

# Research Article

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## Artificial Intelligence and IoT in Dairy Farm

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### ABSTRACT

Internet of things (IoT) and data-driven techniques are producing greater prospects for smart dairying. The demand for milk is unceasingly increasing because of rising population of the globe. The employment of the dairy products is more in developed countries as compared to developing countries. To fulfill this increased demand for milk products, better technological techniques for improving milk yield are required. It's foreseeable that the use of IoT and different AI techniques can lend a hand a farmer to beat different conventional farming challenges and increase the milk production. During this research, the authors give a talk different challenges that a dairy farmer has to countenance in way of life. Brief introduction of smart dairying (SDF) is presented with relevancy the modernization in production and therefor the processes of smart dairy farming. This review concentrations on different facets of smart dairying, and at last a state-of-the-art framework that can aid the farmers to extend the milk yield by using different up-to-the-minute technologies has been proposed. These high-tech methods can reduce the factors negatively upsetting milk production and increase those positively heartrending production with trifling resources.

**Key words:** IOT, dairy industry, smart farm, innovative dairying technology, machine learning

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### INTRODUCTION

Smart dairy farming (SDF) is the keynote concept that may satisfy the increasing demand of quality dairy products. SDF can reduce the environmental issues, decrease the use of resources, and lift the animal health by using advanced sensing and data analyzing technologies. Since 2015, milk is that the most stipulating product and it has become the merchandise with weighty price variation. In order to compete in the worldwide market, the European dairy market needs to improve its production by using Internet of things. (Begum et al., 2014)

Needing requirement for dairy products is growing day by day thanks to increasing population of the planet. In keeping with previous reports, the usage of dairy and dairy products is more within the developed countries as compared the underdeveloped countries, but this variation is getting bigger after increasing of world population and alter in diet. Almost 80% of dairy in underdeveloped countries is from small farmers. These varieties of small farmers and family farmers are far-flung from the technology and run-through traditional farming. For fulfilment of the increased demand of the planet, the use of technology during this podium continues to be required.

In this innovative business world, dairy farmers are challenging many constraints like herd management, fixed production capacity, and farm labors that are very expensive. With these restraints and challenges, a dairyman can nourish productivity and efficiency using enhanced reproduction method, smart monitoring of herd management for counteracting diseases, diagnosis of health issues, and more milk production. Given table presents a relative analysis of unlike researches on dairy farms.

**Table 1:** Table presents a proportional analysis of diverse countries for worldwide cow population and milk production

| Category              | Country     | Worldwide dairy cow population (%) | Worldwide cow milk production (%) |
|-----------------------|-------------|------------------------------------|-----------------------------------|
| <b>Developed</b>      | USA         | 3.4                                | 14.6                              |
|                       | Germany     | 1.6                                | 4.9                               |
|                       | France      | 2.0                                | 3.9                               |
|                       | New Zealand | 1.8                                | 2.8                               |
| <b>Developing</b>     | China       | 4.7                                | 6.0                               |
|                       | India       | 16.5                               | 8.4                               |
|                       | Brazil      | 8.7                                | 5.3                               |
| <b>Underdeveloped</b> | Pakistan    | 3.8                                | 2.1                               |
|                       | Bangladesh  | 1.5                                | 2.0                               |

