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Monitoring Livestock Wellbeing Using IoT Devices in Bangladesh

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Abstract*— The Internet of Things (IoT) has emerged as a game-changing technology, offering unprecedented opportunities for monitoring and managing livestock wellbeing. Real-time data collection and analysis enable prompt intervention in case of any abnormalities, thereby minimizing suffering and improving overall animal welfare. The livestock sector has an integral part of the socio-economic development of Bangladesh. Use of IoT can reduce costs in heat detection, medicine and inbreeding. Services such as detecting of the location of the organism, providing information on diseases, monitoring the body temperature of cattle, and giving information of the timely filling of the seeds can immensely improve productivity.

Index Terms*— Bangladesh, IoT, Monitoring, Livestock wellbeing

I. INTRODUCTION

Advancements in technology have revolutionized various sectors, and the agricultural industry is no exception. In recent years, the Internet of Things (IoT) has emerged as a game-changing technology, offering unprecedented opportunities for monitoring and managing livestock wellbeing. By leveraging IoT devices, farmers can closely monitor various parameters of their livestock, ensuring their health, safety, and overall welfare. This study explores the importance of researching and implementing IoT-based solutions for monitoring livestock wellbeing. The study explores what activities are going on in Bangladesh.

By utilizing IoT devices, farmers can continuously monitor and assess the wellbeing of their livestock. Real-time data collection and analysis enable prompt intervention in case of any abnormalities, thereby minimizing suffering and improving overall animal welfare. IoT devices can monitor vital signs, such as body temperature, heart rate, and respiration, providing early indications of potential health issues. This facilitates early detection of diseases and enables farmers to take timely actions, including isolating affected animals and implementing appropriate treatments, thus preventing the spread of diseases within herds.

IoT devices, combined with advanced analytics, enable precision livestock farming. Farmers can track and optimize factors like feed consumption, growth rates, and reproductive patterns, leading to improved resource management and increased productivity. This approach ensures that livestock receive optimal care tailored to their individual needs. IoT devices equipped with sensors can monitor environmental parameters such as temperature, humidity, and air quality in livestock housing. Maintaining optimal environmental conditions reduces stress on animals, mitigates health risks, and promotes their general wellbeing. IoT-based livestock monitoring can contribute to sustainable agricultural practices. By effectively managing resources, optimizing feed consumption, and reducing waste, farmers can lower their environmental footprint and improve the sustainability of their operations.

The Netherlands, renowned for its precision agriculture practices, has made significant strides in utilizing IoT for livestock welfare. Dutch farmers employ wearable IoT devices equipped with sensors to track the movement, behavior, and health parameters of their animals. This data is analyzed to identify potential health issues or deviations from normal behavior patterns, ensuring timely intervention and improving animal welfare.

Monitoring livestock wellbeing using IoT devices has emerged as a crucial research area for the agricultural industry. The ability to collect real-time data and analyze it enables farmers to make informed decisions, enhance animal welfare, and optimize resource utilization. Countries such as the Netherlands, Australia, the United States, and New Zealand are at the forefront of implementing IoT solutions for livestock wellbeing. Their successful endeavors underscore the potential of IoT in revolutionizing animal agriculture. As we move forward, continued research and collaboration in this field will pave the way for sustainable and compassionate livestock farming practices that prioritize animal welfare.

II. METHODOLOGY

In this paper, we have used qualitative research method, which is exploratory research, to get important information about the livestock sector in Bangladesh.

A. Primary Data

Primary data was collected through means of one focus group discussions and ten direct interviews. Direct interviews of industry experts like Mr. Fida Huq, Dr. Shamsul haq, Mr. Reefat Hasan, Mr. Kolimullah Ahmed and others. They are experts from the livestock industry. Focus group discussion took place with the participants from Department of Livestock, Government of Bangladesh, a2i, ICT division, and

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Livestock company owners.

B. Secondary Data

Secondary data was collected from the internet to aid us in having a better understanding of the livestock sector and how animal healthcare is monitored currently in the livestock sector.

