Considerations for the Future of Animal Science

Growing Sustainable Smallholder Livestock Productivity
world’s poorest people

National Academies of Science

March 10, 2014

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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
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.**

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

Focus Geographies:
- Burkina Faso, Ghana, Mali, & Nigeria
- Tanzania & Uganda
- Ethiopia
- Bihar, Odisha, UP in India, & Bangladesh

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

March 10, 2014
Livestock Investments Make a Dramatic Difference for Smallholder Farmers in Four Ways

1. Income Source
2. Nutrition Source
3. Farm Productivity
4. Asset Holding
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.

Livestock Demand is Projected to Grow Until Year 2050

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

<table>
<thead>
<tr>
<th>SSA population, 2010-2050e</th>
<th>SA population, 2010-2050e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Million people</td>
<td>Million people</td>
</tr>
<tr>
<td>2010</td>
<td>863</td>
</tr>
<tr>
<td>2025</td>
<td>+103%</td>
</tr>
<tr>
<td>2050</td>
<td>1,780</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>SSA/SA per capita income growth, 1951-2050e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
</tr>
<tr>
<td>1951-73</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>3.6</td>
</tr>
<tr>
<td>-0.1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Rural</td>
<td>Rural</td>
</tr>
<tr>
<td>Urban</td>
<td>Urban</td>
</tr>
<tr>
<td>66</td>
<td>60</td>
</tr>
<tr>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>2010</td>
<td>2010</td>
</tr>
<tr>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>2020e</td>
<td>2020e</td>
</tr>
<tr>
<td>55</td>
<td>49</td>
</tr>
<tr>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>2030e</td>
<td>2030e</td>
</tr>
<tr>
<td>49</td>
<td>51</td>
</tr>
<tr>
<td>51</td>
<td>51</td>
</tr>
</tbody>
</table>

Note: SA Urbanization rate estimates for 2020 not calculated

**Focus on dairy cattle, chickens, and small ruminants**

1. **Need and Relevance**
   (# of animals and impact on smallholders)
   - Cow milk
   - Goat milk
   - Cattle meat
   - Chicken meat
   - Hen eggs
   - Goat meat
   - Buffalo milk
   - Buffalo meat
   - Pig meat
   - Sheep meat
   - Sheep milk
   - Bird meat
   - Camel milk
   - Cow hides
   - Duck meat
   - Turkey meat
   - Goose and guinea fowl meat
   - Other bird eggs

2. **Demand and Opportunity**
   (current value of product, future VOP, yield gap)
   - Cow milk
   - Goat milk
   - Cattle meat
   - Chicken meat
   - Hen eggs
   - Goat meat
   - Buffalo milk
   - Buffalo meat
   - Pig meat
   - Sheep meat
   - Sheep milk

3. **Fit with Program Objectives**
   (impact on women, nutrition, and environment)
   - **SSA**
     - Cow milk
     - Cattle meat
     - Hen eggs
     - Goat milk
     - Chicken meat
     - Goat meat
     - Sheep meat
     - Sheep milk
   - **SA**
     - Cow milk
     - Goat milk
     - Hen eggs
     - Chicken meat
     - Buffalo milk (SA)
     - Cattle meat
     - Goat meat

**Species Selection**
- Dairy Cattle/Buffalos
- Chickens
- 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% of fish 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

Estimated opportunities to increase smallholder productivity

<table>
<thead>
<tr>
<th>Region</th>
<th>Smallholder Productivity Opportunity ($ Billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Genetics: $60, Animal Health: $10, Nutrition: $5</td>
</tr>
<tr>
<td>South Asia</td>
<td>Genetics: $70, Animal Health: $15, Nutrition: $5</td>
</tr>
<tr>
<td>Total</td>
<td>Genetics: $130, Animal Health: $25, Nutrition: $20</td>
</tr>
</tbody>
</table>

Genetics (for dairy and poultry) has the largest opportunity, and properly managed improvement tends to be permanent, not requiring constant increases in inputs.

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.

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


**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: ~1,500 L/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
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


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 Adapted Locally 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; VanMarle-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

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Cost (Euro/kg cwe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americas</td>
<td>US</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Argentina</td>
<td>0.69</td>
</tr>
<tr>
<td>Europe</td>
<td>EU</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Russia</td>
<td>0.91</td>
</tr>
<tr>
<td>Asia</td>
<td>China</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>0.85</td>
</tr>
</tbody>
</table>

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.

Survival is progressively improved with specially formulated “creep feed” for chicks.

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


Note: CP = crude protein
### Examining animal health, fourteen diseases cause the most significant loss for smallholders

#### 1. 14 diseases prioritized based on global need

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

#### 2. 7 new products** selected based on:
- Feasibility / ROI
- What others are doing
- Our unique advantage

<table>
<thead>
<tr>
<th>Disease / Pathogen</th>
<th>Product Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBPP</td>
<td>New vaccine</td>
</tr>
<tr>
<td>East Coast Fever</td>
<td>Vaccine</td>
</tr>
<tr>
<td>Ectoparasites</td>
<td>New formulations</td>
</tr>
<tr>
<td>Endoparasites</td>
<td>New formulations and vaccine</td>
</tr>
<tr>
<td>Trypanosomiasis</td>
<td>Vaccine</td>
</tr>
<tr>
<td>PPR</td>
<td>DIVA vaccine, Eradication in SSA</td>
</tr>
<tr>
<td>Newcastle Disease</td>
<td>Vaccine delivery improvements</td>
</tr>
</tbody>
</table>

Estimates based on BMGF analytical models referencing multiple data sources. * zoonosis, serious threat to human health, ‡ assumed to be endemic, outbreak 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, antimicrobial regimen 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