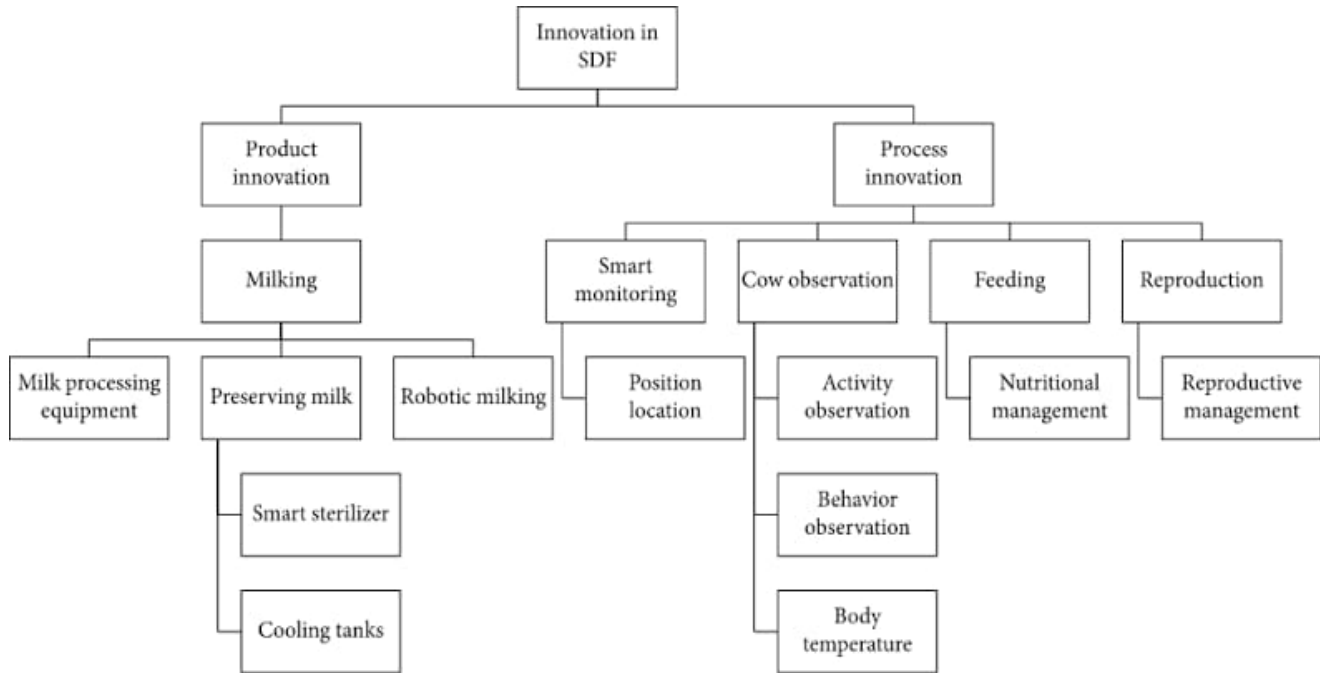
## LITERATURE REVIEW

The basic concept of SDF has been launched by different researchers approximately two decades ago. A lot of researchers have presented various theories in this regard. In research (Verhoosel et al., 2015) different ontologies have been gathered in order to get a variety of over-viewing data in SDF. Having a variety of ontologies is fruitful for better feeding procedure. The authors have labelled and enforced a smart dairying project with sensor-based technology. Smart herd management system has presented a theory of observing the health and behavior of animals for getting milk yield (Donepudi, 2017). In this regard, micro service designed a model has facilitated to attain disseminated calculation. This study also highlights some problems for enforcing the IoT-based dairying like internet connectivity that are existing at distant zones. For analyzing this major issue, the researchers have presented a fog-based planning that diminishes contract cost by 84%.the health issue and behavior of animal set up the most important hurdle for dairy farmers. The review in (Caja et al., 2016) underlines the incorporation and amalgamation of new establishing sensor-built technology with the activity-based-system. This fresh technology assists farmers in examining cow behavior and reproductive system. For taming milk yield the investigators and industries are doing their best to better the vigor of dairy animals... In the research (Ipema et al., 2012) different writers indicate various basic areas for managing the reproductive system with the association of sensing instruments. This research has proved beneficial enough in context of latest and ongoing aspects. The authors also believe that there is a dare need to contemplate the genetic selection for breeding and reproduction mechanism. In the research (Donepudi, 2016) According to the authors, temperature extent in fertility management is the most complicated task. For betterment of this, a tool introduced i.e. automatic heat detection which can aid in fertility and reproductive methods. Supreme productivity in place of larger herd is the main goal of the researchers to fulfill the demand. In research (Kamilaris et al., 2016) the authors have engaged a real time big data warehouse in dairy farms. This study builds on different categories of smart dairying include milk productivity, mastitis diagnosis, feed efficacy and incorporation of big data streams. For implementation of smart farming, many confronts are faced like integration of heterogeneous entities. In research (Tomic et al., 2015) the authors launched a project named agriOpenLink for combination of different heterogeneous entities in smart dairying. According to their approach, dairy farming ontology is laid its foundation on data management which may further be promoted with agriculture.