III. LITERATURE REVIEW

At present, livestock farmers face cattle medical issues far and wide due to constant ascent in air temperature in the troposphere. These variations in temperature has resulted to a destructive impact on animals prompting to illnesses, for example, foot and mouth disease, swine fever, bovine spongiform encephalopathy (mad cow disease). A report by WHO stated that severe acute respiratory syndrome corona virus (SARS-CoV) is said to be a virus that spreads effectively to other animals and have likewise influenced humans recently. The proof of people getting tainted through SARS has been accounted for by different nations over the globe. As a result, it has brought an economic downfall in nations which have been influenced and consequently, a framework should be established for constantly monitoring animal health and to control and forestall the outrush of diseases at a larger scale [1].

Agriculture is not something that individuals consider promptly, with regards to internet. The vast majority relate it to their Smartphones and Computers. Much to their dismay, Internet of Things (IoT) isn't just permitting farmers to associate and work their devices with internet yet additionally influence web to diminish waste and increase productivity. All in all, how does a farmer choose which viewpoints are generally helpful [2]?

In the ongoing decade, milk production has been improved by hereditary headway and synthesis yet has made cow's bodies direct vitality assets to drain at the cost of fertility and life expectancy. At the beginning of lactation and particularly right after calving, dairy animals have exceptionally high vitality prerequisites following the extreme increment in milk production. At the point when cow can't expend enough energy from nourishment, excessive body fat mobilization will occur, bringing about loss of body condition showing the cow is in a negative energy balance (NEB) [3].

In 1986 Grieve et al. proposed that an increased milk fat to protein proportion demonstrates negative energy equalization and ketosis. In an investigation of 42,355 lactations 132 cooperative Israeli herds calving in the period of 2009-2011, it was found that the measures of fat and protein (in rates of milk kg/180 days) in the cow's milk in which the fat to protein ratio (FPR) was above 1.4, were more prominent than 7.7% and lower than 2.6% respectively, than that of bovines with a FPR 1.4 or less [3].

Every farmer's goal is to have a practical program to develop out and inseminate his quality females to his preferred bulls. Planned impregnation with top demonstrated sires must be utilized on all cows and substitution calves to accomplish most extreme hereditary gains in a dairy group. The advantages of AI are clear; however, AI isn't without its issues, the essential one being heat detection. Estrous is the time of warmth. Precise detection and resulting insemination increment the likelihood of convenient and effective origination. Cows which are in estrous can be identified mostly by obvious side effects: distress, mounting and vaginal discharge [4].

One of the most significant issues is to control and upgrade the quality of milk through IOT. This device gives information that can be utilized to associate activities with explicit practices, for instance, grazing, socializing, or lying down chewing the cud. This can succor farmers with enhancing milk production by keeping cattle healthier and improving breeding effectiveness [5].

Farmers can track specific behaviors in their herds to determine how habitually they feed with the assistance of IoT device. The sensors work inside wearables which are around cow's neck and it notifies farmers when the cow is going to be milked, personalizing the session for her. This gadget also tracks the sum and speed milking. Farmers can furthermore follow the amount of food cow consumed and number of steps taken in a day. With the assistance of the database picked up from each cow's action, the farmer can assist with improving their eating regimens to build lactation [2].

IOT devices are transforming even the most remote industries. With an expectation of more than 25 billion objects connected together for 2020 (Gartner information), it is inconceivable to not understand that everything around us is evolving, from the manner in which we speak with one another, to the manner in which we work. Cattle industry is no special case. Sensors and software are gathering information for farmers by unveiling tremendous opportunities beyond shooting up the productivity of herds [5].

