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High-credibility RFID-based animal data recording system suitable for small-holding rural dairy farmers

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ABSTRACT

In order to remain globally competitive and to ensure traceability, intensive and extensive livestock operations are adopting radio-frequency-based electronic identification (RFID) and data recording systems. Such integrated systems offer dual advantages of lowered labor costs due to automation and enhanced profits due to optimization of animal productivity, health and welfare. However, RFID-based systems might not be economically viable for small-hold livestock farmers unless there is considerable value advantage. Further, the set up and operation of a data recording system for small-hold farmers is also difficult due to size-constraints and distant farm units. We have developed an integrated system for small-hold dairy farmers to enable employing of RFID technology to ensure credibility of data recording, and avoidance of livestock insurance-related claim malpractices. The system can additionally be used to periodically collect performance records and to operate veterinary service delivery. The integrated system comprises of: (a) an RFID tag or insert; (b) an RFID reader; (c) a PDA/mini-laptop with custom software installed; (d) a USB modem internet connection; and (e) a central data server on web platform with dedicated server-level software. The unique feature of the system is that the veterinary health worker (VHW) is able to register and enter new records only when the RFID reader connected to a mini-laptop is within reading range of the associated RFID tag. This also authenticates the visit by the VHW. Other data management operations such as browsing, sorting, data analysis and report generation can be carried out when the VHW is away from the RFID field. We have deployed and validated the system in a cluster of 5000 dairy animals spread over more than 10 villages with an average of two to three animals per farmer in Thanjavur district, Tamil Nadu, India. The system is user-friendly and easy to operate in that the animals' insurance registration and issuance of policy documents can be done in a single farm visit. The system can also be used for collecting periodic animal records and sending SMS 'alerts' to the farmers. Initial economic analysis suggests that the investment cost would be recovered even if fraudulent claims in around 0.5% of the insured animals can be prevented. The sustenance cost can be recovered from the improvised health and production management service delivery to the farmers. It is however emphasized that the system can only be implemented in organized dairy operations wherein the milk processing company can establish functional collaboration with veterinary service providers, insurance company micro-finance companies and this consortium can bear the cost of RFID in exchange for long term multilateral benefits to all the stakeholders.

1. Introduction

Livestock rearing is now recognized as an essential supplementary activity that can safeguard farmers from the economic distress associated with repeated crop failures. Government development agencies in countries like India hence promote livestock rearing schemes for small-hold and marginal livestock farmers. These public-funded welfare schemes include induction of productive livestock to resource-poor farmers, insurance to minimize risk of loss of animal or productivity, and field progeny testing programs for local breed improvement. The success of these schemes primarily depends on the integrity of animal records provided by public veterinary officials. Secondly, it is also important that such farmers are provided with timely veterinary/extension services at their doorstep and alerts to undertake management tasks such as estrus detection, AI, and pregnancy testing. Unavailability of credible animal performance records distorts the impact assessment of welfare schemes. In the event of slackness in services and supervision

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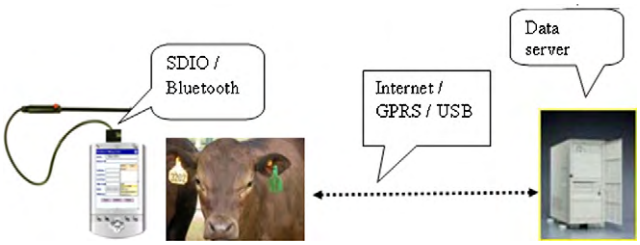


Fig. 1. General scheme for integrated RFID-based identification and animal data recording system.

(which is common under government administrated programs), there is an increased likelihood of reporting falsified data leading to incorrect evaluation of livestock development projects and filing of false insurance claims and losses to cattle insurance companies.

Animal identification and performance recording (I & R) are critical to efficient farm management (Lissemore, 1989). Data management and retrieval have become extremely efficient with introduction of desktop computers and radio-frequency identification (RFID) based electronic animal identification (Eradus and Janssen, 1995; Pires, 2002). Such integrated systems offer advantages such as decrease in recording errors, automation of farm implements (Naas, 2002), reduction in labor costs and overall productivity optimization (Artman, 1999). These developments have led to the evolution of herd health programs focused on maximizing production (Voelker, 1981; Menzies et al., 1988), health (Dohoo, 1988) and fertility (Lehenbauer, 1987). The general perception is that RFID technology is cost-prohibitive to small-hold dairy farmers (Geers et al., 1997; Saatkamp et al., 1997) since such farmers can easily identify animals and the farm implements are not mechanized or automated.

