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Smart livestock farming: How technology, preventive healthcare and farm data can reshape animal production in india

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ABSTRACT

Livestock keeping in India is moving from decisions based mainly on daily observation towards decisions supported by recorded information. Smart livestock farming brings together animal identification, sensors, mobile applications, cameras, machine learning and electronic records, and applies them to routine husbandry. This article explains what these tools measure, which management questions they answer and where they fail. Preventive healthcare remains the core, covering vaccination, biosecurity, clean water, balanced feeding, parasite control and prompt veterinary attention. Records convert scattered observations into patterns that can be acted upon. National programmes have already given a digital identity to a large share of Indian livestock, creating a base for use at farm level. Adoption still depends on cost, network coverage, training, data quality and veterinary support. Value comes from acting on reliable information at the right time.

Key words: Animal welfare; Artificial intelligence; Farm records; Precision livestock farming; Preventive healthcare

INTRODUCTION

Livestock rearing supports a very large number of rural households in India and contributes a growing share of agricultural income. India produced 247.87 million tonnes of milk in 2024-25, about 3.58 per cent more than the previous year, while per capita availability reached 485 grams per day (Department of Animal Husbandry and Dairying, 2025a). When a sector is this large, a small gain in fertility, feed efficiency or disease control adds up to a very large national figure, and small repeated losses that pass unnoticed on one farm become heavy losses once multiplied across millions of holdings.

Livestock management in India has long rested on what the keeper can see. Appetite, rumination, gait, coat condition and behaviour at oestrus have guided decisions for generations, and that skill should not be discounted. What has changed is the setting in which it is applied. Herds are larger, labour is scarce, weather is less predictable, and disease pressure and market expectations have both risen. One person cannot watch forty animals closely for sixteen hours a day.

Smart livestock farming attempts to fill that gap. Scientific writing usually calls this precision livestock farming and defines it as the combination of sensors that capture biological information, algorithms that process it, and interfaces that let people use the result (Kleen and Guatteo, 2023). Nothing in that definition promises to replace the farmer or the veterinarian. The purpose is narrower and more useful, which is to make existing judgement faster, better targeted and less dependent on chance observation. In practice the idea reduces to four steps. Observe consistently. Write it down. Notice the pattern early. Act before the problem becomes expensive.

What Actually Makes a Farm Smart

A smart farm is not defined by the price of its equipment. A shed full of imported machinery may still be poorly run, and a ten-animal unit with a disciplined register may be managed very well. What separates the two is the quality of the information loop, and five elements must be present: sensing of some kind, whether by device or by a person looking carefully; identification, so every observation belongs to a known animal; recording; a means of comparing today with last week; and an action that follows.

Sensors can measure movement, lying time, rumination, body temperature, weight and shed climate, identification can be an ear tag or a registered digital number, and software can then flag an animal whose values have drifted from its own normal range.

The final link is where most farms lose the benefit, because data collected but never reviewed has no value at all. If a cow shows reduced activity, someone must walk to that cow and look at her, and if rumination falls at the same time as milk yield a health check is due. Precision livestock farming is therefore better understood as decision support than as a collection of devices (Kleen and Guatteo, 2023).

The Mobile Phone as the First Smart Device

For most Indian livestock keepers, the entry point to smart farming is already in their pocket. A basic smartphone can do the work of a well-kept register and often does it better, since it does not get wet, torn or lost in the same way. It can also capture evidence, and a photograph of a swollen quarter or a short video of a limping animal gives the veterinarian something concrete before the visit. Where a veterinarian may take a day to reach the farm, this alone changes the quality of the first consultation.

India has built substantial national infrastructure on this idea. Under the National Digital Livestock Mission, animals receive a twelve-digit ear tag identity, often called Pashu Aadhaar, linking breeding, vaccination, treatment and ownership records to a single number on the Bharat Pashudhan platform. By the end of 2025 roughly 35.9 crore animal identities had been generated and more than nine crore livestock owners registered (Department of Animal Husbandry and Dairying, 2025b), which is among the largest such exercises attempted anywhere. Infrastructure of that size becomes useful only when it reaches the shed. The task now is to convert a national database into something a farmer opens on a Tuesday morning to see which animals need attention.

