Unleashing the Power of Data in Transforming Livestock Agriculture in Ethiopia

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Presented at the 27th Annual Conference of the Ethiopian Society of Animal Production (ESAP), EIAR, Addis Ababa, 29-31st August 2019

Summary

The purpose of this paper is to explore possible areas where data can be efficiently collected and used to effect a positive change in the livestock sector. Information on applications of data available in Ethiopia and other developing countries has been synthesized to understand inherent relationships, patterns and principles. The experience of developed economies and other African countries proves that data plays critical roles in achieving faster genetic gain, expediting economic progress, sustainable utilization and conservation of animal genetic resources, and making informed policy decisions. It is high time our country should make proportionate investments in generation and utilization of data, information and knowledge to bring transformative changes in livestock agriculture.

Background

The potential benefits of data in transforming livestock agriculture of developing countries like Ethiopia are enormous. Without harnessing the potential of data science, it becomes increasingly difficult to meet growing demand for animal source proteins and stay competitive in the international market.

Data is an item or event out of context, with no relation to other things. Livestock-related-data in the broadest possible sense, comprise a wide variety and volume of 'small' and 'big' data empowering us to make decisions and act swiftly in our social and economic context. These include, among others, data generated by research and academic institutions, input suppliers, service providers, government ministries, donors, social networking websites, mobile phones and other digital communication tools. Big Data (BD) is a term that refers to high-volume, high-velocity, high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation (gartner.com). On the other hand, Small Data (SD) can be defined as small datasets (e.g. those accumulated on Excel) that are capable of impacting decisions in the present. Algorithms, procedures or formulas for solving specific problems, are even more important than the data as they convert data into information and knowledge that can improve the effectiveness and efficiency of development efforts. Available information can be synthesized to develop business models applicable to prevailing production environments. In the cloud computing model, computer applications are hosted on servers delivering services via the internet.

Only when the relationships among various data are understood that information useful for the livestock sector can be produced. Understanding of the patterns in livestock related information (e.g. on breeding, production, marketing, consumption) leads to generation of knowledge with a potential to transform the sector. Wisdom is the culmination of this context independent process entailing the recognition that knowledge patterns in the sector arise from fundamental principles and the understanding of what those principles are (Figure 1).

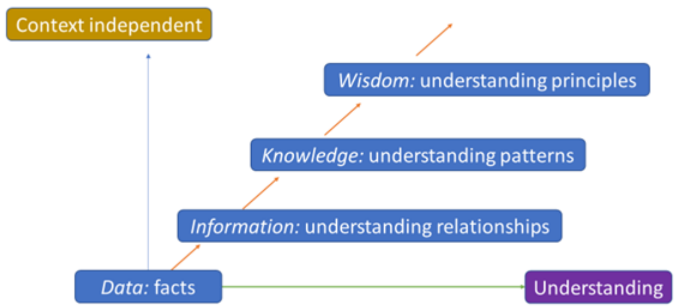

Figure 1. The data, information, knowledge, wisdom (DIKW) progression

In the sections below, we will discuss key components of the livestock sector which demand a paradigm shift in the utilization of data.

Genetics and breeding

Data is the raw material for making breeding decisions, such as identification of the best performing animals which need to serve as parents of the next generation. Estimation of breeding values (true genetic worth) of farm animals through classical quantitative genetic approaches or applying genomic prediction tools, all require performance records. Pedigree information should not only comprise relationships among animals but also accurate performance data.

Underdeveloped data infrastructure and absence of breed societies have so far impeded systematic animal performance recording and hindered sustainable livestock genetic improvement in Ethiopia. Let us explain our case by taking the Horro indigenous chicken breed improvement program as an example. Mass selection based on own performance of individual birds has been used to estimate breeding values whereby the EBV was computed by multiplying the deviation of individual phenotypes from the population mean by heritability of the traits (egg productivity, growth, and survival). With own performance only, the response to selection after 6 generations improved significantly, achieving an increase of 128% for egg production at 45-weeks-of-age, i.e. from 35 to 80 eggs; and an increase of 95.6% for live body-weight-at-16-weeks, i.e. from 620.9 to 1215 grams. The Horro breeding program demonstrated that within a few generations of selection, a modest data recording scheme (without meticulous collection of pedigree information and with the use of small laying houses) helped realize genetic gains that can be translated positively into the household economy. If we include more information (applying animal model), or genomic information, the genetic gain would have doubled because the accuracy of selection would increase with more information. On the other hand, genome editing for a monogenic trait can result in up to four-fold fixation for a desired allele (Bastiaansen, et al, 2018). These instances show the collection and use of a variety of high-quality breeding data expedites genetic progress in livestock.