We have developed an RFID-based animal recording and service delivery system with a significant feature of highly credible animal records. This not only minimizes losses due to fraudulent claims in livestock insurance, but also provides protocol-based veterinary and extension services to the farmers, cost-effective collection methodology, and periodic transfer of animal performance records. The combination of these features would ultimately lead to a rational impact assessment of various public-funded welfare interventions. We have tested the system in a pilot project being implemented by a non-governmental organization (NGO) (the IFMR Trust, Chennai, India) involving a cluster of 5000 animals belonging to very poor small-hold farmers. The results indicate that RFID-based identification and computerized data recording system are economically feasible even for such farmers—the investment and operations costs are much lower than those incurred due to fraudulent insurance claims and scheme failures due to inaccurate animal records.

2. Materials and data acquisition techniques

2.1. Hardware

The integrated identification and recording system (Fig. 1) comprises: (a) a Windows/SQL-based central data-web server (with 2 GB capacity, retained on an annual contract basis), and a local server; (b) an RFID reader (300 mHz, read range 1 cm) and a mini-laptop (128 MB RAM, 80 GB hard disc, Pentium IV processor) supplied to each veterinary health worker (VHW) and (c) ICAR-compliant three-way RFID ear tags (visual laser-printed, bar-coded and microchip-embedded) manufactured indigenously by Bartronics, Hyderabad, India. The integrated system was planned such that field data could be captured at the time of animal registration and subsequent providing of services in the mini-laptop and by using the wireless internet connection the data can be simultaneously transferred to the central server for instant update.

2.2. Software

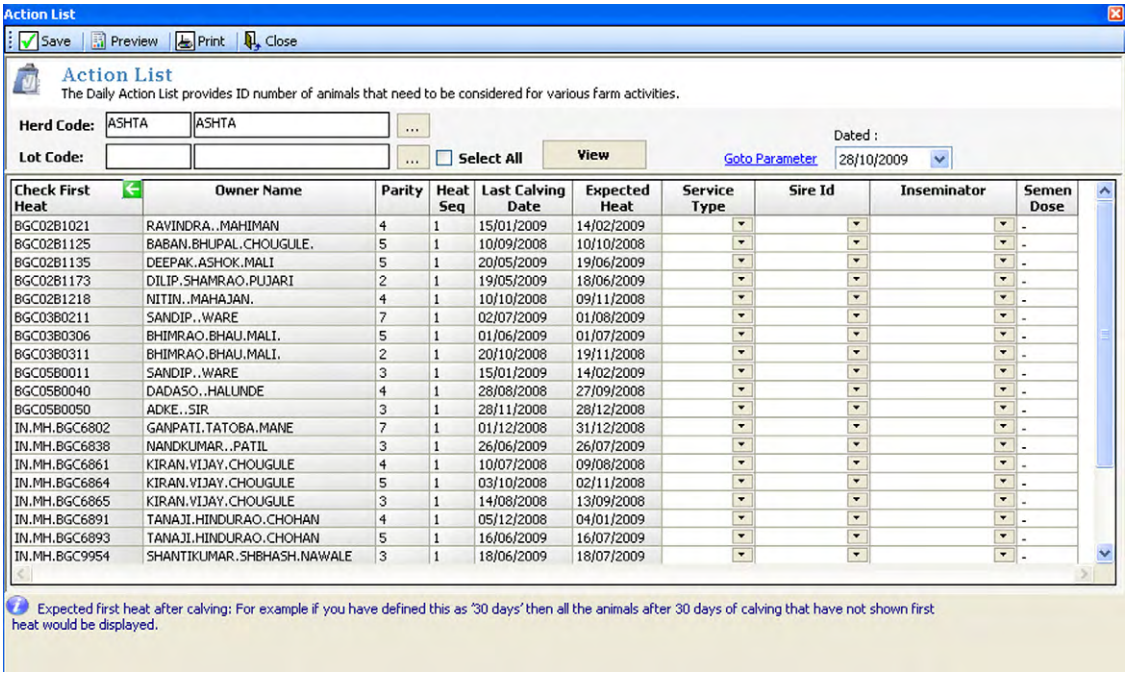
We have developed dedicated computer software suitable for implementing herd health and productivity management program for small-hold dairy farmers using VB.NET/SQLServer programming languages (Herdman-server; www.infovet.in). The software can be used to register villages and to maintain individual farmer and lifetime animal records. The database created on the local server is uploaded to the web server in order to provide administrative access to the staff from different locations. The software has the capability of validating and synchronizing data to individual animal files every time new records are sent over the internet. The software can also send SMS alerts to farmers' mobile phones in regional languages. A customized data recording program (Herdman-PDA) has been developed for use with mobile computing devices such as the mini-laptop or PDA. The software has been designed to enable the RFID reader to interface with the database such that when the reader detects signals from an RFID-tagged animal, the respective data entry form for the individual animal is made available on the screen. Breeding, production or health records can be accessed, entered, or updated. Once the data is recorded and saved in the mini-laptop, updated records are transferred to the central server via the wireless internet USB modem. The records are time-stamped on the mini-laptop and the server so that the visit of the VHW can be authenticated.