Sensors and What Animal Behaviour Reveals

Animals report their condition continuously, but through behaviour rather than in words. Lying time changes, feeding slows, rumination drops and walking becomes uneven, and many of these changes appear well before signs a person would call clinical.

Accelerometers record movement and can separate standing, walking, feeding, ruminating and resting with reasonable accuracy once the underlying models are properly trained (Balasso et al., 2023). Collar mounted systems now combine accelerometers, RFID, positioning receivers, microphones and gyroscopes in one unit, and reviews describe applications across behaviour, health status and productivity (Lamanna et al., 2025).

Two cautions matter. A sensor detects change but does not explain it, since reduced activity is equally consistent with lameness, early fever, a slippery floor or oestrus in a neighbouring animal. Interpretation still belongs to the person. Performance also varies, and reviews note that evidence differs widely between systems, so results from one farm may not transfer to another (Kleen and Guatteo, 2023; Tangorra et al., 2024). The working rule is simple. Treat an alert as a reason to look, never as a diagnosis.

Artificial Intelligence and Camera Based Monitoring

Machine learning finds patterns in volumes of data no person could hold in memory. In livestock work it has been applied to individual identification, behaviour classification, body condition and weight estimation, lameness scoring, oestrus prediction and disease risk modelling, and a recent review of artificial intelligence in dairy and beef cattle describes rapid growth alongside continuing questions about validation (Michelena et al., 2025).

Computer vision uses cameras instead of wearable devices, so nothing is attached to the animal and the problems of battery life, device loss and damage are avoided. Cameras have been used to score locomotion, estimate body measurements and identify individuals by coat pattern. Fuentes et al. (2022) describe how remote sensing and artificial intelligence are combined to measure traits previously scored by eye alone. Machine learning has also been applied to veterinary public health surveillance, where unusual patterns must be detected across many farms and districts (Guitian et al., 2023), and sensor derived traits are now being examined for breeding programmes, since several are heritable and can be recorded cheaply on large numbers of animals (Brito et al., 2025).

The limits deserve equal attention, because a model learns only from the data it is given. If it was trained on Holstein cattle in a European free stall barn, its behaviour on a Murrah buffalo in a tethered shed in Punjab is an open question. Coat colour, lighting, housing, ambient temperature and daily routine all affect performance. Before any Indian farmer is asked to trust an automatic alert, the system should be tested on Indian breeds, in the season when it will actually be used.

Preventive Healthcare Remains the Core

Technology finds changes. Preventive healthcare decides what to do about them, and it is the part that pays. A sound programme is not complicated to describe. Vaccinate on schedule against the diseases that matter locally, keep newly purchased animals separate before mixing them, clean the shed and the milking equipment, supply clean water without interruption, feed a balanced ration, deworm on the basis of need rather than habit, examine animals after calving, call the veterinarian early rather than late, and write down every treatment given.

That last point is often skipped, and it is the one that turns healthcare into a system. If mastitis cases rise in the two months after a change in milking routine, the record makes the association visible, and an investigation of teat condition, hygiene, equipment and housing can follow. The same records support responsible use of antimicrobials, since a farm that can see how often it treats, with which product and with what result is better placed to cut unnecessary treatment than a farm relying on memory. Digital reporting also strengthens information flow between farmers, field veterinarians and authorities, which matters for early detection at population level (El Idrissi et al., 2021; World Organisation for Animal Health, 2022). Prevention is best pictured as a repeating loop: observe, record, identify the risk, act, follow up, record again.

Feeding Decisions Guided by Records

Feed is normally the largest recurring cost on a livestock farm, and nutrition influences growth, yield, fertility, immunity and disease risk together. Where equipment allows, electronic weighing, automated feeders and intake monitors give precise figures for each animal or group. Most Indian farms will not have these for some years, and that does not block progress. A record of body condition score, daily yield, ingredients used, quantity fed and feeding times is already enough to show which animals are losing condition while still milking well, whether yield changed after the fodder source changed, and whether concentrate is being fed in proportion to production or in proportion to habit.

