The need for national livestock surveillance in Pakistan

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Abstract

Ranked amongst the top five milk-producing countries globally, the Pakistan dairy industry can help to overcome food shortage and hunger, alleviate poverty and positively impact economic growth. This influencing role could potentially be more significant while the COVID-19 pandemic severely affects humanity, challenges the economy and increases the risk of global food shortage. However, its large national population of dairy livestock contrasts with Pakistan's top-five ranking, indeed, four to five Pakistani cows produce milk equivalent to one dairy cow of countries with a well-developed dairy industry. Low milk yield per cow negatively impacts the national production and compromises the development of an efficient processing sector, such that consumers are very often forced to use adulterated milk sold by local 'milkmen.' As a consequence, while committed to alleviating global hunger, Pakistan imports in excess of half a million tons of milk and milk-based products annually. Many studies have identified unproductive, inefficient and imprecise management issues combined with poor genetics and imbalanced nutrition as the leading barriers to improvement in the Pakistani dairy livestock sector. At an individual level, lack of awareness, affordability issues, illiteracy and low ambition of a large percentile of dairy farmers creates additional significant barriers. To address low productivity and poor genetics, Pakistani corporate farms and wealthier individual farmers import genetically improved breeds to attain high milk yields. However, they are then faced with the challenge of managing such breeds to attain sustainable and persistent milk yields under Pakistani climatic conditions, often risking excessive culling even to the point of business liquidation. In developed dairy industries, automated sensor-based livestock management systems are now available to help monitor, compute, and optimize procedures in real-time and are proven to increase productivity and profitability. The term precision livestock farming (PLF) is used to describe systems that monitor individual animals or groups of animals to overcome management deficiencies and optimize productivity. My stance in this Opinion Paper is that adopting and utilizing such precision technologies may support Pakistan in raising its livestock resources toward greater productivity, thereby helping to overcome the global food shortage.

Pakistan's livestock population and its influencing role

Pakistan is an agriculturally rich country, with a farming sector that is primarily divided into crops and livestock, empowering 45% of the national workforce and contributing 21% to national GDP. The livestock sector taken alone (as far as that is possible) contributes 56% value addition in the agriculture sector and 12% contribution in GDP, with significant positive impacts on poverty alleviation and economic growth. Milk is the single most important agricultural commodity, signified as the 'white gold of Pakistan.' Most of the country's 30 million cattle, 27 million buffalos, 54 million goats, 27 million sheep and 1 million camels are owned by rural families or small farmers (of whom there are more than 8 million), and herein lies the challenge (Rehman *et al.*, 2017; Tahir *et al.*, 2019). In fulfilling their own personal and minimal milk needs, small farmers are incurious and disengaged about the potential of developed livestock (Ashraf *et al.*, 2013; Khan *et al.*, 2013; Chhachhar *et al.*, 2014). As a consequence, Pakistan had to import 185 749 metric tons of packed liquid milk worth 50B Pak rupees (474 million US dollars) in the three years commencing 2014 (Faizan, 2018), simply to meet public needs.

Distribution of Pakistani dairy population

The dairy population of Pakistan can be categorized based on level of management, herd size, and milk production, as 'small farms,' 'mid farms' and 'corporate farms.' I identify small farms as 'the game changers,' since they hold well in excess of 70% of the national dairy herd. However, their primary intention is to fulfill family needs for liquid milk, with an average of 4 to 7 l daily milk yield. A sub-category of small farms keeps 3 to 6 cattle per household, and milk in excess of family needs is sold to nearby families, milkmen or to produce butter,

ghee or cheese for the family. These farmers often seek to buy cattle discarded from big farms, not realizing that these are the poorer-performing animals. Small farmer cattle are fed with readily available fodder or grazed, often in open areas to eat any suitable feedstuff. There are no specific practices available to optimize, manage and preserve livestock resources. Idle performing cattle are mostly slaughtered rather than being restored to the herd (Ashraf et al., 2013; Khan et al., 2013; Chhachhar et al., 2014; Iqbal et al., 2015; Farooq, 2016). The term 'idle performance' is used in computer systems to measure a CPU performance when no program is using its resources. Likewise, cattle are idle when their potential is not being used by employing suitable management practices.

