IMPACT OF INFORMATION COMMUNICATION TECHNOLOGY IN LIVESTOCK PRODUCTION AND HEALTH MANAGEMENT

Jinu Manoj[1], Manoj Kumar Singh[2] and Mohit Bharadwaj[3]

[1]ADIO, College Central Laboratory, College of Veterinary Sciences, LUVAS, Hissar, Haryana

[2]Department of LPM, COVAS, S.V.P.U.A.T, Meerut, U.P

[3]Ph.D Scholar, Department of Animal Nutrition, GBPUAT, Pantnagar, Uttarakhand

Information and Communication Technologies (ICT) is being used widely for the study and improvement of various aspects of livestock production, research and education. Mainly the ICT is playing a greater role in livestock disease control, dairy herd management, livestock production and for marketing of livestock and livestock produce. ICT encompasses both the internet-enabled sphere as well as the mobile one powered by wireless networks.

Modern ICTs applications are made up of four layers, namely the cloud, edge, physical and network layers. The cloud layer is made up of the virtual server with the presence of big data analytics. There is also the presence of data base clusters with potential for data visualization and enabled machine learning (ML) and artificial intelligence (AI) potentials. The edge layer is where the user's computational activities are enabled with the existence of ML and AI models and data processing capability. The physical layer is the layer responsible for enabling the sensors that are placed on the animals and fitted into farm equipment to collect data. The network layer performs the function of offering the gateway to allow data communication and connectivity.

ICT-enabled applications which enhance the efficiency of livestock farms and aid in precision farming can be broadly grouped into four categories–Sensors, Automation, Decision Support Systems (DSS) and Information dissemination.

SENSORS

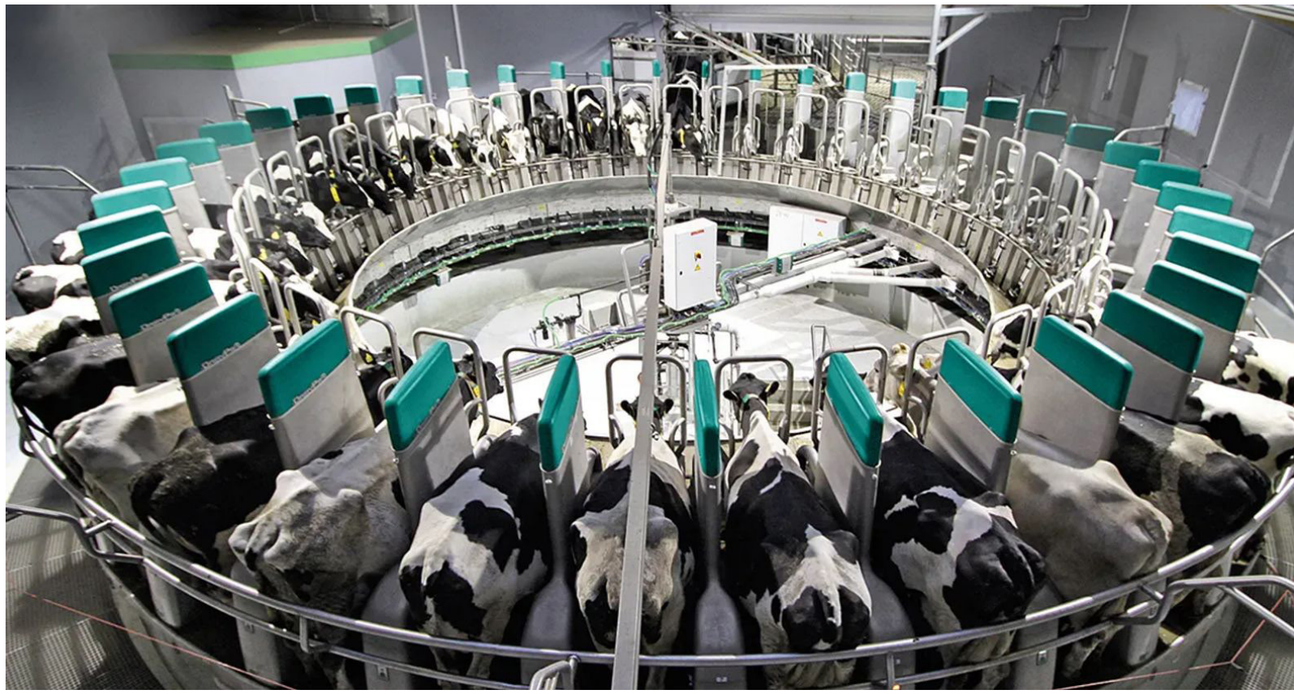
These can be of various types depending on the requirement. Bio-sensors can either be wearable (neck, ears, legs, tail, skin surface) or implanted (subcutaneous, intra ruminal, intra vaginal). They can record temperature, pH, activity (accelerometer), heart rate, respiration rate, mounting pressure, GPS location, biomarkers etc. depending on their location and utility. External sensors which can record animal data comprise video camera, microphone, thermal infrared camera and load cells. Other sensors record environmental parameters like temperature, humidity, air speed, light intensity and levels of noxious gases. In dairy farms, special sensors in the milking parlour can record milk quantity, flow rate, temperature, composition, electrical conductivity, somatic cell count, progesterone levels and antibiotic residues. In most cases, a combination of sensors is utilized to achieve desired management objective.