The objective is neither maximum intake nor maximum yield, because an animal that produces heavily and repeatedly develops ketosis or acidosis is not profitable across a full lactation. Efficiency measured over the whole cycle, with health costs included, is the better target. Records can show that production is drifting, but they cannot formulate a ration, and balancing energy, protein, fibre, minerals and water access remains a task for a nutritionist or veterinarian.

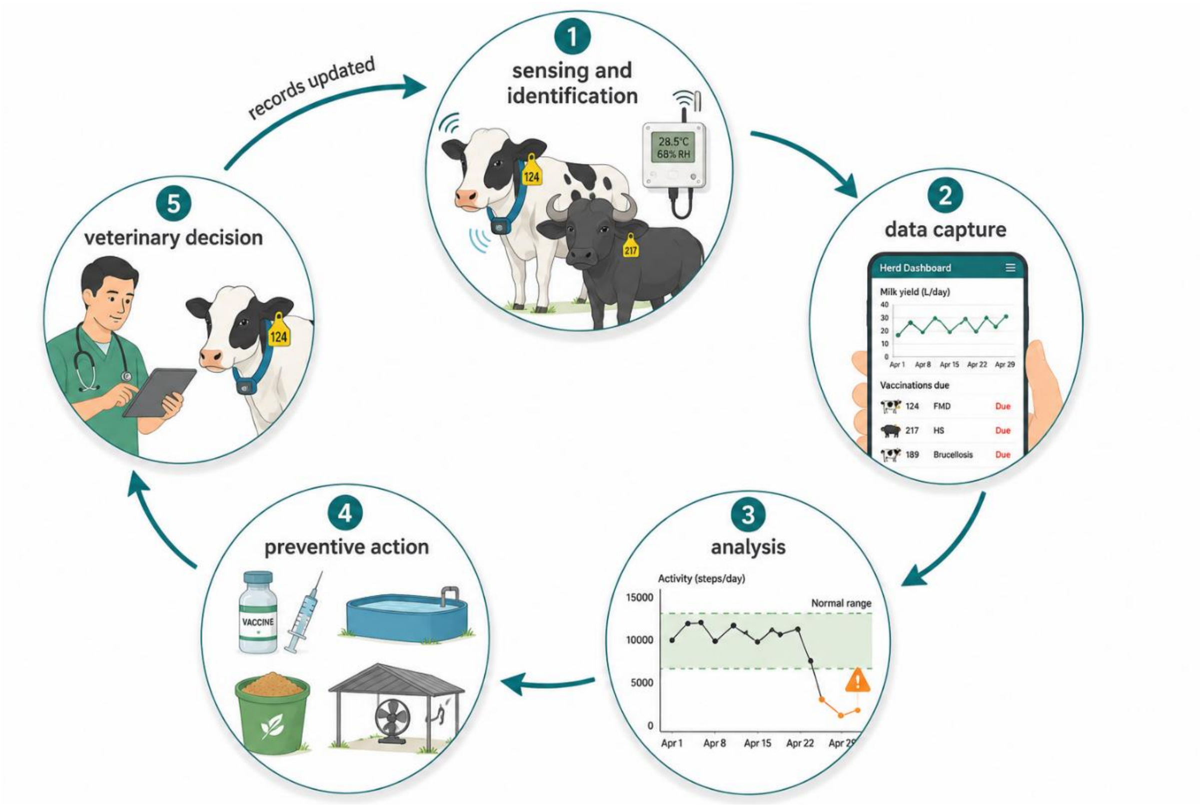

Figure 1. Smart livestock farming cycle linking animal sensing, data capture, analysis, preventive action and veterinary decision-making, with continuous record updating.

Reproduction, Where Records Pay Back Fastest

Reproductive efficiency drives profitability in cattle, buffalo, sheep, goat and pig enterprises. A missed heat costs roughly twenty-one days and a prolonged calving interval costs part of a lactation curve, yet poor records keep both losses invisible until they have grown large.