The second category, mid farms, primarily delivers unprocessed milk to nearby cities and potential markets. They contain on average 25 to 100 cattle per unit, and there around 200 units operating nationwide. These farmers mainly keep local breeds and often obtain castoff cattle from corporate farms. Some of the more affluent farmers import high-producing breeds, which may be why there overall average daily yield is 15 to 20 or, in some cases, 25 l at peak lactation. Cattle are fed concentrates and chopped fodder. However, mid farms also lack precise management practices and fail to optimize the potential of idle performing cattle which results in unreliable and uneven milk production (Khan et al., 2013; Iqbal et al., 2015; Farooq, 2016; Rehman et al., 2017; Tahir et al., 2019).

Corporate farms have been operating now for more than a decade. Businesspeople mainly own these farms; they carry 2000 to 6000 genetically proven imported breeds per unit and around 16 units are operating nationwide. Sometimes called elite farms, these farms attain 25 to 35 l daily milk yield at peak lactation and produce 0.02 to 0.1 million milk liters daily. Corporate farms are adequately equipped with advanced technologies, primarily employ precise management practices and have adequate feed machinery and practiced procedures. These farms trade raw milk to large processing companies or establish their own dedicated processing units. 'Profit eating' or potentially idle performing cattle are replaced regularly, but this management practice is often not optimized which can lead to problems and a failure to maintain the desired productive herd size (Khan et al., 2013; Farooq, 2016; Rehman et al., 2017; Tahir et al., 2019).

Livestock handling practices

Most Pakistani dairy farmers (i.e. those in the small and mid-farm categories) are not literate in the documented management of livestock. Unfortunately, no traceable system can be identified, meaning that well in excess of 70% of the country's strategic livestock resources are essentially unknown to authorities (Chhachhar et al., 2014; Ziad et al., 2019). By contrast, corporate farms properly apply identifying technologies to their cattle, clearly one of the first major steps toward livestock traceability, and maintain lifecycle events (Marshall, 2014; Azeem, 2016). If a smaller farmer purchases cattle from a corporate farm, retaining identification will help maintain cattle traceability. However, despite curiosity about animal identification and information recording, farmers mostly remove cattle tags, believing them to have little value. Such beliefs lead to missing data and a risk of incorrect assessments, misinterpretation of root causes and unproductive cattle management. Consequently, in lacking essential information, farmers and field personnel mostly gesticulate and deal in a laborious way with their cattle (Barge et al., 2013; Khan et al., 2013; Chhachhar

et al., 2014). This may be why, in the absence of data and to attempt a good milk yield, farmers purchase different semen to produce crossbreeds resulting in gawkish cattle and the disappearance of well-known and precious breeds, such as the Sahiwal (Madrigal, 2012; Khan et al., 2013; Marshall, 2014). Better availability of tracing capabilities may help to develop countrywide livestock surveillance and management (Adam et al., 2016; FAO, 2016). For instance, herd level and individual monitoring, distinguishing individual animals from the anonymous on the basis of their production properties and genomic characterization to identify the potentially high producing animals and then combining that data with downstream information on processing and the ability to trace any food source problems back to individual farms are all technologies that exist but of course are expensive to implement. Disease traceability and identifying contagion risks on specific farms, nearby farms and larger regions to locate zoonotic originators and similar aspects are also much needed (Antanaitis et al., 2015; Adam et al., 2016; Garcia et al., 2019).

