Considerations for the Future of Animal Science

Growing Sustainable Smallholder Livestock Productivity world's poorest people

National Academies of Science

March 10, 2014

Donald Nkrumah, PhD, MBA

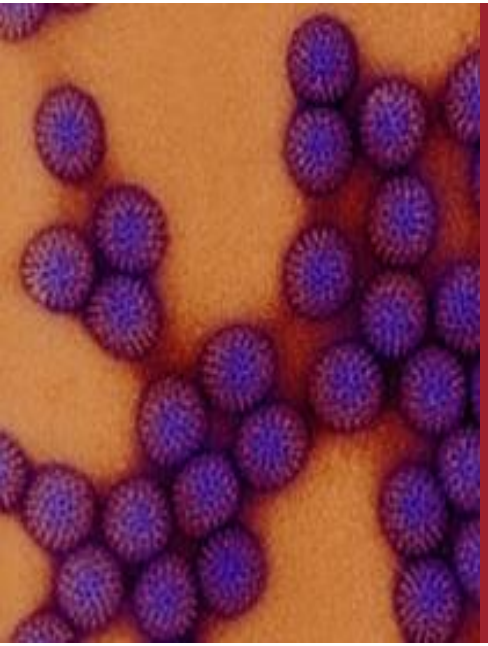
Senior Program Officer, Global Agricultural Development

BILL & MELINDA GATES foundation

EVERY PERSON DESERVES THE CHANCE TO LIVE A HEALTHY, PRODUCTIVE LIFE.

Our History

1998



Bill and Melinda read an article about millions of children dying each year due to rotavirus.

2000

BILL & MELINDA GATES *foundation*

They officially create the foundation.

2006

Warren Buffett decides to give Berkshire Hathaway stock.

2008

Bill joins Melinda full-time at the foundation.

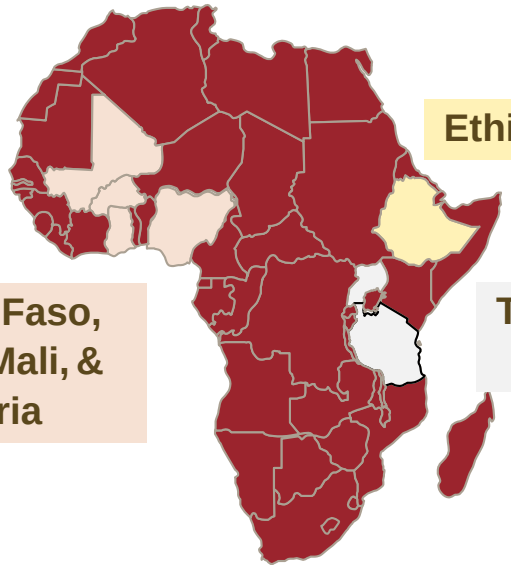
Global Development Program Areas of Focus

Increasing opportunities for the world's poorest people to lift themselves out of hunger and poverty.

Agricultural Development	Helping small farmers boost their productivity, increase their incomes, and build better lives.
Financial Services for the Poor	Expanding access to safe, affordable financial services—especially savings—in developing countries.
Water, Sanitation, and Hygiene	Providing hundreds of millions safe and sustainable access to sanitation and improving the quality of their water and hygiene.
Global Libraries	Providing free access to computers and the Internet in thousands of public libraries in emerging economies.
Special Initiatives	Pursuing other ways of making focused, innovative, and results-driven investments in partnerships we believe can have an impact on people's lives.

We chose select geographies and products for investment

Focus Geographies



Focus Products

- Cereals: Maize, Millet, Sorghum, Rice
- Legumes: Groundnuts, Cowpeas, beans
- Vegetatively propagated: Cassava, Yams, Sweet Potatoes, Bananas
- Livestock: Cows, Goats, Chickens

- Cereals: Maize, Wheat, Rice
- Legumes: Chickpeas, Groundnuts
- Livestock: Cows, Goats, Chickens, Water buffalo

Livestock Investments Make a Dramatic Difference for Smallholder Farmers in Four Ways

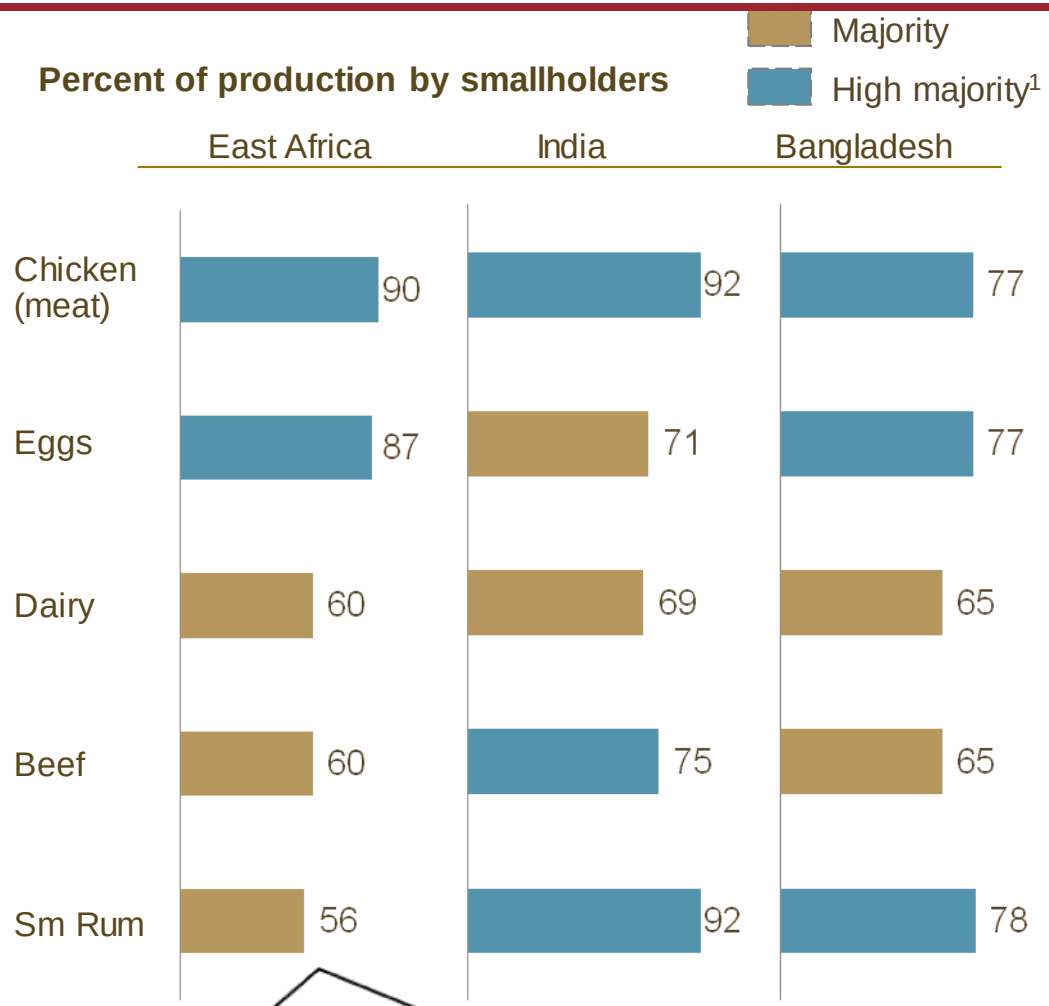
Why is livestock important to smallholder farmers?