Numerous farmers occupied with domesticated animals' reproduction can likewise utilize IoT-sensors to gather information for location, prosperity, and health of their dairy cattle. With this data, farmers can improve the monitoring of livestock, for example, identifying the debilitated animals so they can be isolated from others to abstain from spreading a malady. In addition, these sensors can assist farmers with dropping down the cost of labor. Moreover, these IoT sensors, aside from locating cattle in farms, can watch if certain cows are pregnant or going to conceive an offspring or in warmth and set to fertilize. Therefore, IoT-sensors can help farmers in various manner by generating information which can be used in controlling things that are liable for better cultivating [6].

IoT leverages the benefit to monitor the livestock health, which can prevent losses. IoT solutions in the livestock industry generally employs wearables which connect low-bandwidth technology which helps to stream data to the cloud. Farmers are alerted to the sign of illness through

connected wearables which monitor heart rate, respiratory rate, blood pressure, digestion, or other important factors. The IoT health monitoring can resolve feeding issues and prevent animals from illness. The built-in wearable sensors measure animal's behavior and conditions. This can help farmer mitigate costs by taking proper actions properly [2].

IV. IoT and Agriculture

Internet of Things (IoT) deals with two terms – 'Internet' and 'Things'. The term 'Things' alludes to various IoT devices with unique identities and abilities to perform remote sensing, actuating and live monitoring of certain set of data. They also enable live exchange of data with other connected devices and applications via direct or indirect communications. The obtained data from the connected devices is then processed and transmitted to various servers. Whereas the other term 'Internet' deals with the connection between Global Communication Network and trillions of computers across the planet. This enables the exchange of information across the globe. Thus, IoT can be defined as: "A dynamic Global Network Infrastructure with self-configuring capabilities based on standard and inter-operable communication protocol where physical and virtual things possess identities, physical attributes and virtual personalities. This infrastructure uses intelligent interfaces which are seamlessly integrated into the information network transmitting data associated with the users and their environment."

An ideal IoT device consists of interfaces responsible for establishing connection, wired or wireless, to other devices. Any IoT based device consists of following components:

- I/O interface for sensors.
- Interface for connecting to Internet.
- Interface for Memory and Storage.
- Interface for Audio/Video files.

These devices can vary in forms such as wearable sensors, smart watches, IoT smart home monitoring, IoT intelligent transport systems, IoT smart health devices etc. [10]

There is a huge potential to adapt everything to 'Intelligent and Smart' with the implementation of IoT in various sectors such as industries, homes and even cities. Recent adoption of IoT technology in agricultural sectors has led to the development of "AGRICULTURAL Internet of Things (IoT)". [10]

A. *IoT Applications in Agriculture*

Crop Water Management: Adequate water is an essential necessity to perform agricultural activities efficiently. Agriculture IoT is integrated with Web Map Service (WMS) and Sensor Observation Service (SOS) to ensure proper water management for irrigation reducing water wastage in the process.

Precision Agriculture: High accuracy of weather information is mandatory to prevent chances of crop damage. Agriculture IoT ensures delivery of real time data in terms of weather forecasting, quality of soil, cost of labor and much more to farmers.

Integrated Pest Management Control: Agriculture IoT systems assure farmers with accurate environmental data via proper live monitoring of temperature, moisture, plant growth and level of pests so that proper care can be taken during production.

Food Production & Safety Agriculture: IoT system monitors various parameters such as warehouse temperature, shipping transportation management system and integrates cloud-based recording systems with great accuracy.

Livestock Monitoring: Agriculture IoT system accurately monitors parameters such as digital record keeping, heat detection, advance disease notification, calving detection & movement and temperature tracking. It also integrates cloud-based recording systems.

B. *Benefits of IoT in Agriculture*

Data collection: Data such as weather conditions, health conditions of cattle, crops, etc. can be collected with the aid of sensors installed in required fields. The collected data are stored in a single server for farmers to access and analyze the data with ease in order to determine the correct decision.

Reduction of risks: Using the data obtained, farmers can assess the situation and predict future problems which may arise. Moreover, these data can be used for the improvement of sales and alteration of business processes.

Automation of business: With the automation of various business processes, the efficiency of these processes grows. Automation of such processes allows farmers to pay attention to other important manual processes.