Digital tools help in two ways. The first is bookkeeping, since heat dates, service dates, sire used, pregnancy diagnosis, expected calving date and postpartum events can be stored against each animal and recalled instantly, while automatic reminders remove the need to remember. The second is detection, because activity monitors register the rise in movement associated with oestrus and can flag animals nobody saw in heat, which is useful for silent heat and for activity at night.

The gain is real but conditional. An electronic alert is not a confirmed heat, and certainly not a confirmed pregnancy. What it does is shorten the list of animals needing examination, while rectal examination, ultrasonography and the judgement of the inseminator still decide the outcome. Because breeding activity is now recorded nationally, individual reproductive histories are increasingly available in a form a field veterinarian can retrieve (Department of Animal Husbandry and Dairying, 2025b).

Farm Records as an Asset

Most farmers already hold valuable data without describing it that way. Daily yield, animal numbers, vaccination dates, deworming history, service records, disease events, medicine bills, feed purchases, deaths and sales are all data. The difference between a notebook and a record system is whether entries can be compared with one another. A farm with consistent records can say which animals produce below expectation for their stage of lactation, which are overdue for vaccination, what treatment cost per animal was, and whether yield moved after a management change.

At herd level these answers reveal patterns invisible in daily work, while for the individual animal a long record becomes a clinical history. Data quality decides everything, since a wrong tag number, a missing date or a duplicated entry will produce a confident conclusion that happens to be wrong. Accuracy first, then consistency, then analysis, and that order cannot be reversed. Table 1 summarises the main tools available, what each measure, the decision it supports and the limitation that applies under Indian conditions.

Table 1. Selected smart livestock technologies, what they measure, the decisions they support and their main limitations under Indian farm conditions.

Technology	What it measures	Decision it supports	Main limitation in Indian conditions
Ear tag or RFID identity	Unique identity of each animal	Links every record to the correct animal and enables traceability	Tag loss and errors made at registration
Mobile record application	Vaccination, service, treatment, yield and cost	Due lists, reminders, cost tracking, better veterinary consultation	Language and literacy barriers, and irregular daily entry
Accelerometer or smart collar	Activity, rumination, lying and feeding time	Oestrus detection, screening for early illness, suspicion of lameness	Cost per animal, battery replacement, little validation on Indian breeds
Milk meter with conductivity sensor	Yield and electrical conductivity per quarter	Mastitis screening, feeding adjustment and culling decisions	Suited to organised parlours, of limited use where milking is by hand
Temperature and humidity logger	Microclimate inside the shed	Heat stress management, shade, ventilation and water planning	Needs correct placement, and readings are useless unless acted upon
Camera with computer vision	Posture, gait, body condition, feeding behaviour	Locomotion scoring, body condition trends, group monitoring	Dust, lighting and coat colour all reduce accuracy

Technology	What it measures	Decision it supports	Main limitation in Indian conditions
Digital disease reporting platform	Case and mortality reports across many farms	Early warning, outbreak response and vaccination planning	Value depends entirely on complete and timely reporting

Moving from Reaction to Early Warning

The most valuable shift these systems offer is in timing. Conventional management begins when an animal looks ill, by which point the disease has often progressed, treatment costs more and production has already been lost. Early warning instead looks for departure from an animal's own baseline. A fall in activity combined with reduced rumination and a drop in yield is reason enough to examine an animal that still looks acceptable from the gate, and at herd level a cluster of respiratory cases or an unexplained rise in mortality is reason to investigate and report at once. This fits the principle of animal health surveillance, in which timely information permits earlier response (World Organisation for Animal Health, 2022).

Two limitations apply. False alarms happen, and a system that cries wolf is ignored within a month. Some conditions also produce no change in whatever is being measured, so a quiet system is not proof of a healthy herd.