## SMART DAIRY FARMING (SDF)

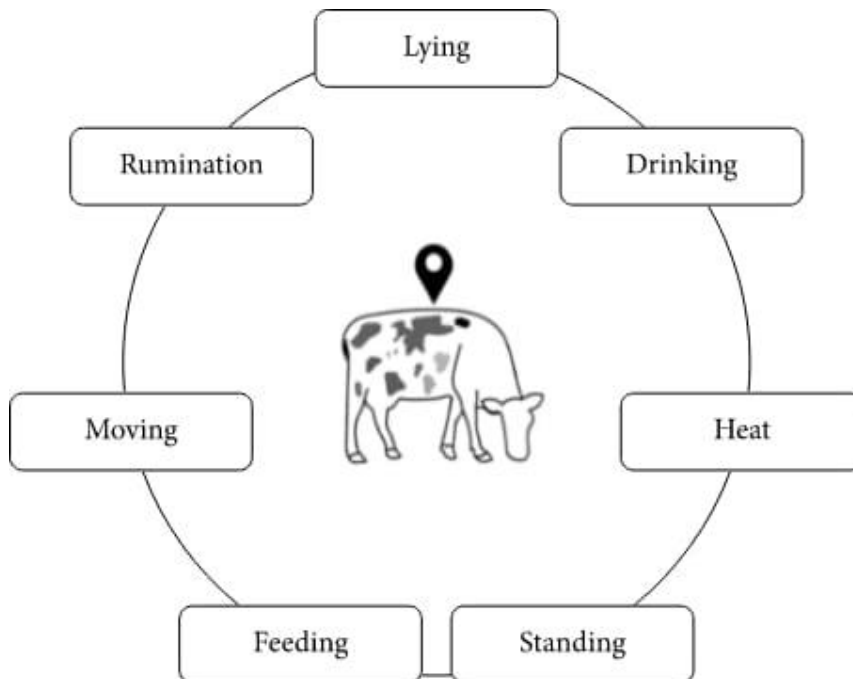
Dairy farmers are in the epoch of exactitude farming which is thought to be more significant for a set of data establishment and for taking competitive marketplace, henceforth the demand for a diversity of data sources that possess the active and static cow information about sustenance, calving, nutrition, insemination, and the method of milk yield. Internet of things commenced affecting the milk production. This pace must primarily be taken to fulfill the requirement for dairy and for enormous population of the globe. These are nearly the preceding epochs when the milk demands are accomplished without the assistance of the up-to-the-minute technology; afterward it will not be easy to tackle the needs for dairy and dairy items with no technology. It is always thought as a difficult task to determine the right time for milking the cow. Dearth of technology may cause the milk to be unpreserved and flimsy. In this situation, IoT may help farmers with habiliment sensor instruments to make them familiar of the condition of

each cow. The sensor-built system can efficiently and properly examine the sickness of the cow, beforehand it influences the milk yield. The farm holder may put the sensor onto the cow’s neck, tail, or leg for getting real time information to observe numerous aspects including cow’s behavior, action, fitness, feed eating, milk yield, and fertility supervision. These wearable devices can detect cow’s ailment and maladies such as mastitis or many other diseases that can lessen milk production (Heinrichs et al., 1997).



**Figure 1:** Innovation in SDF

The smart dairying comprises of real time devices that gather information from cows with the aid of habilitment smart collars, machine learning data assessment, and cloud-built data centers that organize information and patronage the rancher so as to manage worth of dairy items as depicted in Figure.