Savoir-faire of Pakistani corporate farms in relation to livestock management technologies

Over more than a decade of my PLF experience, I have reflected on the savoir-faire of corporate farms in Pakistan with regard to these sophisticated management technologies. I term it savoir-fair deliberately, since this implies more than just the ability to use the technology, but also the capability to comprehend the public view of such technologies and the acumen to apply that knowledge to the common social good. The purpose of this reflection is to help understand the degree of usefulness, to corporate farms, of PLF technologies, challenges to their implementation and possible barriers (against) and beliefs (in) the adoption of technologies that may support the sustainability of corporate farms. Further, I shall consider whether such adoption might help to support the establishment of national livestock surveillance. I shall break this down into six categories of technology, those concerned with identification, with herd management, with individual cow management, with milk management, with feed management and with the impact of climate.

Identification methods and traceability

Pakistani corporate farms typically use visual identification to assess and deal with cattle and paper data for further entering data into the herd management system (HMS). In this scenario, the field personnel dealing with cattle are often deprived of real-time data and repeatedly call the dairy data processing center to know the cattle status in HMS (HBR, 2020). When dealing with large herds and complying with corporate procedures, such methods are too slow and risk the creation of errors or missed observations. Memorizing visual observations and recalling these to input into HMS will create data veracity problems, and hence erroneous management (Muzari et al., 2012; Ashraf et al., 2013; Zottl et al., 2015). The fast-moving procedures required for management of large herds may need speedy and precise data retrieval and simultaneous recording (Barge et al., 2013; Azeem, 2016). To progress toward this capability, the use of radio frequency identification RFID may help corporate farms to automate their procedures. Typically, RFID tags are applied as eartags or collars, and wand scanners linked with smartphones and herd databases help provide actionable information during cattle handling. Such a method helps for on-the-ground data-driven decisions.

It facilitates live-updating events through cell phones with error-free automated procedures and real-time data delivery to other members' mobile phones and computer systems for accurate and quick decisions. Currently, RFID is mostly in practice for milking systems (Barge *et al.*, 2013; Zottl *et al.*, 2015; Azeem, 2016). The extent to which RFID has been adopted by corporate farms in Pakistan is unknown and this is an area that urgently requires data.

Herd management systems

Corporate farms are the primary users of HMS in Pakistan, and use it as a core tool to inform dairy herd operations such as individualized health, reproduction, and production activities and transform data into actionable information. Often, due to the unavailability of local expertise, language, or social barriers in technology adoption it becomes challenging for farms to efficiently implement HMS and its procedures to comply with the data quality and corporate needs (Chhachhar *et al.*, 2014; Capel, 2020). However, farms with fully functional HMS (such as Dairy Comp 305) are able to achieve herd-related actionable information by systematizing standard operating procedures into physical action plans. In such a way, HMS help corporate farms to compute complex processes precisely and assist users in retrieving analyses promptly and conveniently using system-based or clientele-based reports such as specific group lists, breeding reports, treatment logs, milk production data and various graphical analysis supporting day-to-day development (Capel, 2020). Increasing herd size is enabled by use of HMS but at the same time creates a requirement for it (Knight, 2020) and in Pakistan it is not clear whether HMS is the driver toward more large corporate farms or the consequence of their existence. These systems principally focus on managing cattle life-cycle-based events, and are not always used efficiently by the farms to the benefit of their business. The reason may relate to difficulties in mapping and integrating herd information and data between third-party systems to meet requirements associated with the fiscal year, financial needs and strategic planning. Corporate-focused HMS design may open new management methods for enterprise dairy businesses (Antanaitis *et al.*, 2015).

Individual cow management

Some corporate farms, those that are the most technologically enthusiastic, have taken the additional step of investing in sensor-based individual cow activity monitoring systems empowering those farms for in-depth monitoring, integrated automated broadcasting reminders through cell phones and emails for monitoring of estrus signs, rumen efficiency, lameness detection and anomalies such as imbalanced milk production and disease forecasting (Van Hertem *et al.*, 2013; Hill and Wall, 2015; Zottl *et al.*, 2015; SenseHubDairy, 2021). However, the number of such farms is believed to be rather small, perhaps as few as four in the whole country.