reaching about 930 million people total in SSA and SA

Smallholder livestock farmers account for the majority of production in a number of regions

"Smallholder", in the context of livestock, can be denoted by space or by number of animals:

- Dairy farmer <=6 milking animals and / or less than three hectares of land
- Pastoralist with less than 10 mature cattle
- Farmer keeping less than 30 small ruminants
- Farmer keeping less than 200 birds



All data above was collected from a number of case studies (published between 1997 and 2007); for this study, West Africa was not included as a region of research

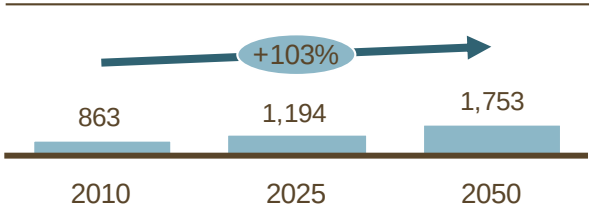
1 High majority denotes>75% production

Source: ILRI (2008) based on Peeler and Omore(1997), India National Sample Survey Organization (2007) and Bangladesh Bureau of Statistics (1999)

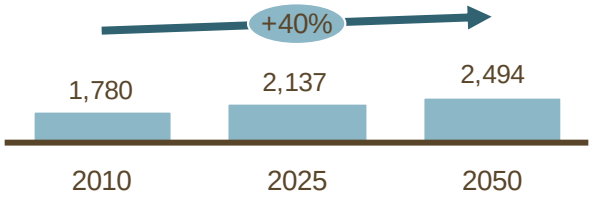
Livestock Demand is Projected to Grow Until Year 2050

Population is expected to increase, especially in Sub-Saharan Africa;

SSA population, 2010-2050e
Million people

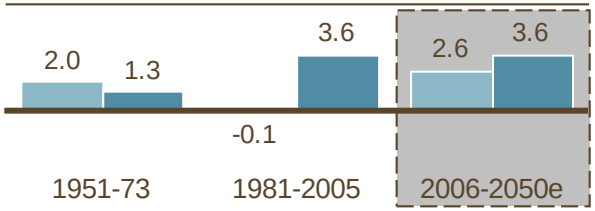


SA population, 2010-2050e
Million people



Furthermore, demand will be stimulated by increased per capita incomes…

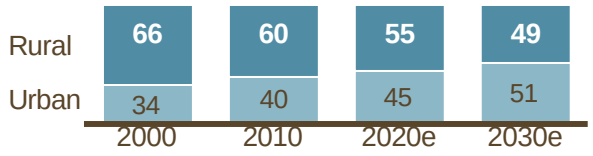
SSA/SA per capita income growth, 1951-2050e
Percent



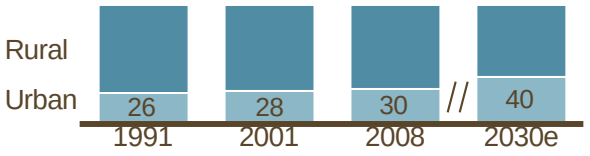
Steinfeld et al ("Livestock's Long Shadow," FAO, 2006) found that as income grows, so does expenditure on livestock products

…as well as increased urbanization rates, which stimulates consumption and infrastructure

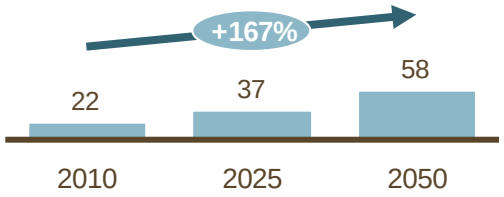
SSA Urbanization Rates, 200-2030e
Percent



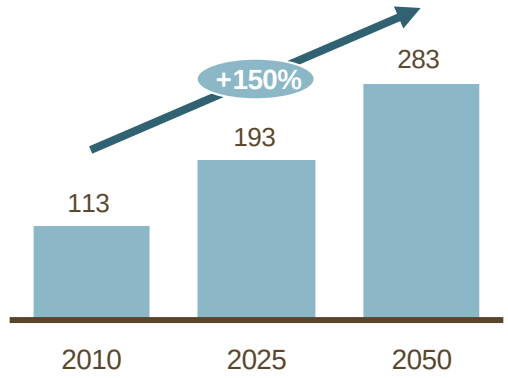
SA Urbanization Rates, 1991-2030e[1]
Percent