Higher quality: Smart agriculture holds the key to avoid challenges and remove any issues which may arise during farming processes. Hence, the consumers get a product of higher quality. [11]

C. *Challenges of IoT in Agriculture*

The Internet of Things (IoT) is a recent concept and best known to people who work with cutting-edge technology. Most farmers are unaware of this concept while some of them are opposed to adopt new ideas even when its overall benefits are evident. This may seem problematic in order to promote IoT among farmers. The best way to promote IoT's impact is to demonstrate each device related to IoT using real-world examples for easy understanding of the concept.

The equipment necessary for implementation of IoT in agriculture are expensive. Acquiring this equipment may occur as problematic for farmers. Sensors are the cheapest component. Yet, outfitting all of a farmer's fields can cost several thousand dollars. Automated machinery is relatively more expensive and added costs for the management software and cloud access is a topic to put more thought into. Even though the potential for higher profits down the line is significant, many farmers may find the initial investment hurdle difficult to overcome.

Finally, there is the matter of security. Since IoT devices

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connect with older equipment with access to the internet, there is no assurance that someone will not access a drone's mapping data or sensor readouts by taking advantage of the public connection. Agricultural IoT systems gather enormous amounts of data which are difficult to protect. A person with unauthorized access to an IoT provider's central database could steal information on projected yields and manipulate the market [12].

V. Bangladesh Industry Overview

The economy of Bangladesh is mainly based on Agriculture. Livestock plays a crucial role in the agricultural economy. The livestock production is characterized by a wide range of agro-climatic conditions, a large number of livestock of different species, a high degree of integration of animal production systems in agriculture and participation of large number of farmers with small land holdings.

The main characteristic of agriculture in Bangladesh are small sized farm and rice-dominated farming systems. With irrigated land making of only 31% of total land, rainfed farming still remains predominant. Major crops are paddy, wheat, corn, sorghum, cotton, millets, sugarcane, groundnut and other pulses, while mango, banana, jackfruits, pineapple, black berry and palms are the major fruits in the country. The Bangladesh Economy although growing at an impressive rate to become a middle-income country, is still largely dependent on agriculture sector. Around 70-75% of the Bangladeshi population resides in rural area and are directly or indirectly linked to agricultural activities.

The livestock sector has an integral part of the socio-economic development in our country. It has an ample amount potential in terms of economic development perspective. The fisheries and livestock sub-sector make up almost 30- 40% of the agriculture sector. This sector contributes almost 7-8% of the total GDP of our country of which 3% is derived from livestock. Moreover 90% of the protein which we get from animals comes from this sub-sector. Since this sector is mainly labor intensive and gives quick earnings, it plays a significant role in reducing poverty and aids in earning foreign currency and is also a source of employment for the poor and marginal people. Hence, we can easily see the importance this sector has on the economic development of our country.

Technological progress in Bangladesh has been slow. However, thanks to the recent intervention policy which began from the 1990s that it has shown some promise. There are three main organizations which helps the government to support the livestock industries. They are:

(a) The Ministry of Fisheries and Livestock responsible for the overall direction and development of the livestock industry.

(b) The DLS responsible for providing extension services to farmers.

(c) The BLRI responsible for conducting research on genetics and feed [7].

However, many private companies also provide significant support for the development of livestock sector.

Another sector which has shown significant improvement from the policy intervention is the dairy sector. Intensive research and cross breading of cows have led to increased production of milk in recent years. Use of deep-frozen semen for artificial insemination has significantly improved the cattle breeding program. The introduction of new and improved milk processing and packaging techniques has led to rise in the number of small-scale dairy farming, successful examples of which include MILK VITA, BRAC-ARONG and PRAN. Of these, Milk Vita, run by Bangladesh Milk Producers Cooperative Union Limited, dominates the dairy industry. They collect the milk from cooperative members, process the milk in their manufacturing and distribute it to Dhaka and other areas of the country. Their products are marketed through Dhaka.