Milk management systems

Corporate farms in Pakistan use sophisticated milking parlors to milk many cows as efficiently as possible. These milk systems are equipped with technology to help analyze milk dynamics using precision system techniques (Zottl *et al.*, 2015). Fully implemented and understood milk management systems support

Pakistani corporate farms to obtain healthy cattle development, improved immunity, healthy udder and better milk production (Antanaitis *et al.*, 2015; Lima *et al.*, 2018). Information enthusiast farms are able to predictably segregate sick cows for treatment and to separate compromised milk where necessary (e.g. after antibiotic treatment), so as to ensure hygienic and standardized milk production (see GEAParlor, 2021)

In evaluating system performance, there is usually a need for automated data to be accurate and accountable, hence the milk system's accuracy is often backed up by labor-intensive manual recording of milk yields and shipped milk volume (see Andreen *et al.*, 2020). Dissatisfaction with evaluation criteria normally leads to an assumption that the system is unreliable (see Jakku *et al.*, 2019), however, rather crude comparisons of this sort may actually be the problem rather than the remedy, since automated recording has come a long way since its inception and nowadays is generally regarded as very accurate (Jakku *et al.*, 2019; Andreen *et al.*, 2020). In contrast with manual recording, the automated computations made by precision systems simultaneously assess dynamic changes and monitor the degree of accuracy between the change in values; thereby identifying potential deviations of individual milk meters. This also allows for computation of 'missing values' on the odd occasion when the identity is missed by the RFID scanner. The focus is on individual cow performance, enabling the farm to analyze and optimize cattle-based resources (Ashraf *et al.*, 2013; Andreen *et al.*, 2020). Similar precisely measured variations in flow rates, milk conductivity, and composition help to identify udder disease incidence and, potentially, other health related issues (Van Hertem *et al.*, 2013; Zottl *et al.*, 2015; Lima *et al.*, 2018; Andreen *et al.*, 2020).

Problems remain. Farms may acquire automated milking, cow monitoring or similar systems but then find a lack of local support, challenges with implementation, technology acceptance barriers or an inability of staff to understand how to use the technology (see HBR, 2020). This in turn leads to livestock management issues and a possible increase in idle performance of cattle (Muzari *et al.*, 2012; Jakku *et al.*, 2019; Andreen *et al.*, 2020).

Feed management

Precision feed management systems help monitor cattle feeding habits, enabling rumen efficiencies that can lead to improved cattle health, better immunity, cost-effective feed procedures, and excellent milk yields (Libelium, 2019). However, such precision feed systems are not widely in use in Pakistan, instead, farms either modify inventory software programs to manage feed inventories or use spreadsheets for rations that may be unproductive in precise operational needs (Grothmann *et al.*, 2010; Chhachhar *et al.*, 2014; Iqbal *et al.*, 2015). Precision feed management systems may help engineer nutrition, provide guidelines for cultivating actual need-based crops, control feed costs and enhance milk productions within current resources (see Intel, 2015). There is a need for greater use of proper systems: at the moment it appears that only four of the Pakistani corporate farms are using precision feed management systems.

Climate impacts and meteorological services

Pakistan's tropical climate monitoring is critical to growing specific crops in order to fulfill the nutritional needs of livestock. Given the effects of high ambient temperatures on cattle physiology, the weather monitoring system can also play a critical

role in helping to manage cow performance in a tropical climate (Libelium, 2019). This relates to cow comfort and various performance issues linked to reproduction, feed intake and milk production, and in the longer term such information may help to develop specific breeds for the Pakistani environment (Chhachhar et al., 2014; Hill and Wall, 2015). Meteorological data may be needed from project initiation to help design ventilated farm facilities and develop consistent cooling systems for optimum cow comfort and reduced energy consumption. Locally installed weather stations and advisory data services may be essential to keeping farms (of all sizes) fully updated and operating efficiently (Khan et al., 2013; Hill and Wall, 2015).