SSA demand for livestock products, 2010-2050e
Million tons



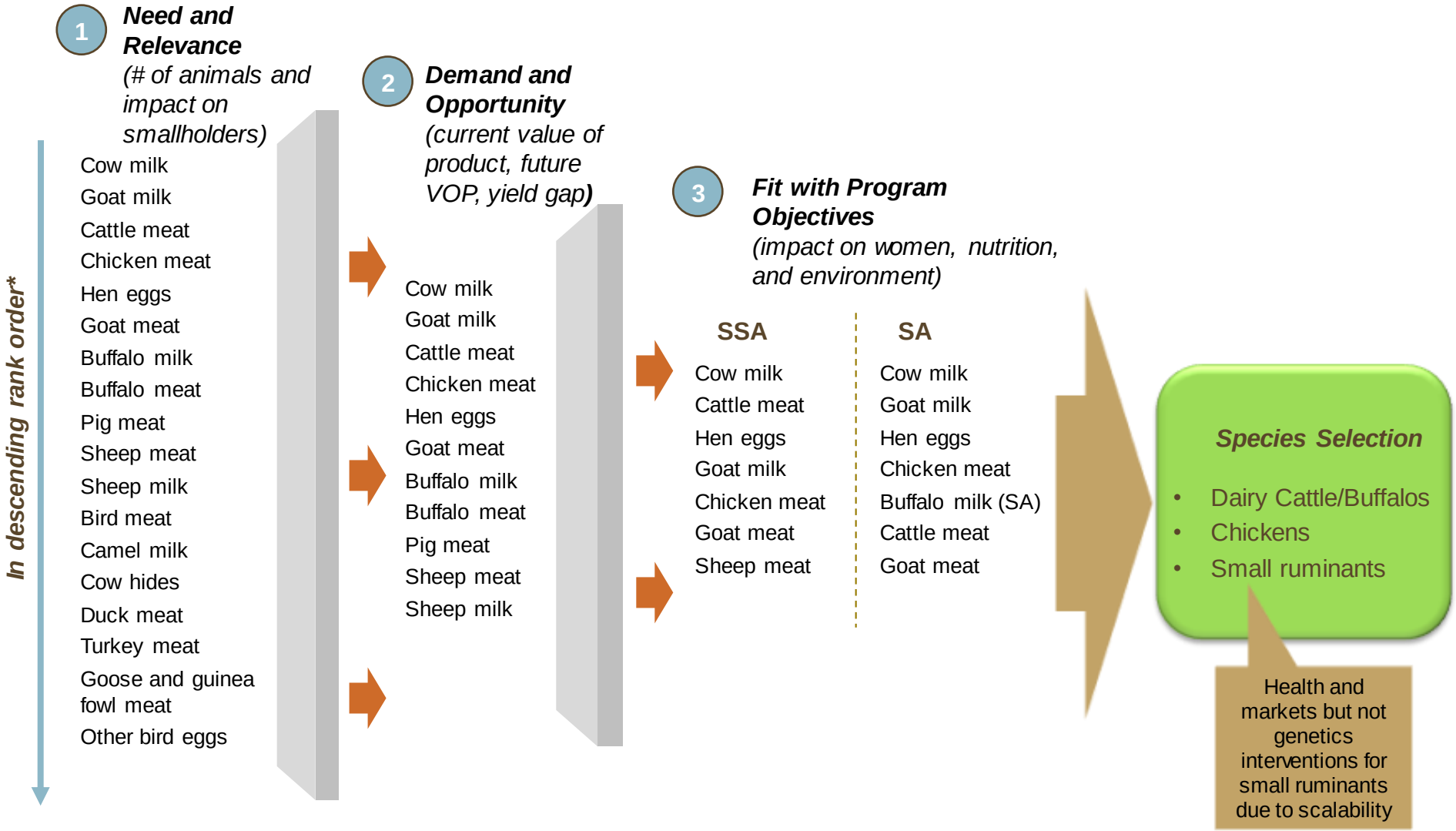
SA demand for livestock products, 2010-2050e
Million tons



Note: SA Urbanization rate estimates for 2020 not calculated

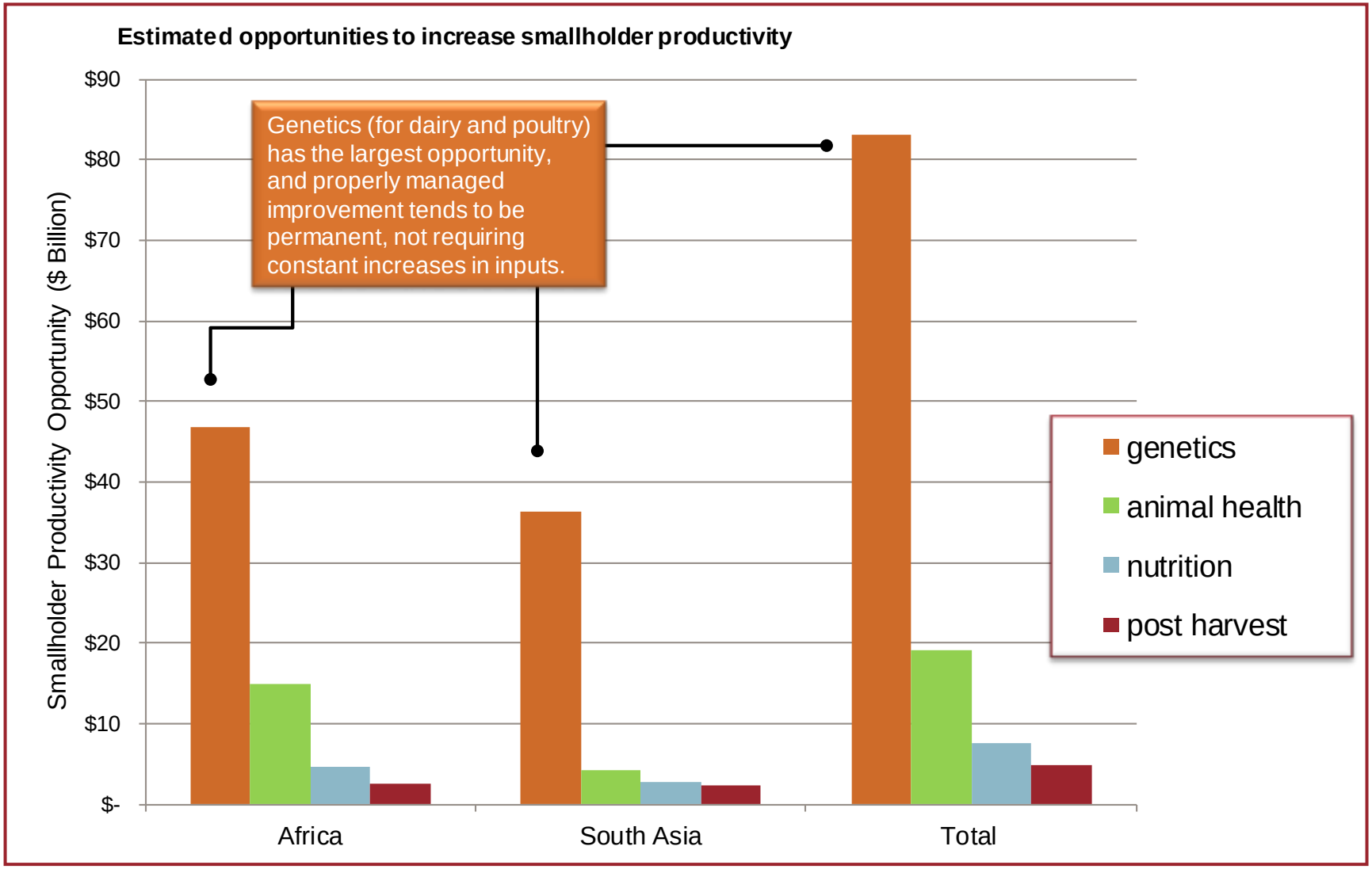
SOURCE: FAO, UN Population database, Hillebrand "Global Distribution of Income", McKinsey Global Institute, Livestock's Long Shadow

Focus on dairy cattle, chickens, and small ruminants



NOTE: **Aquaculture** was omitted from this analysis because 1) it is a separate system with little relevance to land-based species and 2) limited team capacity to take on a new area. Research indicates that in SSA, aquaculture contributes only 5% of fish production and 10% offish consumption (World Fish Center, 2009), and fish are expected to become more expensive compared with other food products (IFPRI 2003)