AUTOMATION

In view of the rising costs and unreliability of skilled labour, and the reduction in prices of automatic farm equipment, many livestock farms have adopted automation in routine operations milking, feeding, livestock handling, weighing, body condition scoring and climate control. This enables timely and precise farm operations. The data generated from automatic farm equipment is vital for handling large herds/flocks.

DECISION SUPPORT SYSTEMS

Data from biosensors, environmental sensors and external sources is fused to form a Decision Support System which aids the farmer in taking appropriate management decisions. These can in the form of livestock breeding, feeding, herd management and disease control. Computerization of these process increases speed of decision making and reduces errors. Incorporation of ICTs leads to change in livestock management strategy from Reactive to Proactive to Predictive, with the system being able to predict the best management response in the future based on past data.



INFORMATION FLOW

Creating awareness about scientific livestock management practices is vital for enhancing efficiency and saving of scare national resources. With the advent of wider mobile network coverage and low-cost smart phones and internet data, mobile apps have become the preferred route for information dissemination as compared to earlier technologies like information kiosks or CDs. They have advantages in the form of multi-lingual text, audio and video content and timely updates and notifications. In addition to extension activities, critical information regarding extreme weather events, emerging diseases and vaccination drives can also be shared using ICT tools. Access to market information and online trading of livestock, livestock products and inputs like feed ingredients etc. can greatly enhance the profitability of farmers by removing middle men.

Advanced digitalization technologies can help modern farms optimize economic contribution per animal, reduce the drudgery of repetitive farming tasks and overcome less effective isolated solutions. There is now a strong cultural emphasis on reducing animal experiments and physical contact with animals in order to enhance animal welfare and avoid disease outbreaks. This trend has the potential to fuel more research on the use of novel biometric sensors, big data and block chain technology for the mutual benefit of livestock producers, consumers and the farm animals themselves.

Some of the ICT-enabled applications which enhance the efficiency of livestock farms and aid in precision farming are given below.

IDENTIFICATION

Development and commercialization of animal identification systems has reached a very advanced state. A variety of systems based on Radio Frequency Identification (RFID) are available, some of which work reasonably well and have been adopted at the country level. These systems greatly facilitate the traceability and certification of products, particularly of meat and therefore are crucial tools to minimize the losses and market disruptions caused by localized diseases. RFID systems communication with other ICT enabled systems to aid data logging in milking, feeding, and weighing equipment.

INSTRUMENTATION

This involves a control system that consists of sensors that measure variables related to the system's state and actuators that provide input of mass, momentum or information to the system towards directional modification of the state. Animal state is estimated by the history up to a recent time, position, activity, temperature, live weight and other physiological variables of all individuals in the herd. This is especially observed in commercial poultry farms where controlled environmental conditions are essential for the profitability in high producing lines.

GPS

The use of GPS collars for livestock and wildlife has opened the possibility of recording detailed position information for long periods of time, thus allowing a more complete understanding of the habits and causes of spatial distribution of ruminants. Current commercial GPS technology can determine position of individual animals with a precision of 10m or better. The position information can be stored on small flash cards together with large amounts of behaviour and physiological data and it can be transmitted to a management centre in real time or in periodical sessions.