Nationwide livestock surveillance

The current situation in Pakistan does not include any national livestock surveillance and does not allow widespread adoption of improved genetics or production and health management protocols. It may be challenging to identify and exploit potentially beneficial cattle from elite herds that could otherwise help to sustain a specific farm or countrywide genomic improvement. Chance occurrences of improved production, resistance to health or environmental challenge or altered product quality are likely to be missed, when capturing that event and analyzing the genomic properties of that individual would again help to develop a more vigorous population, potentially producing higher quality products (Madrigal, 2012; Garcia et al., 2019).

Government authorities and transnational agencies such as USAID are generally keen to transform the livestock sector, including in Pakistan (Agrilinks, 2019; USAID, 2019; LivestockPunjab, 2021). The first steps may involve developing a livestock management platform with local language and voice support to help farmers interact and, potentially, integrate their smartphones with a centralized system. The system would need to process information such as animal registration, periodic and recurring events and analytics in a rigorous manner. Cattle registration information would ideally be RFID based, but would also need to include capabilities for visual identification number and other information such as calving, pedigree, breed, birth date, enrollment date, handling owner and cattle location. Periodic information would include such items as life cycle phase and growth history, reproduction status and events (ready to breed, semen or bull used, reproductive checks and statuses such as pregnancy, calving, calf growth status). Recurring events might comprise disease information, treatments administered, vaccination status, milk records, financial and other relevant aspects. (Madrigal, 2012; Choi et al., 2015; Velasova et al., 2015; Adam et al., 2016; Azeem, 2016; Garcia et al., 2019)

For national herd improvement, the livestock surveillance system would need to be capable of sophisticated calculations, strategic reporting and provision of analytics for relevant authorities, researchers, policymakers and economists. For instance, demographics of the livestock population and distribution by area, lactation and age groups, breeds, lifecycle phases, reproduction history and milk production performance are all important pieces of information. Flowing from this basic data and of economic interest to the individual enterprise would be forecast calculations for such elements as 305 d predicted milk, future nutritional demands and resource and workload planning. For population-level health monitoring the required information would include disease distribution by category, localization of disease clusters and estimation of risk of disease incidence.

In terms of logistics and for ease of registration and data collection, broadcast cellular messages may help farmers update data by selecting simple voice, text or smartphone app menu responses, which would be especially beneficial in case of a major disease outbreak or pandemic.

An important element of successful surveillance at national level is that the system must be capable of integrating data from different software platforms, for instance herd management packages run by corporate farms and management software used by governmental or regional authorities (Choi et al., 2015; Iqbal et al., 2015; Velasova et al., 2015; Zottl et al., 2015; USAID, 2019).

Popular livestock management software programs are readily available, but such systems may offer fewer customization features and hence be fit only for local herd management purposes. The initial cost per animal is around $2 to $4, excluding annual subscription, implementation, training, and dairy data processing center infrastructure costs. Beyond livestock management, more sophisticated platform may include features such as livestock data integration with geographical information systems, to help national or regional analysis during major disease outbreaks and to support the sort of surveillance system envisaged above. In this case, cost per animal may reach $4 to $6, and once staff hiring, training and system implementation costs are included this may reach up to $8 per animal. Pakistan has a good software industry and competent development teams, which may help reduce the costs, and a strong influence of precision livestock systems experts may help achieve successful system development and deployment (Adam et al., 2016; FAO, 2016; PITB, 2021).

Any identification system needs to meet the requirements of the farmer but also the national agencies. Traceability essentially means being able to recognize the animal and locate it to the province, district, city and owner, and the information provided must be applicable to the needs of product quality, genetic improvement and large-scale health management. Visual plastic identification tags cost about $2, and RFID costs up to $4.50 per animal. Tag retention depends on the application procedures (Madrigal, 2012; Van Hertem et al., 2013; Chhachhar et al., 2014; Zottl et al., 2015; Adam et al., 2016; Azeem, 2016). The RFID wand reader costs about $1000 to $1300, prohibitively expensive for small farms (who would need to rely on agency field workers for data collection), but potentially within the budget of mid farms and certainly corporate farms. Traceability costs may reach $13 to $15 per animal, including establishing facilities (Adam et al., 2016; FAO, 2016). Additional costs would occur if activity monitoring devices were added to enable estrous detection, for instance. In the longer term this will happen, but it will be mainly on corporate farms. Part of the benefits of such automated technologies is that data will be added in real time with minimal human interaction and minor data errors, which may help to overcome human adoption barriers, illiteracy, and suchlike challenges. Regrettably, these problems are almost certainly worse on small farms, where the technology is unlikely to be adopted (HBR, 2020).