**Figure 2:** Sensors for SDF

**Table 2:** Dairy farming features

|                  |   |   |  |  |                                    |
|------------------|---|---|--|--|------------------------------------|
| Smart monitoring | Position location tracking  | Geofencing RFID auto tracking                                   | Approaching and treating all animals individually  | Inexpensive resources<br>Yield is higher<br>Low labor cost                         | Shortcomings                       |
| Cow examination  | Monitoring of activity, Strength, Body balance, strong organs, have capacity to produce higher productivity | Biotechnological techniques are used for monitoring any disease | Milk productivity, conductivity and to observe strength of animal, observe animal capacity | Identification of strength of animal at initial stage to reduce the mortality rate | Expensive management ,costly setup |
| Feeding          | Nutrition values should strong  | Plants than can automatically control feeding                   | Supply rate depend on productivity ratio, High productivity greater supply                 |  |                                    |
| Milking          | Preserve for long time, robotic milking   | Auto milking  | The strength, age should matter for milking productivity                                   |  |                                    |

## GEOFENCING

It is an area-based method in which an application or other programming techniques may use GPS, RFID, Wi-Fi, or mobile data to activate a remodified activity when a cell phone or RFID label comes in or exits virtual limit system around a topographical area, recognized as a geofence.

In dairying, a rancher prepares a herd of cattle with hardware gadget that comprises of various sensors and GPS tracing unit. Sensors are treated to pin down animal fitness and other main behavior to build-up output and general animal wellness. Geofencing utilizes GPS program and other associated ways including Wi-Fi nodes and Bluetooth beacons to generate a geofence nearby the farmer area; then the geofence is combined with animal collar and software application, and when the animal departs that precise location, it stimulates the alarms for the farmer.

## AUTOMATIC DISEASE DETECTION

In dairy farming animals may acquire many diseases because of various.it is very difficult and lengthy process to check each animals one by one when there is a rush of animals. Moreover, the animal's disease is also spreadable, so if not diagnosed in time, the other animals may be diseased too, bringing about loss. Production of milk may also be checked and controlled, and any slight change in animal behavior may be recorded too. So, to cater for this condition and get automotive mean of observing animals' health, go towards automatic disease recognition.

An animal passing from any malady alters its daily practice habits like lying down on here and there, separating itself from crowd, or varying its feeding habit. Sensors that sense variations in animal body make it comfort for a rancher to spot and treat that animal. Mounted sensor may detect the behavior of an animal and make a record of it. These kinds of records aid us in doing future planning like sending for a doctor. Any anomaly in this pattern is easily spotted by the sensors, and the farmer will be warned by messages or other ways. For example, the farmer can diagnose any malady with the aid of accelerometers determining animal movement, and activities can be recorded, whether the animal is less energetic related to its usual routine. Just like any other sensors (e.g., heat sensors, weight sensors, microphones, and heartbeat sensors), these sensors can make recording of animal daily life's behavior such as disease indications, temperature change, mooing, body mass changes, and pulse rate change.

## MILKING

Manual milking in a dairy farm is very lengthy and sluggish process. The conserving method of milk is also not sanitary. Manual process may cause biotic infection in milk. IoT has resolved this issue more professionally, by introducing auto milking. If the temperature is not optimal, the probabilities of milk getting spoiled are very high, but auto milking may conserve the milk by utilizing various smart cooling tanks. Ordinary auto milking systems depend on two components: computer and special herd management software. Auto milking is further distributed into several jobs like as gathering the animal, washing the animal before milking, attaching the milking equipment, getting milk, detaching the equipment, and routing the animal out of the specific place. Milk production relies upon the quantity and quality of food given to the animals. Each cow possesses its own sum of nutrients demand.