The Smart Farm is one of the first cattle care service focused on IoT. Smart farm's approach has the advantages of detecting the hormonal heat cycle at the right time for insemination and early detection of any medical problem for treatment. With our solution, the probability of heat loss is reduced to 5 percent. It also helps in identifying quiet livestock heats that are normally skipped. [8]

Smart Farm Benefits:

- Smart tag reads body temperature and shifts in hormones
- Determines the right insemination period
- Any disease is expected
- Be told 48 hours in advance of your cow's illness

Smart means connecting to the internet where there is any information. All of it is smartly regulated. All are monitored using the internet, from feeding cows to collecting milk. There is a chip for every cow in the smart farm management. The chip is usually attached to the neck collar or ears. It is a chip that can gather all of the cow's physical and surrounding information.

For example, the body temperature of the cow, blood circulation, chewing practice, breeding period; it gives detailed information about everything. it helps avoid premature abortion by providing all sorts of details on a mother cow's maternal physical status. What kind of nutrition a cow needs, how much light and air it needs, and even when the cow is ready to milk; a farmer can easily know everything from the information coming through an internet link to the base station to his cell phone. This technology still doesn't cover the milking cycle. Eco-monitoring technology was not implemented either. [9]

VI. Findings and Analysis

A. *Livestock Sector*

The population of livestock has been on the rise in the last 10 years. The population of cattle has increased from 23 million in 2010 to 57million in 2022, which is around 150% rise in the total number of cattle in Bangladesh. Goat has been

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the other species which has had a similar increase in number in the last decade. The increase in the number of livestock is due to the change in policy, or due to the emergence of new policies to protect the livestock sector. Critical policy areas include: Dairy Development and Meat Production, Veterinary Services and Animal Health and Access to Credit and Insurance [7].

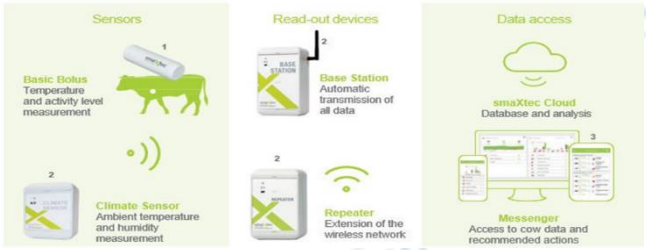
With the increase in number of livestock in the industry, the production of milk and meat are meant to increase. Milk production has risen from 2.37 million metric tons to 13.07 million metric tons, which is a 450% increase in production of milk. But the dairy sector cannot meet the requirement of 15million metric ton milk locally yet.

The meat production has also increased from 1.26 million metric tons to 9.3 million metric tons. This increase in meat production has made Bangladesh self-sufficient in the local requirements of meat. An increase in production could lead to Bangladesh going global and importing beef to foreign land, and thus, helping in economic growth.

The GDP of Bangladesh has been on the rise in the last decade, as we can see from the picture above. But we have seen a decrease in the contribution of livestock in GDP in the last decade. This is partially due to the unavailability of credit support to the farmers, who sometimes need that backing when there is a sudden death of the cattle or when cattle are stolen from the farm. With the RFID tag, the location of the cattle can be monitored and also which cattle is numbered what can be identified, so during the case of a sudden death of the cattle or cattle theft, the cattle can be identified easily and the credit support can be provided by Phoenix Insurance. [13]

B. Technical Aspects

The following picture shows the bolus process in a cow's stomach:



BOLUS working process

• First lift the label underneath the smaXtec Balls. Next, activate the sensor (including the smaXtec base station) using the provided magnets.

• If the smaXtec bolus is successfully activated, the LED light at the bottom of the smaXtec bolus shines briefly every 0.5 second.

• Note the exact position of the magnet mentioned in the given guide.

• Add pH 1.0 to the buffer solution in a thin container and remove the sponge from the sensor tip. Then place the smaXtec Premium bolus on the container sensor and tap.