ANIMAL BEHAVIOUR SENSORS

The data recorded by these sensors is somewhat ambiguous, but models can be developed to infer activity. Various types of sensors are necessary for a detailed record of behaviour. Accelerometers have been useful to document not only head movements but also walking and lying behaviour. Sensors have been tested for measuring head angle, head acceleration, leg acceleration, steps (pedometers), swallowing, jaw movements, biting and chewing sounds, weight, heart rate, core temperature etc

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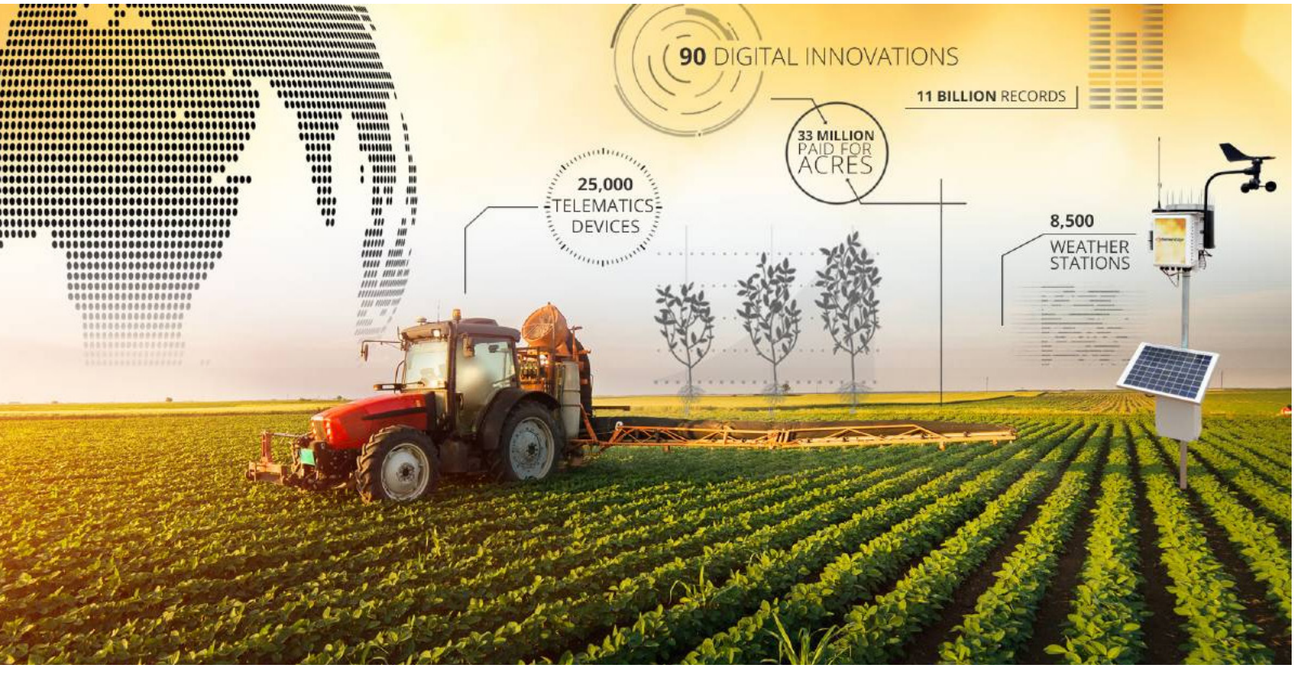
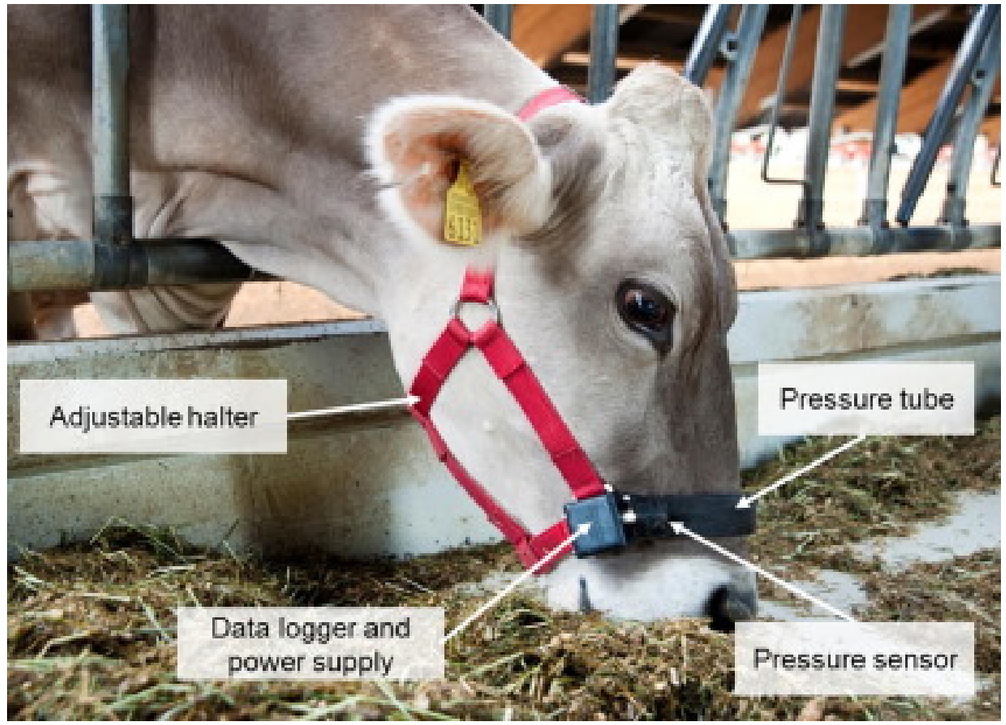
HEALTH MONITORING