## AUTOMATIC WATER AND FOOD SUPPLY

Water is an essential nutrient for all animals. For the well-being and fitness of the animals, it is significant that cows must have sufficient quality water. There is almost 87% water in the milk. The water supplies are closely connected to milk yield, the moisture content of the food, and environmental elements such as air, temperature and humidity. Programmed irrigation system is benchmark in most farms for the reason that it is practical and effective. The program comprises of a shielded floor and a warmed bowl, which spontaneously fills with water from a pressure line. A float valve controls the water balance in the bowl. A thermostat fixed to 4 to 6° C that regulates the water temperature in the bowl.

Diet is essential for nutrition because it detects the amount of nutrients obtainable to the animal for fitness and yield. Concrete or valuable food averts underfeeding or overfeeding of nutrients and boosts the in effect use of nutrients (Salem and Smith, 2008). Malnutrition of stops production and can affect animal health. Overfeeding of nutrients rises feed costs that can lead to excessive dietetic load of the environment, and can be too poisonous or risky to health.

## FRAMEWORK FOR SDF

This research focuses on livestock farming and proposed a framework with different levels. The overall architecture has been described in Figure. A wearable sensor for capturing data from cows will send data to the nearest gateway and, with the help of Internet, the data will be transferred to a base station. The base station sends the data to cloud, and the cloud will analyze data using different techniques and methods. IBM cloud with IoT-based platform analyzes the data with respect to different procedures; for example, when the sensor detects the cow hunger need, then the automated system will feed the animal. Smart dairy farming which is IoT enabled has some herd management techniques for maintaining the logs and historical data.