Welfare, Heat Stress and the Animal's Experience

A farm should not be judged only on litres, kilograms and eggs. Welfare is a legitimate objective in its own right, and it is linked to production, since animals in discomfort eat less, conceive less readily and fall ill more often. Monitoring helps because welfare problems are usually gradual, and reduced lying time, changes in locomotion and altered social behaviour can be measured continuously and compared over weeks. Work on precision livestock farming and artificial intelligence argues that these technologies can support more animal centred management while also raising ethical questions about the relationship between animals, technology and the people who care for them (Neethirajan et al., 2024). Reviews of digital tools for cattle health and welfare reach a similar mixed conclusion (Neculai-Valeanu et al., 2025).

Heat stress deserves particular mention in India, since much of the country experiences long periods in which temperature and humidity together exceed the comfort threshold for cattle and buffalo. Low cost loggers give an objective record of what animals experienced inside the shed, which is frequently worse than the reading taken outside, and that record supports decisions about shade, roof insulation, fans, sprinklers, water points and feeding times.

Cost, Connectivity and Other Real Constraints

Enthusiasm for technology should be matched with honesty about barriers, particularly where most animals are held in small units. Cost is the first, since sensors, subscriptions, batteries and repairs all cost money, and the return has to be demonstrated before a farmer with ten animals can justify the expense. Analyses of this market consistently identify purchase price and rural connectivity as the leading constraints on uptake.

Connectivity is the second, because systems assuming continuous internet and stable electricity will fail in many villages, whereas designs that store data locally and synchronise later suit Indian conditions far better. Training is the third, since a device requiring English literacy or frequent software updates will be abandoned; interfaces must work in regional languages and be usable by the person who actually handles the animals, who is very often a woman. Ownership and privacy form a fourth concern, as farm data carries commercial value. Interoperability is the fifth, since breeding, milk, health and laboratory records are of limited use when held in systems that cannot exchange information, and digital technologies for veterinary services are valued precisely because they support sharing across such boundaries (El Idrissi et al., 2021).

A Practical Path for Indian Farmers

Adoption works best in stages, and farms that buy everything at once usually waste money on the first purchase. Begin with identification, since every animal needs a unique and readable identity, and the national ear tag system already provides this at no cost in most states. Build the record next, entering vaccination, service, treatment, calving, yield and mortality on the day they happen. A phone is convenient and a disciplined register is acceptable; an undisciplined system of either kind is useless.

Then name the biggest loss by asking which single problem costs the farm most in a year, since infertility, mastitis, calf mortality, heat stress and feed wastage do not carry equal weight on every farm. Choose the technology that addresses that specific problem and nothing else. If the answer is missed heats, an activity monitor may be justified. If the answer is calf mortality, better colostrum management and a reliable thermometer will achieve more than any sensor.

Pair every alert with a physical check, because an alert is a prompt to observe and never an instruction to treat, and review the records with a veterinarian monthly or quarterly, looking for repetition rather than single events. Finally, measure whether it worked by comparing clinical cases, calving interval, calf mortality, yield or feed cost before and after adoption.

The Changing Role of the Veterinarian

Digital livestock farming does not reduce the need for veterinarians; it shifts part of their work from treatment towards prevention and herd level analysis. With continuous records, a practitioner can arrive already knowing which animals have repeated problems and how the herd has performed since the last visit, so consultation becomes possible between visits and advice becomes specific to the farm.

Veterinarians also hold a role no algorithm can take over, which is deciding whether a signal means anything biologically. An unusual pattern in a dataset is a hypothesis, and turning it into a diagnosis requires clinical reasoning, examination and often laboratory work. The smart farm is therefore a partnership in which technology supplies measurement, the farmer supplies local knowledge and daily management, and the veterinarian supplies clinical and population level expertise.

CONCLUSION

Smart livestock farming changes how decisions are made rather than what good husbandry requires. Sensors, phones, cameras, machine learning and digital records help detect problems earlier, manage feeding and reproduction more precisely, monitor welfare and strengthen disease surveillance, but none of them replaces vaccination, hygiene, balanced feeding or veterinary judgement. For Indian livestock keepers the sensible route is gradual: reliable identification first, then honest records, then one technology chosen against one clearly identified problem, and regular review with a veterinarian. The value of a smart farm lies in what is done with the information, not in how much of it is collected.

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