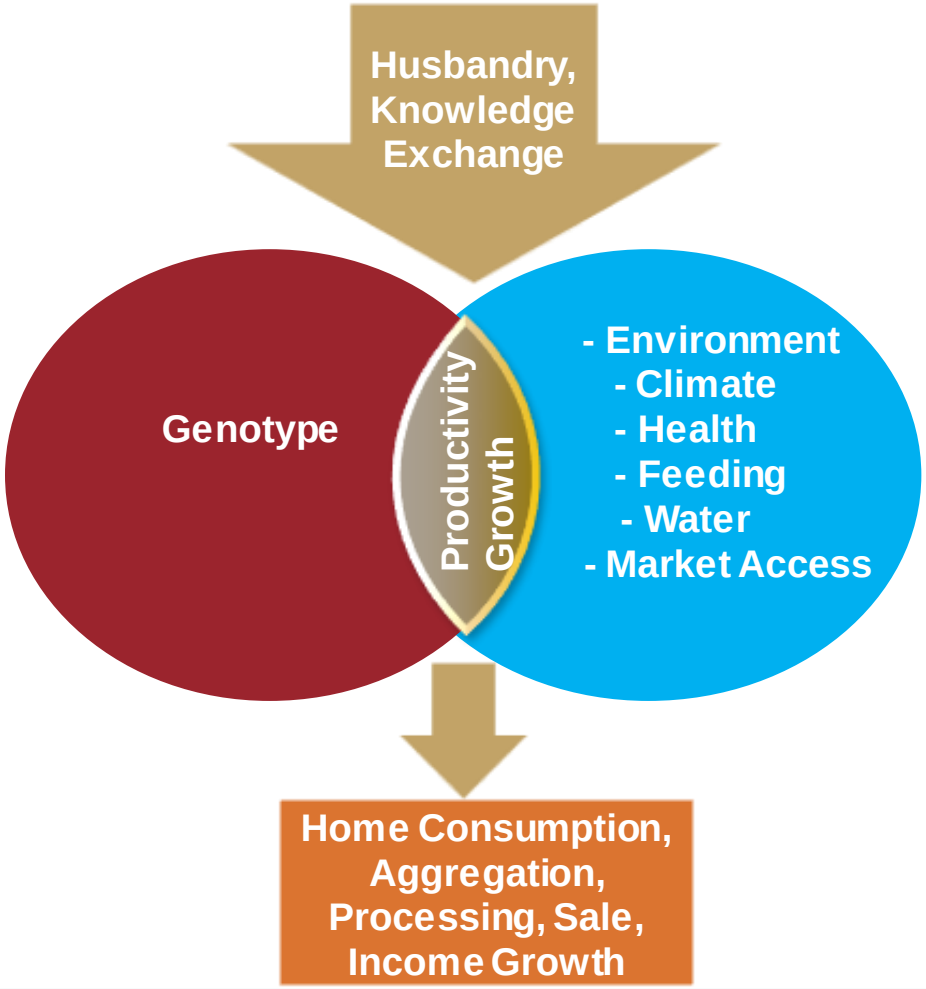
Genetics and health investments to optimize potential opportunities under existing feed resource constraints



SOURCE: 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

Genetics is the prerequisite for significant productivity growth, but interactions with other factors are significant

In the developed world, dramatic on-farm productivity gains were driven by genetic selection and technologies for reproductive performance, animal nutrition, and health management



- **In dairy:**
  - Improving feeding or disease control leads to better health and survival but little increase in milk yield.
  - Agro-ecologically appropriate germplasm is the prerequisite to dramatic productivity growth.
- **In poultry:**
  - Better genetics must be integrated with systems for proper brooding, feeding, and vaccination of chicks and affordable access for smallholders.
- **Overall:**
  - Genetically improved animals are the best incentive to improve other systems, to take full advantage of the productivity potential.

Source: Johnson 1991, Syrstad 1991, Williams, 2005

More than *100 years* of sustained breeding separates the genetic potential of African/Indian cattle from developed world dairy cattle

1900 | 1925 | 1950 | 1975 | 2000 | 2013

SSA:

Indigenous cattle used for dairying → Imports of tropically adapted breeds → Imports of exotic breeds → Crossbreeding and potential synthetics (**~1,500 L/Lact**)

Limited improvement of indigenous animals



Brazil:

Gyr/Girolando imports from India via Europe ~1,500 L/Lact → ~40 years of 1-2% gains/yr conventional selection (**~3,500 L/Lact**)




USA/ Canada:

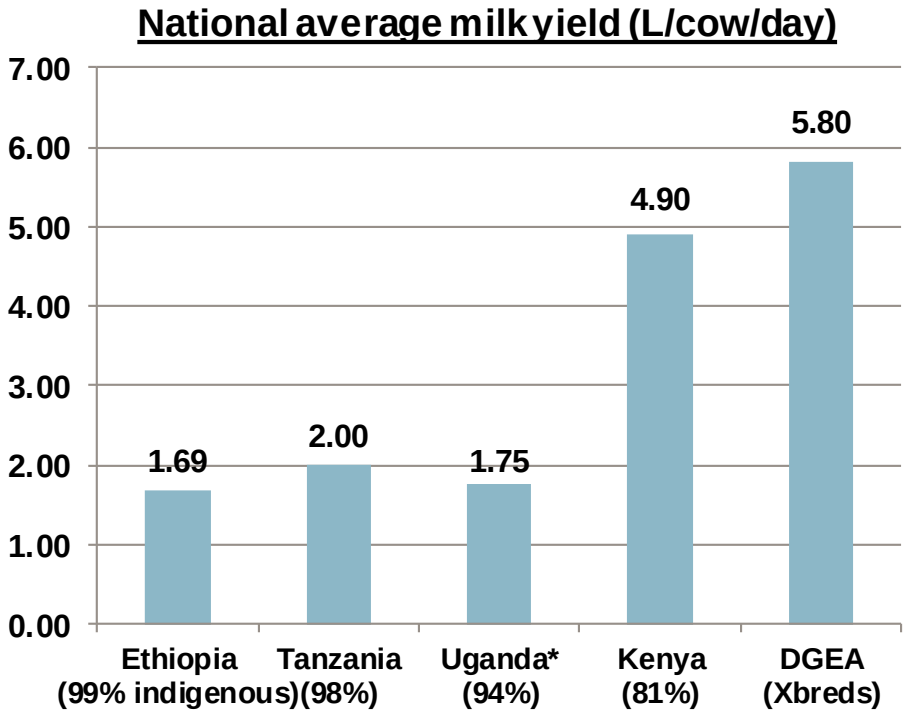
Holsteins: ~1,500L/Lact → ~110 years of conventional selection with genetic gains of 1-2%/yr (**~12,000 L/Lact**)