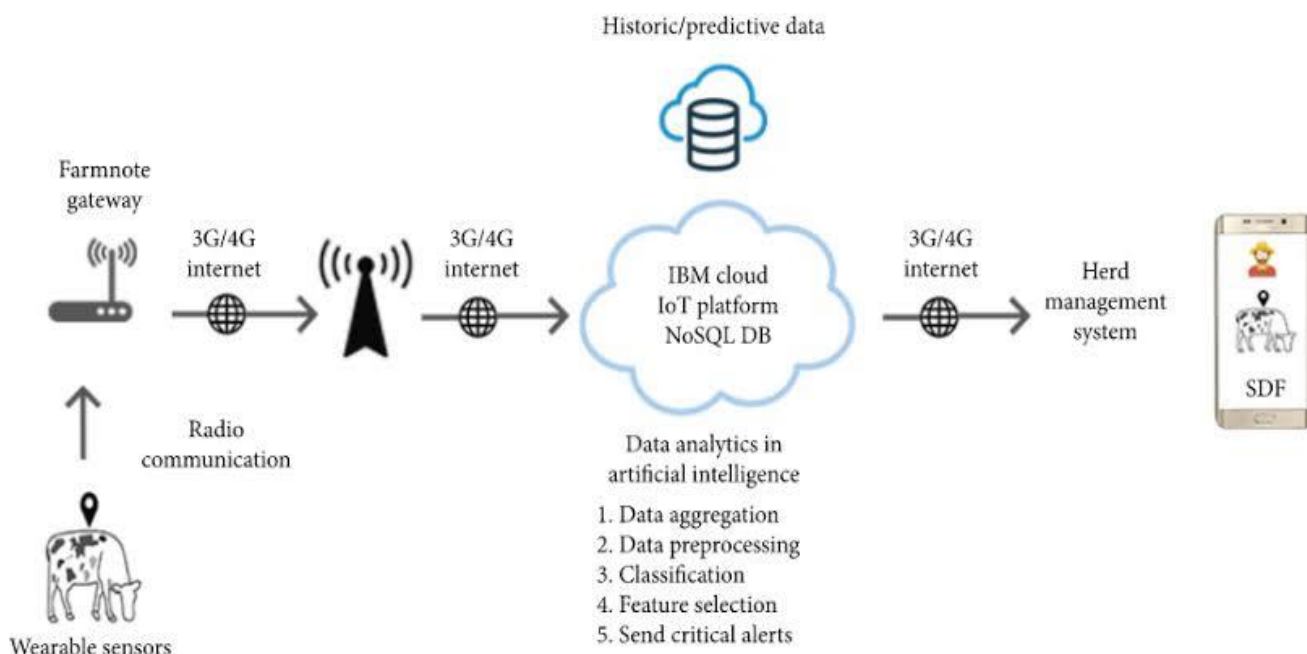


Figure 3: Framework for SDF

## REVOLUTIONIZING DAIRYING WITH MAGIC DATA BY CARGILL

**What happens when big data meets dairy farming?** The 152-year-old Minneapolis-based company and one among of the world's biggest agricultural conglomerates, is leveraging the ability of massive data to assist dairyman make their cows healthier, happier and more productive. Tapping into the proliferation of information it collects from in-house product testing and a large customer base of dairy farmers from 70+ countries, Cargill has introduced a various portfolio of state-of-the-art digitized solutions to produce in-depth analysis of knowledge which will help optimize dairy farm operations.





Figure 4: Dairy cow

## DATA RESOURCES, DIGITALIZED SOLUTIONS & PROGRESSES AND VALUES BUILT

One primary source of knowledge assets come from the innumerable sample tests the corporate has run on its feed products (e.g. forage, premixes and concentrates). By means of its original Near-Infra-Red Reflectance (NIR) technology to amount nutrients and quality strictures in feed provisions, Cargill has built the world's biggest database of NIR tasters (two million across 200 ingredients) and adding 60,000 samples more p.a, supplying over 10 million nutrient results.

### Competing within the age of AI

With such gigantic pool of nutrient data, Cargill is ready to supply a vast range of nutritional solutions and recommend optimal feed products for dairy farmers. Central to the company's data-empowered nutrient solutions is that the Cargill Nutrition System ("CNS"), which uses big data analytical tools to mine information from the NIR database and supply farmers with highly-customized, real-time nutrient analysis of feed ingredients that are most needed for his or her cows.

**How the CNS works is fairly straightforward?** A sodbuster can either submit a collection of required information regarding his farm, cows raised (e.g. type and age of cows), site and feed used into the CNS online portal, then get a made-to-order nutrient analysis report complemented with recommended feed products from the Cargill end. Alternatively, Cargill dairy solution experts can visit a farm, take inputs from cows directly on-site, and so return to the CNS portal to get recommended nutrients and feed products.

**One foremost value created by CNS is that it lets for clear-cut feed preparations tailored to unique farm operations,** because the big-data empowered system can sufficiently address basic variables like cow species, geography, climate also more advanced and case-specific variables like business goals, specific nutrient requirements and local ingredient costs. By providing customized feeding solutions to farmers and enable them to deliver an optimal diet that promotes healthiness in cows, Cargill manages to boost both customer loyalty and financial performance.

### CARGILL GROWTH PREDICTION SYSTEM (CGPS)

Another key source of information that Cargill has been able to compile comes from dairy farmers' use of RFID (radio frequency identification) tags and sensors to trace the status of cows on-site. The employment of RFID has become a typical practice across the globe, but most farmers lack the know-how needed to fully utilize the collected data for better feeding and farm operations. (Horowitz, 2015)Cargill has been able to fill the gap by introducing the "Cargill Growth Prediction System" ("CGPS") in parallel to the CNS. The CGPS gathers and uses cow data, information on rations fed, in addition as local environmental factors to predict growth from birth to calving.

To participate within the CGPS programs, farmers simply must to grant Cargill access to their operational and cow data, which is able to then be fed into the CGPS system for mining and analysis. Before accessing data, Cargill enters into agreements with farmers and guarantees that everyone shared data are protected and kept confidential from third parties.

Key metrics modelled by the CGPS include feed costs and usage estimated cow growth compared to optimal growth (based on the animal age initially calving) and the overall financial impact to farmers. The program then recommends ways of improving these upshots.

A pooled use of the CNS and CGPS programs vintages many benefits to farmers, amongst which an enhanced nutrition and feeding line of attack, a stronger and on the mend herd and ultimately higher milk production of higher quality within the future (Parker, 2017).



