – local (lab) to global (modelling)
- Local context relevance – different systems & climate zones
- Multi-currency assessments – trade-offs & synergies
Environment and Climate Smart Livestock Production

Natural resource use and Environmental footprints
- Developing country figures – local (lab) to global (modelling)
- Local context relevance – different systems & climate zones
- Multi-currency assessments – trade-offs & synergies

Evidence based strategies and interventions
- How to mitigate GHGs emission – feeds/manure/etc.
- Improved natural resources use efficiency
- How to adapt to climate change – stakeholder engagement
- Strengthening resilience of entire socio-ecological system


Livestock health and food security

Bernard Bett, Johanna Lindahl

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015
Impact of livestock diseases

- Livestock diseases – important constraints to livestock production in developing countries

- Predicted to increase with:
  - Agricultural intensification
  - Climate change
  - Inadequate policies

- Challenges on control vary with specific diseases:
  - Endemic diseases
  - Epidemic diseases
  - Emerging diseases

NB: No data for PPR in south Asia but it is widespread in this region

Estimates from BMGF
EIDs – productivity losses

**HPAI – Nigeria**
- 2005 - 2008
- 711 birds died and 1.3m culled
- Losses by producers and traders

**HPAI – Indonesia and region**
- From 2003
- >140m chickens culled

**RVF – SA**
- 2010
- >50,000 animals infected with >1500 deaths

**RVF – EA**
- 2006 – 2007
- $32m - Kenya

**ASF – Georgia**
- 2007 - 2008
- >200,000 pigs slaughtered

**Nipah – Malaysia**
- 1999
- Shut-down of >half pig farms
- Embargo on pig products
Impact on Food Security

• **Availability**
  - Productivity losses – meat, milk, eggs
  - Premature mortality, reduced offtake
  - Reduced crop production – draft power, manure
  - Restrictions on types of livestock breeds kept, hence productivity
  - Epidemics and slow recovery rates of livestock populations

• **Physical and economic access**
  - Control measures – quarantine, slaughter bans
  - Food substitution and price hikes
  - Diseases as non-tariff barriers to trade
  - Livelihoods of market chain actors
Knowledge gaps and on-going research

• Risk detection
  o Disease drivers and interactions
  o EID surveillance – need for biomarkers to identify potential EIDs?

• Risk management
  o Safe and effective technologies - vaccines
  o Improved targeting of interventions
  o Decision Support Tools

Livestock & human nutrition; livestock & human health

Prof Eric Fèvre and Dr Silvia Alonso

Agriculture for Nutrition and Health

Sustainable Agricultural Development for Food Security and Nutrition, including the role of Livestock, HLPE Seminar with ILRI, 8 May 2015
Livestock production is important for general health

- Products provide cash money for food purchases
- Provides income for healthcare expenses
- Provides direct access to ASF **

May also have adverse health outcomes (eg zoonoses)
Evidence from intervention studies

<table>
<thead>
<tr>
<th>Observational studies</th>
<th>Intervention studies - few</th>
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<tbody>
<tr>
<td>Strong evidence for ASF = improved child growth and micronutrient status</td>
<td>Meat (70 g/d) improved activity and leadership, cognitive function, school tests....</td>
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<tr>
<td>Increasing milk intake improves growth of young children and school children (including in industrialized countries)</td>
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Meta-analysis of dairy products and physical stature (de Beer et al., 2012)

Animal source food interventions in Kenya, 7-10 y (Neumann, C. et al.)
Research gaps

• Scientific evidence of causative ASF-nutrition link still weak
• Limited evidence for many ASFs; variations by population strata not quantified well (illness, pregnant, breastfeeding)

And essential research questions remain:

“which are the most effective ways to increase ASF in the diets in low income populations (livestock VC actors and others)”

ILRI is currently undertaking studies to assess the impact of livestock interventions on women and children nutritional outcomes in Uganda (pork VC) and Tanzania (dairy VC), and evaluate the mediator role of women’s empowerment in livestock systems

Survey completed to assess access to ASF and nutritional outcomes in households in low income areas in Nairobi.
Zoonoses and zNTDs in extensive and intensive livestock systems

Push-pull benefits of livestock to health
Focus tends towards the role of livestock in adverse health events
Mitigation: human health benefit from livestock targeted intervention
One Health

A concrete example: cysticercosis

Problems in livestock production leading to adverse health

Most significant parasitic food borne disease (Asia, Africa, S. America) in terms of DALYs

Human infection: inadequate systems of meat inspection at slaughter
Porcine infection: poorly integrated pig husbandry systems with free-ranging pigs
Env. Contamination: lack of sanitation in small-holder livestock production systems

Tools exist: new pig vaccines prevent infection, drugs to kill worms, new diagnostics (ILRI)

Research needs:
How to best deploy these tools on a large scale?
Finding geographical foci of infection in farming systems
Intervening sustainably to eliminate transmission
= better food safety and health
- What do food borne diseases contribute to ill-health globally? Regionally?
- Metrics have been applied at global scale
- Data at country levels are severely lacking
- How can we estimate country-level disease burden, apply better diagnostics?
- How does the disease landscape change in rapidly urbanizing societies?
- Quantifying the contribution of ASF has not been formally undertaken
- Determine risk in formal and informal sectors is important and interesting
Urbanization

Urban food production (including livestock) is important for food security, especially for the poorest

Challenges for veterinary care

Challenges for hygiene and managing waste

Challenges for pathogen emergence – cities as ecosystems

Policy frameworks are – at best - inconsistent

There is a need for sound evidence for decision-making