Another aspect of national surveillance is the ability to monitor milk quality at an animal level, which could be very important for maximizing genetic progress. Suitable 'in-line' (i.e. operating automatically in the milking line) technologies are available for use in more advanced farms, but there is also a need for the establishment of national or regional milk testing bodies. In addition to milk yield itself, useful information would include fat, protein and lactose concentrations as well as SCC, and derived data that would

assist management would include fat corrected milk, protein corrected milk and projected 305 d milk. At the moment, even corporate farms would have data of this sort only for the herd (i.e. bulk tank testing: Agsource, 2021).

Government authorities may encourage interested corporate farms, those smaller farmers who can afford to invest and external investors to join hands in developing the nationwide system through technical support, finance stacking, or information aligning. In a subsidized plan, already developed farms may help other farmers to connect their livestock and form regional livestock surveillance networks. Authorities may help equip small farmers by subsidizing systems or adopting policies that minimize costs. Information exchange between corporate farms and government authorities may help develop robust research facilities that may help universities, researchers, policymakers, and economists to reform the sector (FAO, 2016; USAID, 2019 and see VASPulse, 2021).

Recommendations for future progress toward technology adoption

Potential opportunities are available for investors, government departments, researchers, economists and policymakers to positively influence the future development of Pakistan's livestock sector and thereby contribute to poverty alleviation, food security and economic growth. There follows a list of possible actions:

- Government authorities to introduce relevant curricula and conduct hands-on training to help students learn advanced technologies to meet practical goals
- Community-based advanced systems training and workshops to train farmers and agricultural consultants in advanced technologies
- Government livestock departments to take initiatives to develop individualized cattle-based traceability, monitoring, and evaluation
- Make PLF consultants and service providers more aware of the conditions prevailing in Pakistan such that they understand and can respond to farmer's needs
- Extend this consultant/farmer relationship to provision of practical solutions together with physical support for appropriate training, smooth deployment, timely resolution of issues and avoidance of overly-complex and hence impractical technology
- Develop systems to connect small farmers with each other to form viable conglomerates that can afford to invest in advanced technologies
- Expand these systems to connect small, mid and corporate farms and create links to regional and national agencies in order to establish national livestock traceability and surveillance
- Establishing a national or regional dairy herd association(s) and promoting an open information-sharing culture within the developed farmer networks may support researchers, institutions, and agencies.

Conclusion

Pakistan has the potential to manage its livestock resources, and especially its dairy herd, to support alleviate hunger and poverty and stimulate economic growth. However, most farmers have limited aspirations for their animals, resulting in inefficiency, varying and generally low yield, increased numbers of non-performing cattle and frequent culling, all of which compromises productivity and creates shortfalls even just for the farmers domestic needs. Management needs to be improved. Pakistan has much to learn from developed dairy industries, many of which are now adopting precision management methodologies to maximize and optimize productivity. The large corporate Pakistani dairy farms have the potential to employ such technologies, and a few are now starting to do so. However, they face cultural and educational barriers and technology adoption challenges. Hence, Pakistan needs to put in place national or regional policies to employ advanced technologies and simultaneously develop national livestock surveillance systems. The influence of precision livestock experts, the local presence of high-tech companies and the education of the next generation of dairy farmers to use such systems will help sustain livestock resources and make a national and potentially global impact in improved food security and economic prosperity.

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