Figure 5: Smart cow

## DAIRY ENTELIGEN™

Dairy Enteligen™ can incorporate data from your herd-management orderliness like nutrition making, to present a real-time dashboard of maneuver intuitions. In a varying consumer needs, instability and market ups and downs environment, Dairy Enteligen™ aids you to be in rheostat of your farm throughput and withstand long term returns.

Dairy Enteligen™ is supported by a worldwide team of over 600 Cargill counsellors and pundits who complement observation and analysis to the data to convey pertinent and actionable a set of data for decision-making.

Dairy Enteligen™ delivers a significant and total analysis of your on-farm data, allowing ranchers to be more fruitful by improved managing daily operation, evading unforeseen costs and enhancing long term planning.

Cargill broadened its big data and digitization-driven modernization by rolling out Dairy Enteligen™ in 2017. This application constructs on the achievement of the CNS and CGPS programs, and provides a more cohesive solution set for farmers to optimize cow feeding and farm set-ups. Participating farmers simply must to download the Dairy Enteligen™ software onto a smart tablet or computer, sync and update their farm data on the platform, and work with Cargill consultants to research reams of knowledge like cows' health conditions, diet and milk productivity supported on data uploaded.

The Dairy Enteligen™ platform deploys a “cows-to-cloud” strategy, and functions as a real-time dashboard of operations data and insights, allowing farmers to form knowledgeable decisions on farm management practices. The platform has proved preliminary success, as participating farms in Italy have seen a 12% increase in milk production along with lower production costs.

### Why prefer Dairy Enteligen™?

- Puts together information from your dairy herd running systems.
- Powered by acumens from skilled Cargill dairy experts.
- Exclusively associates to Cargill Dairy Sustenance system.
- Clear-cut and whole analysis foremost to better verdicts.
- Avert slipups.
- Established long term tactics.
- Improve outlays in amenities and public.
- Long term commercial health and cost-effectiveness.

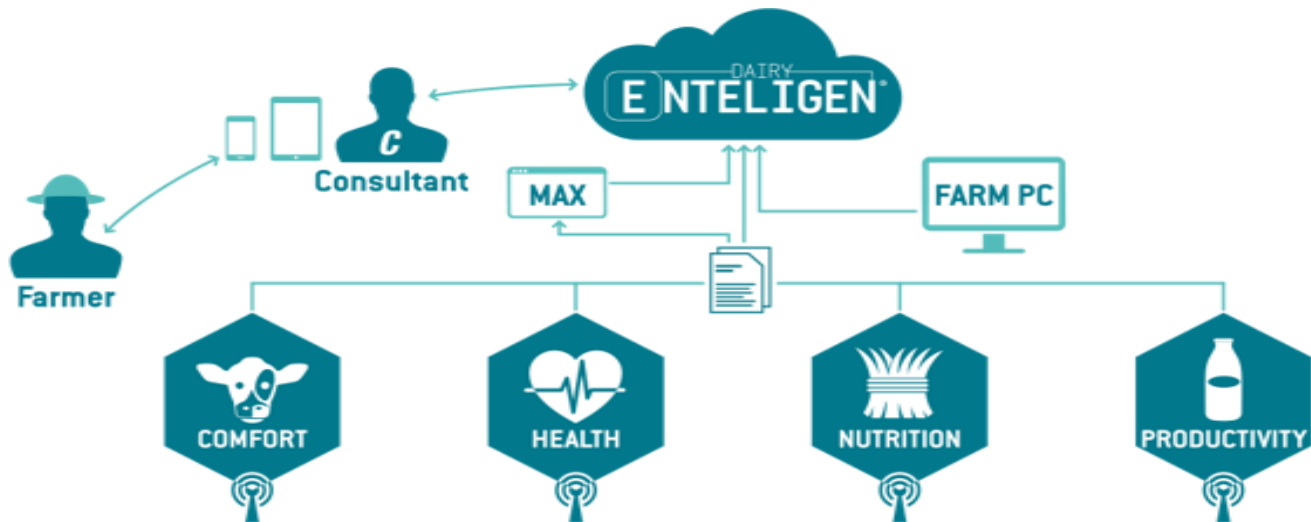


Figure 6: Working mechanism of Enteligen™

**Investments to Unleash the Ability of Knowledge**

Cargill has thru significant investments to extend its data pool and sightsee opportunities from the various data resources. The corporate has recruited a team of 500+ R&D professionals, 200 of whom with a PhD degree. It has launched 14 wet chemistry labs and 15 technical application hubs worldwide.