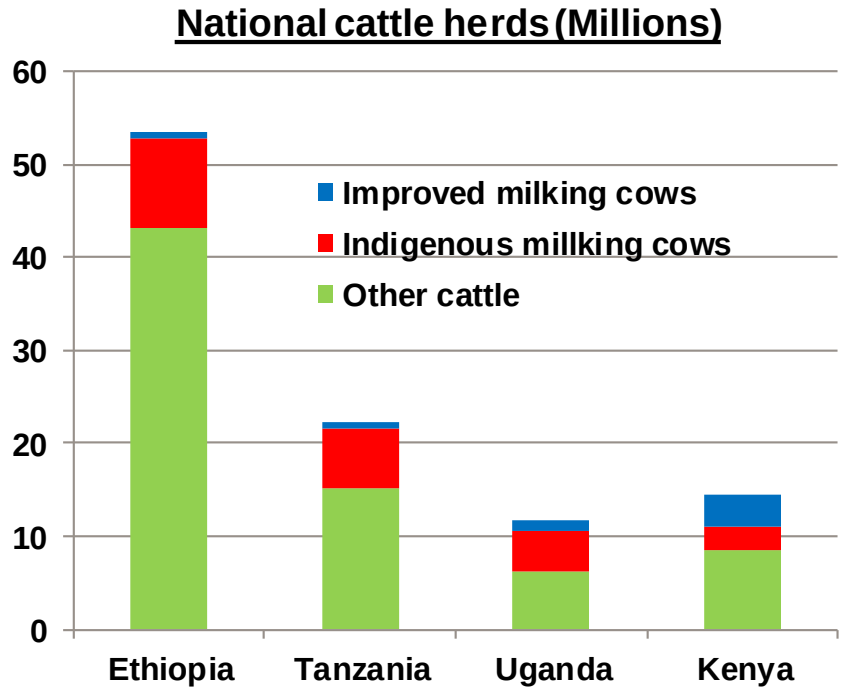



Technologies exist to accelerate genetic gains in SSA, but interventions need scale and private sector to sustainably transform smallholder dairy productivity

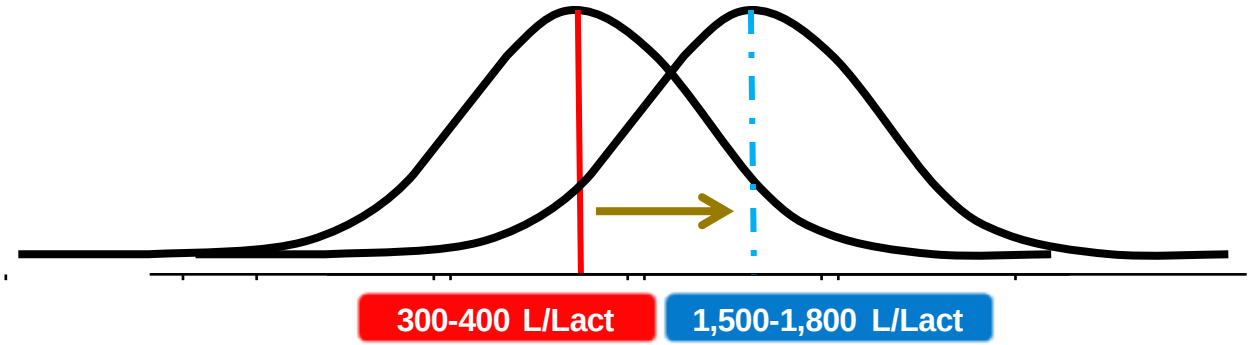
Source: Williams 2005, Syrstad 1991, Netherlands Development Cooperation 1987, Preston 1991, Grand Challenges 2013 presentations

Yield gaps in milk production and the predominance of low producing, mostly beef-type, indigenous breeds in smallholder dairy systems





Potential genotype substitution effect from local cows to crossbreds



Source: FAO 2010, TechnoServe, government central statistics agencies (Ethiopia 2010, Tanzania 2008, Uganda 2008 & 2011, Kenya 2009-10), Kenya Agricultural Sector Development Strategy 2010-2020, SDP 2005, Njombe et al 2011, Gibson et al 2013

Note: Average milk yields/cow/day should not be aggregated for country-level production without accounting for lactation lengths, calving intervals, etc.

Performance measurements drive adoption of improved genotypes and accelerates on-farm genetic gains

Although smallholders delight in their most productive cows, most do not know how much their cows actually produce; the only productivity number they recall is the highest ever recorded, not the average.

Importance of measurement of milk yield:

- Dairy productivity growth is directly related to knowledge of the production and reproduction records of individual cows.
- Performance measurement and analysis has formed the basis of capacity building for animal genetics and breeding in most countries

Lack of data on cow milk yield poses challenges for

- Convincing poor smallholders to adopt superior germplasm, including identifying which bulls have superior performance for use in breeding
- Extension decision support to farmers on breeding & management
- Tracking productivity impact from germplasm development and AI

Source: Galal 1998; Chagunda et al 1998, McDowell 1943, BMGF livestock genetics stakeholder convenings and field visits 2013

Significant genetic variation in production potential and tropical adaptation in chicken germplasm in SSA

Example breeds and average eggs/year:

Local ecotypes
(SSA)
20-50 (low-input)

Nigerian Locally Adapted Poultry
96

Dahlem Red
(Nigeria)
143

Shika Brown
(Nigeria)
182

Frizzle Feather crossbred
(Ghana)
287

Naked Neck crossbred
(Ghana)
288

Horro
(Ethiopia)
80 (low-input)

Kuroiler
(India/Uganda)
180 (semi-scavenging)