Sensors and techniques for heath monitoring are well developed for dairy production under confined conditions. Behaviour and changes in behaviour can be used to detect health problems before disease affects animal productivity. Sensors were able to detect 80% of health problems related to ketosis, locomotion and lameness at least one day sooner than the farm staff by analysis of short term feeding. Use of the oestrus mount detectors, pedometer and advanced time series analysis to detect oestrus in dairy cows has been quite successful. Mastitis detection using in line sensors which evaluate electrical conductivity and somatic cell count have proven to be very effective in detecting subclinical mastitis. Rumen pH sensors enable early detection of acidosis and aid in proper feeding. Thermal infrared imaging, especially of the eye region can monitor stress and detect disease 4-6 days earlier than traditional methods. Other devices like thermometers, accelerometers and microphones, and cameras allow farmers to monitor temperature, activity levels, sound levels in the barn (e.g. vocalizations, sneezing and coughing) and specific behaviours (e.g. aggression in pigs, pain estimation).





WEIGHING

Body weight measurement, either using statically or walk over load cells or through captured digital images have very good accuracy and minimise the stress associated with restraint and body weight measurement.
Body Condition Scoring
This can be done either with image processing from video cameras or using thermal imaging. The captured images and associated expert score are used to train the computer neural network model, which can predict body condition of animals with very high accuracy.

LAMENESS SCORE

This can be measured using data from load cells during milking or while the animal is walking over a grid of load cells. Newer techniques use video tracking and gait analysis. Accuracy of these methods is still not adequate for commercial use.

HERD MANAGEMENT SOFTWARE

The ability to digitally store herd information is a valuable tool for all farms. Data can be entered into this software application manually or automatically through the use of other digital devices (such as milk meters, cow weighing scales) linked to this data base. This enables the farmer to easily view, analyze, manipulate and sort data .Such information storage and manipulation capabilities provide farmers with an extremely valuable resource to aid them in their farm management activities and decisions.

BIG DATA ANALYTICS AND MACHINE LEARNING

The use of biometric sensors and biosensors for monitoring the health and welfare of livestock results in huge amounts of data that needs to be processed and analysed to provide meaningful insights for animal management. Precision livestock farming relies upon proper use of big data analytics and modelling to inform management about nutritional needs, reproductive status and declining trends in productivity, which may indicate animal health and welfare issues. Big data models extract information from sensors, process it and then use it to detect abnormalities in the data that may be affecting the animals. Machine learning technology allows computer algorithms to progressively learn from sensor big data sets and improve themselves accordingly, eliminating the need for a human data analyst .

CONCLUSIONS

Livestock production is in a period of rapid adjustment and development, both regionally and globally. ICT has the potential to change the economy of livestock, agriculture and rural artisans in India. There are intense pressures and concurrent opportunities associated with the need to produce safe and environmentally friendly livestock products. This has created the need and opportunity to use ICTs in the form of computer software, sensors and other electronic material in regards to livestock disease control, dairy herd management, livestock production and marketing of livestock and livestock produce. Simultaneously, advances in electronic communications and GPS technologies have driven major declines in prices and improvements in performance, opening a window of opportunity to create cost-effective systems for large scale precision livestock production.

BLOCK CHAIN

This technology provides several important benefits to livestock agriculture, including decentralized, automated transactions that could contribute to more efficient auditing systems for certification and regulatory organizations, system integration, organized records of chain transactions throughout the life of an animal from farm to table and greater traceability and transparency within livestock agriculture.