For the CNS program single-handedly, it took into service 30 NIR professionals and installed NIR machines in each country where its dairying business functions. For Dairy Enteligen™, the corporation has an intramural team of 600 counsellors who assist farmers in data analysis and deciding.

In late 2018, Cargill acquired Cainthus, an Irish machine vision company that applies identity verification technology to dairy farms to monitor the health and well-being of livestock. The acquired technology will assist Cargill collect data more precisely and efficiently.

**Opportunities & Challenges Ahead**

Cargill has just gone on board on a journey of precision dairying and agri-tech driven by big data analytics. Although there're confronts the company have to face such as suitable education and trainings needed to increase farmers' know-how with and acceptance of the data-empowered programs, promising opportunities lie in wait for the foreseeable future:

First, many of Cargill's data empowered technologies are pertinent in a much broader space. Dairy Enteligen™, for example, has been rolled out in Europe and the US, and can more enter developing countries such as India where the market would-be is massive. Similarly, the technology can spread to other animal species like swine and poultry.

Second, the market for exactitude agriculture could be worth \$240 billion by 2050 as more farmers behold to enhance productivity by data analytics and digitization in return to population escalation and a greater demand for food. Cargill is well stood to profit from the macro trend and engender a more significant impact as an industry leader.

Table 3: Reasons for low milk yield and their possible solutions

| Category | Reasons  | solutions   |
|----------|--|---|
| Health   | <b>Body weight</b><br>Milk production is openly influenced by the heft of the animal.  | Personal data analysis and context elucidation                            |
|          | <b>Masititis</b><br>Mastitis is triggered by bacteria that attack the udder and reproduce in the milk-producing tissues, reducing milk production. | Automatic milking claws that may spot udder diseases like mastitis        |
|          | <b>Calving interval</b><br>The atypical time period amid the birth of calves may be cause of lesser milk production.                               | Smart thought and placed historical information for footage the interlude |



|                       |  |  |
|-----------------------|--|--|
| <b>Food and water</b> | <p><b>Nutrition</b><br/>The main nutrition that must be a part of dairy cows fodder comprises of magnesium, calcium, phosphorus, sulphur, sodium, chlorine, and potassium.</p> <p><b>Feeding</b><br/>Animal nourishing can be a complicated task. Congested forage bunk can decrease feed consumption and this may cause reduced milk yield.</p> <p><b>Water and supply</b><br/>Dairy milk has 87% of water, and lack of suitable water intake may reduce the milk production.</p> | <p>Automation of information gathering to amount sustenance</p> <p>Robotic system that may nourish automatically later on witnessing the digested foodstuff.</p> <p>Automated water delivery after watching being thirsty.</p> |
|-----------------------|--|--|

## CONCLUSIONS

In this innovative globe, dairy farming is a good-looking trade which may be backed to aid economics of any country. This approach centers on various spontaneous procedures including auto milking and feeding. These two are the main effective t that can be the upcoming of a smart dairy farm. Proficient feeding and technological drinking method may result in better sustenance of cows that can eventually cause more milk yield. Moreover, a mechanism of more milk production has been presented. The presented plan is a total program for implementation of the up-to-date methods for improving feeding and milking procedures. The system with comprehensive architecture, better version of technology, and multipurpose design can make IoT-built farming more proficient. Even though it can demand hefty investment in preliminary stages, afterward, the upgraded technological setup can make balance amid the invested amount and the grossed amount.

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