Fayoumi
(Egypt)
146

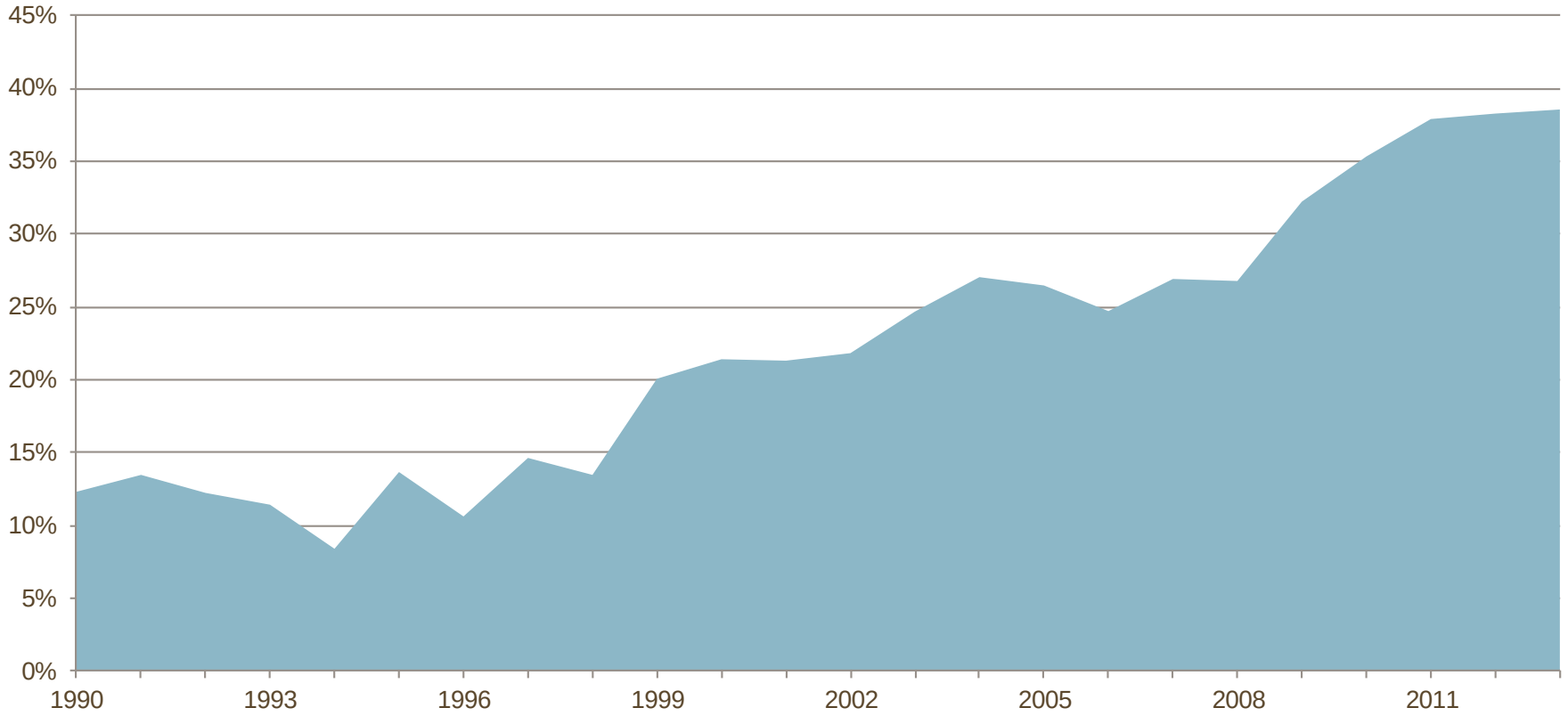
Koekoek
(South Africa)
204

CARI Sonali
(India)
280

CARI Priya
(India)
298

Source: Grand Challenges presentations in Brazil October 2013; Dessie et al 2011; FAO 2010; Sharma 2013; Van Marle-Koster 2011; Ahuja et al 2008

The Middle East and Africa now account for nearly 40% of the global chicken trade



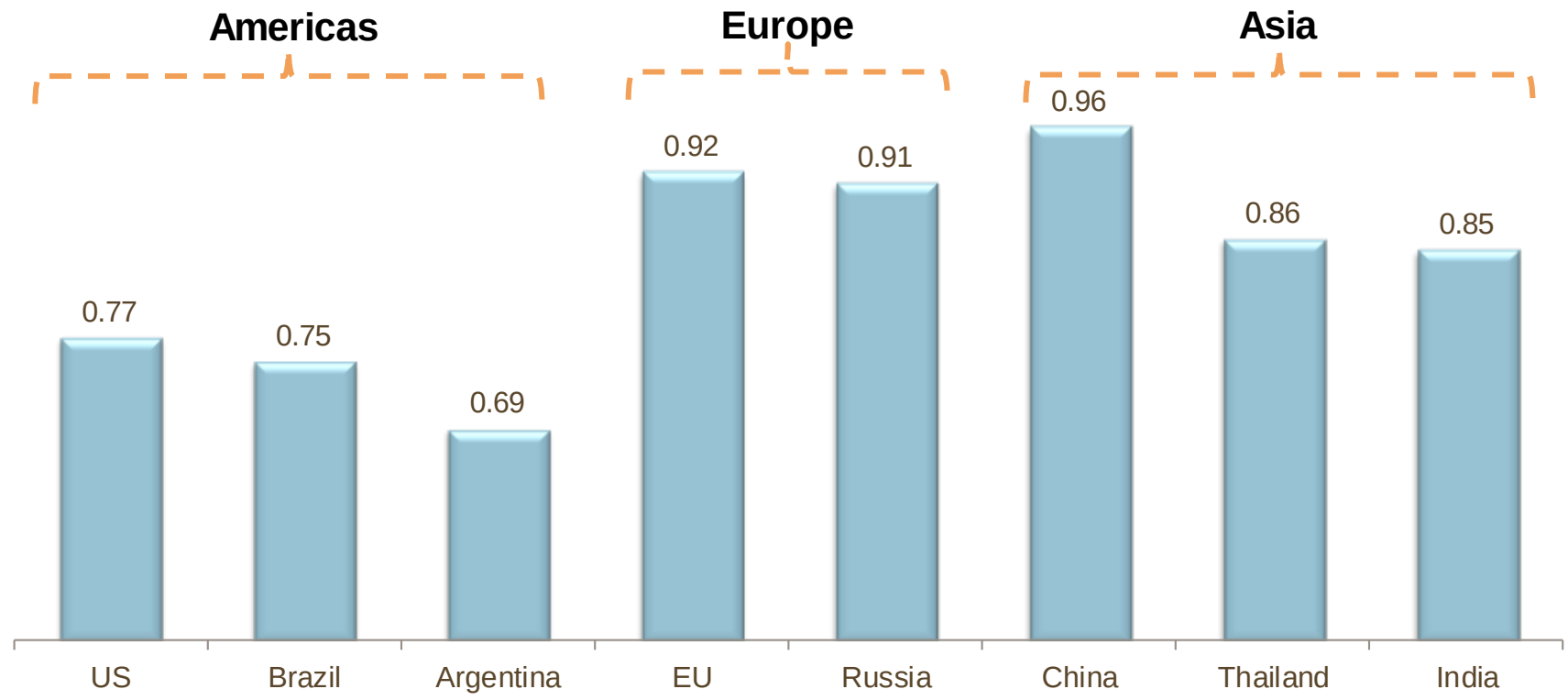
Strong population and income growth in these regions coupled with high production costs have driven higher chicken imports

Source: USDA PSD, Rabobank 2010

Competitiveness in *intensive* poultry production starts with feed cost, and it is dominated by countries with excess grain