Animal identification, recording, evaluation and data management should be planned and executed in line with the global standard for livestock data recording (https://www.icar.org/). Standardization of livestock data recording schemes at regional states and Federal levels lays the foundation for long-term genetic improvement and allows interoperability of animal evaluations/breeding programs at national and possibly at continental levels. This key role is expected to be played by the newly established National Animal Genetic Improvement Institutes (NAGII).

Marketing and development

Data infrastructure and online platforms can be used to increase agri-business efficiency, create ecommerce opportunities, facilitate a trading platform for farmers to access buyers, provide financial services (e.g. insurance and credit facilities), develop a produce or warehouse receipting system, trace products, and ensure continuous collection of timely and relevant data within the agricultural sector. The experience of other east African countries in enabling groups of farmers to access financial services, markets and other services through mobile phones and web platforms is worth mentioning here. Kenya's Agrilife is currently being used by smallholder farmers in Kenya and Uganda; it operates a cloud-technology based platform designed to be compatible with the mobile phone which is used as the main tool and channel to link farmers to markets, financial institutions and other stakeholders (e.g. dairy processors) through provision of relevant data. The platform is also being used in Zimbabwe, Zambia and Senegal (https://www.f6s.com/agrilifekenya, 2019).

Mobile phone-related data often provides high-quality, valuable information because a mobile phone is usually the only interactive technology for most low-income individuals in developing countries. Mobile tablets connected to central Servers have been used by African Chicken Genetic Gains (ACGG) and African Dairy Genetic Gains (ADGG) projects of ILRI to collect performance records and monitor activities on various production aspects (e.g. artificial insemination, vaccination). The mobile application iCow developed by Kenya's Green Dreams, helps small-scale dairy farmers track and manage cows' fertility cycles. The application educates farmers about important stages of a cow's gestation period, collects and stores milk and breeding records, and sends best practice information. Attempts were made to introduce iCow to Ethiopian farmers through ADGG (2016-2018) in Amharic, Oromiffa and Tigrigna languages.

An on-line platform (dashboard) developed by the ACGG project has presented the results from on-station and on-farm chicken productivity tests accessible to the public. The dashboard produces performances of specific strains for selected traits (e.g. live body weight at 20-weeks-of-age, number of eggs per bird/year) by agro-ecology in each of the project countries (Ethiopia, Nigeria, Tanzania). It is interactive web page that is accessible to farmers, managers, clients, scientists, and the wider public. Researchers can share the results of their work with out a need for physical presence and beneficiaries can view only those aspects of most interest to them. More importantly, when linked to a database, the system updates automatically, rendering the itself scale-able when new projects are launched.

Conservation

Animal genetic resources conservation is one of the components of the livestock sector which vastly benefits from efficient use of data. BD from molecular and GIS studies are becoming useful to identify important agroecological variables potentially driving the adaptive changes and dissect the underlying genetic and spatial structure of existing ecotypes. Large volume of data has been generated from numerous molecular studies conducted on major farm animal species of Ethiopia. In a landscape genomic approach, the genomic information on indigenous livestock populations and geo-spatial data can be combined to identify biodiversity hot-spots and make priorities for *in situ* and *ex situ* conservation considering with-in and between-breed genetic variability and contributions to overall species diversity. The biorepositories in Ethiopian Biodiversity Institute should enhance capabilities to store big bioinformatic data apart from preserving animal tissue samples. Besides, regulatory frameworks need to be put in place to urge researchers share nucleotide and protein sequences generated from their projects.

Environment

Predicting breed-specific environmental suitability has paramount significance in tropical livestock production systems. Geographic Information Systems (GIS) tools and predictive habitat distribution models are being used to make sense of large volumes of geographic and spatial data from climatic databases such as WorldClim (www.worldclim.org/). For instance, Lozano-Jaramillo et al. (2019) have used this approach to predict possible suitable habitats for Koeokek and Fayoumi breeds in Ethiopia. There are further opportunities to utilize the data available at the National Meteorological Agency in undertaking breed adaptation and suitability mapping studies; the agency generates and makes available 30-year time series data on rainfall and temperature at 10 daily timescales for every 10-km grid over the country (Dinku et al., 2011).

Data can also be efficiently used to compensate farmers on verifiable losses. Under an index insurance scheme, like that of Kilimo Salama, ("Safe Agriculture"), an innovative micro-insurance program designed for Kenyan farmers, payment to an insured farmer depends on the observed value of a specified index (Miranda and Gonzalez-Vega, 2011). In this new paradigm, insurance payouts are pegged to easily measured environmental conditions, or an "index," that is closely related to agricultural production losses. Possible indices include rainfall, yields, or vegetation levels measured by satellites. When an index exceeds a certain threshold, farmers receive a fast, efficient payout, in some cases delivered via mobile phones. A similar approach can be followed to serve Ethiopian pastoralists who live in drought-prone areas.