• It takes at least 5 minutes to start the smaXtec bolus. Flash three times during this period. If the preparation is consistently successful, the LED flashes for 5 minutes every two seconds. If unsuccessful, the LED flashes very fast (every 5 milliseconds) for a duration of 5 minutes.

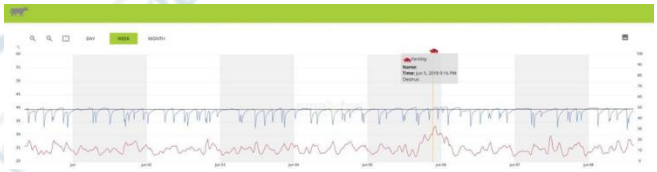
• After a successful startup, the smaXtec bolus can be sorted using a smaXtec sensor amplifier. After selecting the appropriate animal, the animal identification data must be entered in the supplied list next to the serial number of the smaXtec sensor.

• Activation sensor is required by clicking on the 'animal' icon to the right of smaXtec messenger and activating it in smaXtec messenger to make sure it is correctly directed to one of the entities.

• Read after successfully deploying a readable device, the measured data from the smaXtec sensor will be available in smaXtec Messenger in about 5 minutes.

Heat Detection: Smaxtec Example Curve

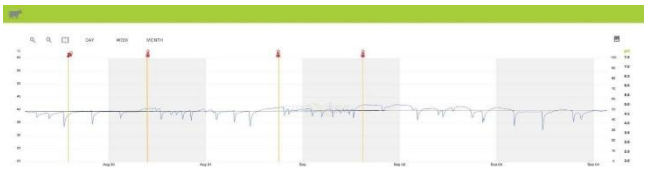
The smaXtec framework spots estrus dependent on normal varieties in the movement of the cows. In the given model, the development action (red bend = development movement) expanded altogether on June 5, so a thermal location notice was sent. In the wake of arriving at the fundamental heat, the pregnancy window is appeared to the client with the best incubation time. The ideal development time frame for the animal is June 1: 16: 1: 16 to 5: 3. This period in the notification is set apart as green. In the wake of arriving at the red speck, smaXtec suggests swearing off pregnancy.



Heat Detection Curve

Temperature Detection: Smaxtec Example Curve

The smaXtec bolus of Beef Forests gives constant internal heat level estimations inside the bovine's body. The area of the sensor empowers exact and complete estimations to be taken continuously. The utilization of the smaXtec framework implies ranchers will no longer need to take the temperature themselves. It spares time and permits the temperature of every animal to be followed after some time, taking into consideration faster reaction to the root of disease or discovering reasons for the change of temperature. SmaXtec bolus not just empowers to recognize the beginning of malady and calving in the beginning times through



temperature checking, yet additionally offers ranchers the chance to screen how their animals are being recouped. Increased and decreased, both the temperatures can be

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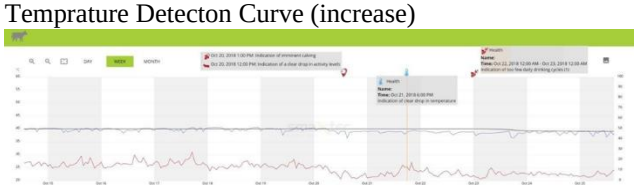
identified right away by bolus and measurements can be taken as fast as possible.

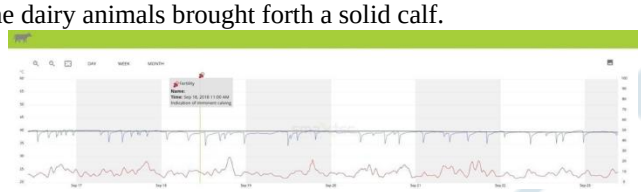
Temprature Detecton Curve (increase)



Temprature Detecton Curve (decrease)

Calving Detection: Smaxtec Example Curve

Calving invention depends on huge temperature drop (blue bend) before etching. The caution is made 36 hours before the real calving. A notification was sent to the rancher at 11:30 a.m. on September 18 at the given chart in Figure 2.7. It was feasible for the rancher to isolate the mother cows and bring it into a feeding of box, avoiding potential risk in this manner ensuring a problem free birth. A couple of hours after the fact the dairy animals brought forth a solid calf.