Broiler Cost of Production

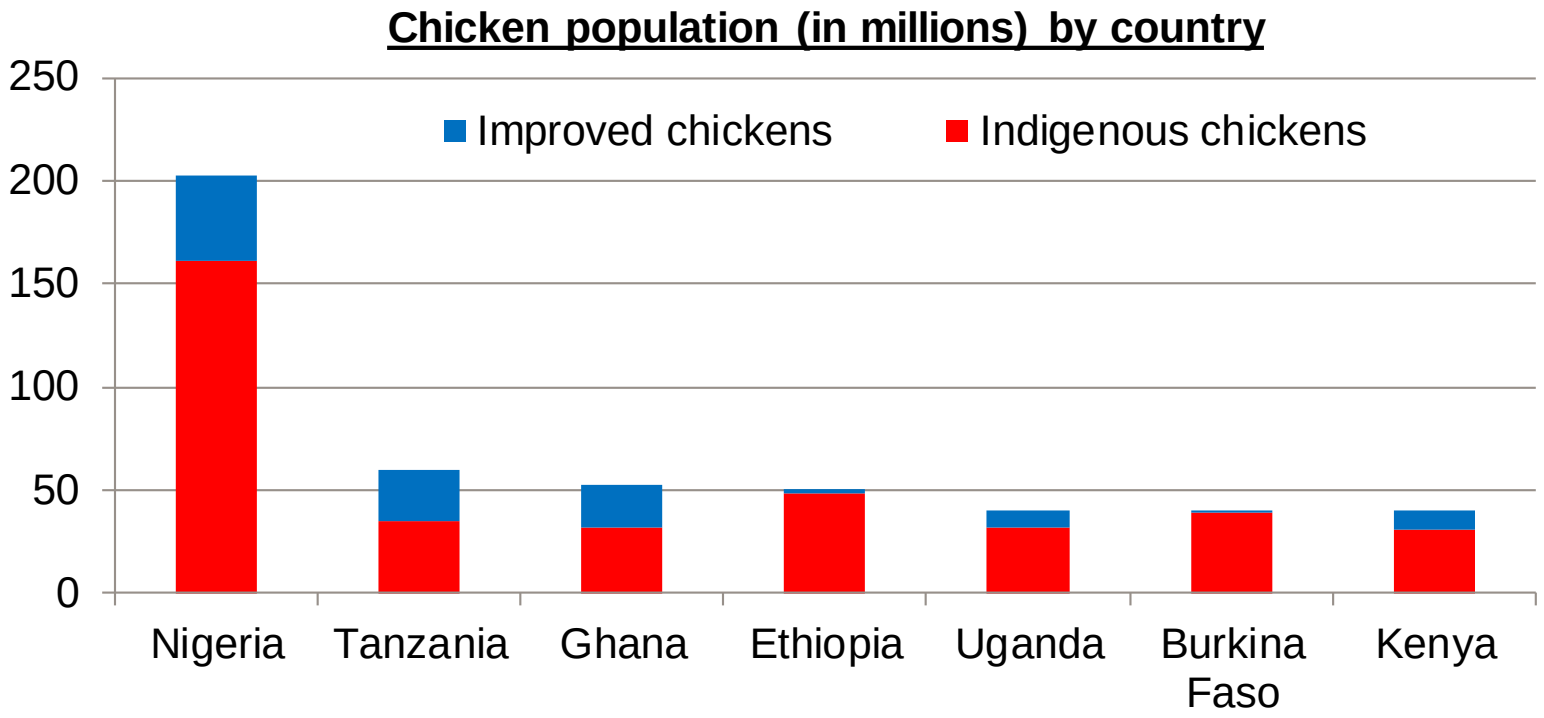
Euro/kg cwe

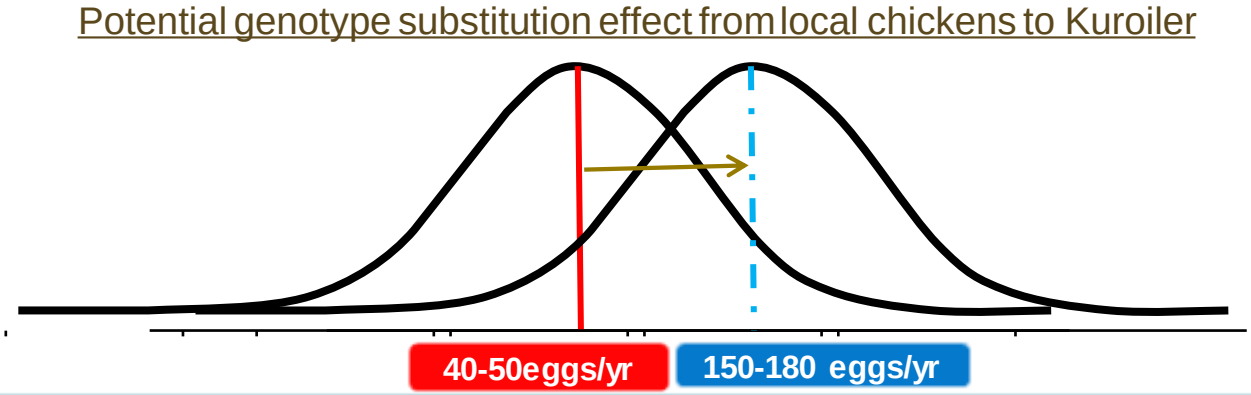


Production in SSA based on the importation of grain has not been profitable and competitive, especially for smallholders.

Source: USDA PSD, Rabobank 2010

Low-producing indigenous chickens are predominant, despite massive global resource of potentially high-producing, tropically-adapted breeds





Source: Mwacharo et al 2008; Dessie et al 2011, Sonaiya and Swan 2004; MLFD 2013

Farmers without modern hatching and brooding systems rely on hens to incubate and brood (care for chicks), taking up 60-80% of productive days

Commercial production systems have selected against 'broodiness'

Great-grandparent/Pure lines

↓

Grandparent lines

↓

Parent/breeding lines (produce ~300-350 eggs)

↓

Commercial fertile chicks

↓

On-farm brooding of layer chicks

↓

Commercial layers (produce ~300-350 eggs)

Broodiness significantly reduces productivity of village hens

Village hen lays ~45 eggs over 3 clutches of ~21 days each

↓

Hen incubates ~10 eggs over 3 sessions of ~21 days each

↓

Hen broods 3 batches of ~6-10 chicks, each over ~56 days, with up to 50-100% mortality