Health

Accurate and timely collection of health-related data are also important to forecast epidemiology of disease. Animal Health Surveillance is the systematic collection, collation, analysis interpretation, and dissemination of animal health and welfare data from defined populations. This process is essentially about gathering intelligence to detect either novel animal health-related events or increases in animal health-related events as early as possible to better inform risk management at all levels within the industry. A retrospective analysis of the 2010 cholera outbreak in Haiti showed that mining data from Twitter and online news reports could have given the country's health officials an accurate indication of the spread of the disease with a lead time of 2 weeks (Chunara et al., 2012). Public access to the data also promotes transparency and helps health-care actors to be more accountable and responsible to resolve issues.

Precision livestock farming

Precision animal agriculture is becoming important in livestock production in the domains of breeding, production, welfare, sustainability, health surveillance, and environmental footprint. Like crop production, animal production economics exhibits small profit margins. This makes the growth, development, reproduction, and well-being of each animal critically important for a profitable enterprise. Precision livestock farming is the use of advanced technologies to optimize the contribution of each animal. This involves collecting real-time or data on several relevant indicators. Current technologies in the developed countries allow producers to monitor feed consumption, feedlot movement, temperature, estrus, disease, milk production, meat composition and quality, and weight gain at individual animal or flock levels—often without any human intervention or presence. It can be noted that precision agriculture involves not only data collection, but also data analysis and modeling.

The TH Milk facility based in Vietnam, for instance, has demonstrated benefits from the use of Big Data tools. Each cow in this farm is tagged with a chip; a warning is sounded if a breast inflammation is detected and the milking machine is then automatically shut down. The cases of TH Milk and other business cases indicates that at least in the high-input/high-output systems, BD-driven businesses may disrupt existing business models, practices and operations.

Policy making

Data is the lifeblood of planning. Accurate, timely, representative, inclusive and disaggregated data provides policy makers an edge by helping them gain better understanding of the contexts of a production system and prioritize solutions. For instance, mobile data and internet platforms can be designed to provide information to them on near real-time basis on market transactions, production performances, conservation priorities, and disease outbreaks. Data will have roles in enhancing transparency and standardization in the livestock industry if regulatory frameworks are set up enforcing value-chain actors to avail information about their entity's operations, structures and other attributes (e.g. product quality) to the public. Great investments in data, information and knowledge also allow to track progresses in line with targets set at national level (e.g. The Livestock Master Plan) and international level (e.g. Sustainable Development Goals). The United Nations Global Partnership for Sustainable Development Data (GPSDD) has declared that transformative actions are needed to respond to the demands of a complex development agenda by improving how data is produced and used, closing data gaps to prevent discrimination, building capacity and data literacy in 'small data' and 'big data' analytics, modernizing systems of data collection, liberating data to promote transparency and accountability, developing new targets and indicators (GPSDD Five-year strategy, 2019-2023). Without data at different levels, progresses towards agendas set to be achieved by 2030 in Sustainable Development Goals (SDGs), to address challenges such as poverty, inequality, and climate change, cannot be measured and hence we will be at risk of not meeting the goals.

Limitations on utilizing data

Livestock-related data in Ethiopia are captured by disparate entities such as agricultural research and academic institutions, the Ministries of Agriculture and Trade, Central Statistical Agency, livestock farms, input suppliers, NGOs, donors, and traders. These agencies have mostly taken a myopic approach in the management of different sets of data that live in departmental silos and agency boundaries. It has also been seen on many occasions that data collected by various institutes lack consistency as different methodologies are followed. Low level of utilization of advanced technologies and low availability of analytic experts (e.g. in the areas of genetics, genomics, GIS, data science); poorly developed telecom infrastructure; gaps in legal frameworks on use of data; putting more emphasis by development practitioners on short-term and rather than long-term results; and poor understanding among decision makers about agricultural information; and lack of sound business models to capture value from data, are other factors limiting its generation and utilization. The internet penetration rate for Ethiopia in 2018 was only 14.9% (https://www.internetworldstats.com/africa.htm#et).

Conclusion

Despite the huge potential benefits, very little is known about how agricultural-related data should be systematically collected, organized, understood, and used in the context of developing countries. In collecting livestock-related data, we must consider the following principles: the data must be high quality, timely and detailed, allowing comparison and generational or trend analysis at different levels, such as in the case of cross agro-ecology or inter-country animal evaluations; put in place necessary technical expertise and smart data collection systems that are robust and utilize new technology; data should be open to enable public analysis and use, in formats that are both human and machine readable, and accompanied by relevant meta-data for transparency and accountability.

It is important for researchers, academicians, development practitioners, policy makers, investors and other value chain actors to have a fair understanding of what, when, where, by whom, how and why data should be collected and utilized in vital components of the sector such as in animal breeding, marketing, environmental sustainability, conservation, climate change, and health. Transformative actions in data science will ignite sustainable development in the livestock sector in developing countries like Ethiopia.