Calving Detection Curve

C. ROI of Farmers

Medical Cost Savings

Name of the Disease	Cost before taking services	Cost after	Savings
Foot and Mouth Disease	600	250	350
Mastitis	800	400	400
Black Quarter	380	50 (Vaccine)	330
Bovine Ephemeral Fever	300	50	250
Anthrax	0	50 (Vaccine)	-50
Gonodotropin-releasing Hormone (GnRH)	300	0	300
Luteienzing Hormone (LH)	220	0	220
Total savings (yearly)			1800

All amount in BDT

The table above calculates the medical costs, which include medications & doctor's fees. When a farmer takes the services, they are initially getting the product which helps them monitor the wellbeing of the cattle and as secondary products, this service saves the farmers a lot of money and also keeps their cattle safe and disease free.

Savings due to Heat Detection

Description	Daily Amount	Single Price	Total	Comment
Concentrate feed (21 days)	4 kg	35	2940	
Raw grass (21 days)	12 kg	5	1260	
Rice Straw	4 kg	9	756	
Labor (21 days)	For 10 cattle	40	840	Monthly salary for a labor is around 12000 taka
Medical expense			250	Average
Utilities			550	Average
Total			6596	

All amount in BDT

Due to the failure of heat detection in a cow or the heat to blow farmers have to wait 21 days for the next heat. As above calculation the farmer has to spend at least 6,596 BDT extra. Thus, when 2-5 heats were missed, farmer was discouraged from rearing cows in addition to financial problems of around 20,000 BDT.

Inbreeing Savings

Inbreeding related probblems	Cost before taking services	Cost after	Comment
Reduction of cow milk	13125	0	5 months a day for 2.5 liters; per liter price is 35 taka
Atresia Ani	3000	0	Surgery fees
Conjuntivities	3000	0	Surgery fees
Total	19125		

Studies have shown that cow's milk is reduced by at least 25% due to inbreeding. If a cow gives 10 liters of milk a day, it will give 7.5 liters as a result of inter-breeding. Give less than 2.5 liters of milk daily. The lactation period is estimated as 5 months. A farmer can make 27,571 Tk profit per year after taking services. On the other hand, the cost is only 7,200 BDT annually.

VII. CONCLUSION

Even though dairy is one of the oldest established professions in the rural environment of Bangladesh, the development of this sector is unsatisfactory due to many problems. The major related problems are breeding, feeding, management, disease, and marketing. Due to lack of attention on current policies, the dairy sector faces many issues in the field of data and research. The economy of Bangladesh is largely based on agriculture and livestock. It is an essential component for the livelihood of the rural economy and farmers. It is impossible to provide accurate services due to lack of information on livestock diseases. As a result, the collection and storage of information about cattle breeding cannot be carried out properly. As farmers do not recognize the heat at the correct time, it is not possible to achieve breeding on time. As a result, farmers suffer huge economic losses. Fertility problems are common in cattle, as cattle farmers do not store seed distribution information. Farmers cannot determine the expected date of delivery, therefore increasing the calorie mortality rate. Without insurance, livestock development and financial investment are obstructed. Services such as detecting of the location of the organism, providing information on diseases, monitoring the body temperature of cattle, and giving information of the timely filling of the seeds are provided. This reduces repetitive reproduction and determines the pregnancy of the cow. Information is made available beforehand for the farmers. They can use this information to solve inter-breeding problems. Therefore, technological advancement in agriculture is a strategy which will produce high rates of economic growth by increase in production and income. Widespread activism in this development process by dispersal of resources to largest potential segment of the population are also in demand in rural areas.

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