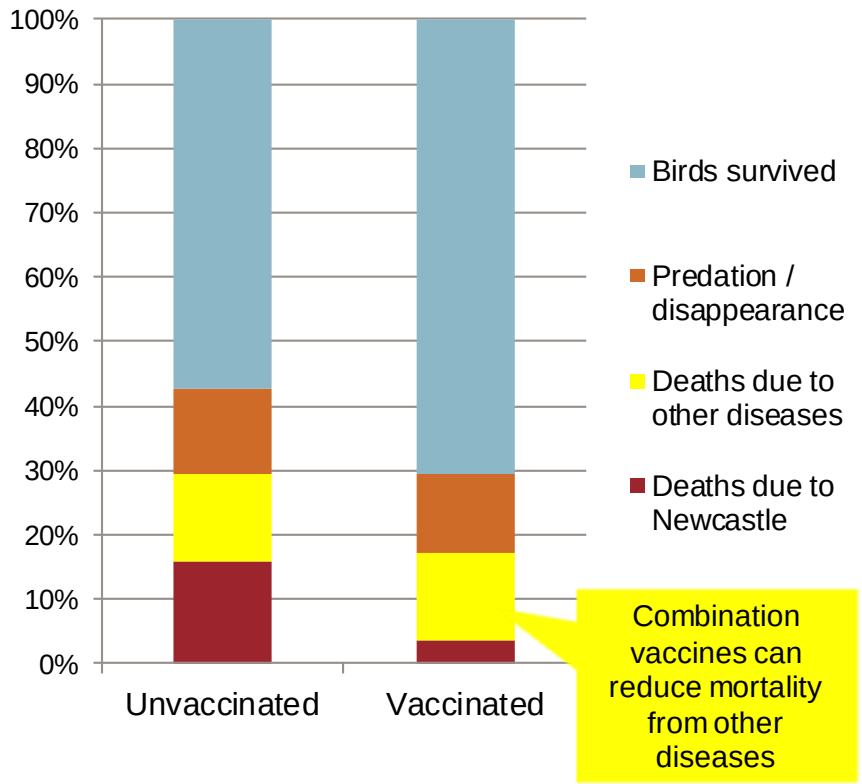
↓

77 x 3 or ~231 potential laying days spent just incubating and brooding

Source: Mwacharo et al 2008; Dessie et al 2011

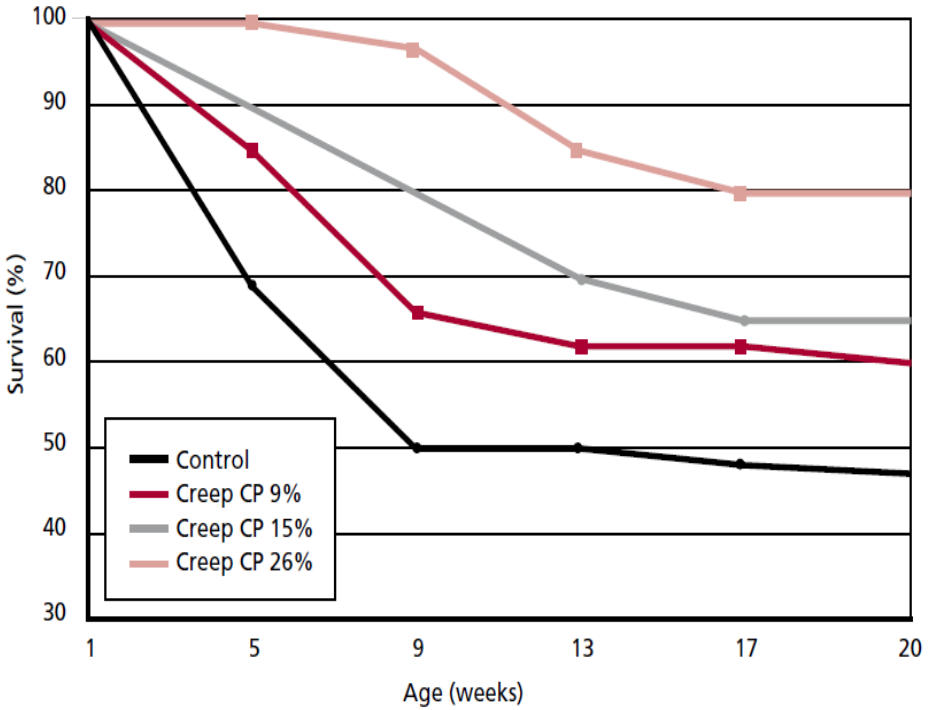
High chick mortality can be reduced through modern hatching and brooding systems

Proper chick vaccination reduces mortality from disease



Typical Newcastle outbreaks can kill 70-80% of unvaccinated village chickens

Survival is progressively improved with specially formulated "creep feed" for chicks



Artificial brooding systems will reduce the primary chick mortality risk through proper vaccination, feeding, and management.

Source: Spradbrow 1994, Barman et al 2010, graph on right from Dolberg (FAO) 2010, modified from Roberts et al (1994)
Note: CP = crude protein

Examining animal health, fourteen diseases cause the most significant loss for smallholders

1 ***14 diseases prioritized based on global need***

	Disease	Total Annual SH Loss (Africa)	Total Annual SH Loss (SA)	Total Annual SH Loss	Cattle	Small Ruminants	Poultry
		Millions USD					
High	Endoparasites	3332	1659	4992	✓	✓	✓
High	Peste des Petits Ruminants (PPR)	3611	NA	3611		✓	
High	Contagious Bovine Pleuropneumonia (CBPP)	3274	NA	3274	✓		
High	Ectoparasites	1851	922	2773	✓	✓	✓
Medium	Foot and Mouth Disease	868	573	1441	✓	✓	
Medium	Trypanosomes ξ (T. congolense, T. vivax and T. brucei)	1166	242	1409	✓	✓	
Medium	Contagious Caprine Pleuropneumonia (CCPP)	1027	NA	1027		✓	
Medium	Newcastle disease‡	415	313	728			✓
Medium	Goat Pox and Sheep Pox	479	234	714		✓	
Medium	Brucellosis (B. Abortus, B. Melitensis)*	344	314	659	✓	✓	
Low	Lumpy Skin Disease	487	NA	487	✓		
Low	Rift Valley Fever (RVF)*	477	NA	477	✓	✓	
Low	Bovine Tuberculosis (TB)*	201	205	407	✓		
Low	East Coast Fever†	286	NA	286	✓		

2 ***7 new products** selected based on:***

- *Feasibility / ROI*
- *What others are doing*
- *Our unique advantage*

Disease / Pathogen	Product Concept
CBPP	New vaccine
East Coast Fever	Vaccine
Ectoparasites	New formulations
Endoparasites	New formulations and vaccine
Trypanosomiasis	Vaccine
PPR	DIVA vaccine, Eradication in SSA
Newcastle Disease	Vaccine delivery improvements

Estimates based on BMGF analytical models referencing multiple data sources * zoonosis, serious threat to human health, ‡ assumed to be endemic, out break value not used to calculate impact, ξ assumed to be endemic in Africa, outbreak value not used to calculate impact, † Calculated from top down economic impact estimate. ** In addition to 11 products GALVmed is working on, including improved vaccine production, antimicrob tx regiment for CBPP; infect and treat method for ECF; multivalent, outbreak vaccine, and diagnostic for RVF; multivalent vaccine for PPR & Sheep/Goat Pox; adapted vaccine packaging for Newcastle Disease; & improved vaccine production for CCPP

Critical Investment Areas in Genetics

- Tools and strategies for accelerating the rate of tropical adaptation of high-producing exotic dairy and poultry germplasm
- Research methods to accelerate on-farm genetic gains under smallholder systems, including performance Measurements to increase adoption of superior genetics.
- Genomic-based strategies to optimize productivity from efficient usage of scavenging feed resources
- Strategies for accelerating genetic gains in indigenous livestock species
- Tools and mechanisms to boost innate immunity and increase the tolerance/immune response of exotic and crossbred genotypes to tropical diseases and pests.
- Genetics of zoonotic and trans-boundary livestock diseases and pests
- Research Programs for Emerging Agricultural Research Leaders for Livestock
- Development of assisted reproductive technologies for tropical countries
- Development and testing of tropically-adapted chicken/cattle for smallholder production
- Research on germplasm that maintain a high level of productivity under scavenging conditions

Thank You