2.3. Broadband connectivity

The area selected for the project has dependable wireless internet connectivity (speed around 512 kbps) serviced by the public sector company 'Bharat Sanchar Nigam Ltd.' (BSNL) and other private internet service providers, such as 'Tata Communications Ltd'. Although infrequent, there is a possibility that the internet connection may fail while transferring the data from field to server leading to loss of data. To prevent such a problem Herdman-PDA has been programmed in such a way that all new records entered into the mini-laptop are stored as a temporary hidden file which gets erased once the data is updated onto the server successfully. In case at the time of transfer there is broadband connection failure, the temporary data file would remain saved in the mini-laptop. In immediate future when the device is connected to internet, the saved temporary data file is synched and the server data is updated. This facility not only ensures rapid transfer of the new data to the central server but also prevents data loss due to transient internet failure.

2.4. Integrated cattle insurance and risk mitigation

The data network set up was funded by Dairy Network Enterprise (DNE), a venture of HDFC Bank. The insurance product, developed jointly by DNE, a dairy supply chain focused company incubated by IFMR Ventures (http://www.ifmrtrust.co.in/ventures/ifmradvisoryservices.php). The insurance project jointly developed by DNE and Ergo-HDFC GIC Ltd., an insurance company, is novel in that it not only covers loss of animal due to death, but also covers vaccinations against two important local infectious diseases and worm medication twice a year. In order to reduce the transaction cost the insurance and preventive health services are implemented at the farm-door through local veterinarians who are franchisee of a customer-centric micro-finance services entity KGFC promoted by IFMR Rural Finance (for process details see Sharma et al., 2010). The KGFC provided finance on easy installment to the farmers to cover the cost of RFID, insurance and in some cases purchase of new



Check First Heat	Owner Name	Parity	Heat Seq	Last Calving Date	Expected Heat	Service Type	Sire Id	Inseminator	Semen Dose
BGC02B1021	RAVINDRA..MAHIMAN	4	1	15/01/2009	14/02/2009				-
BGC02B1125	BABAN.BHUPAL.CHOUGULE.	5	1	10/09/2008	10/10/2008				-
BGC02B1135	DEEPAK.ASHOK.MALI	5	1	20/05/2009	19/06/2009				-
BGC02B1173	DILIP.SHAMRAO.PUJARI	2	1	19/05/2009	18/06/2009				-
BGC02B1218	NITIN..MAHAJAN.	4	1	10/10/2008	09/11/2008				-
BGC03B0211	SANDIP..WARE	7	1	02/07/2009	01/08/2009				-
BGC03B0306	BHIMRAO.BHAU.MALI.	5	1	01/06/2009	01/07/2009				-
BGC03B0311	BHIMRAO.BHAU.MALI.	2	1	20/10/2008	19/11/2008				-
BGC05B0011	SANDIP..WARE	3	1	15/01/2009	14/02/2009				-
BGC05B0040	DADASO..HALUNDE	4	1	28/08/2008	27/09/2008				-
BGC05B0050	ADKE..SIR	3	1	28/11/2008	28/12/2008				-
IN.MH.BGC6802	GANPATI.TATOBA.MANE	7	1	01/12/2008	31/12/2008				-
IN.MH.BGC6838	NANDKUMAR..PATIL	3	1	26/06/2009	26/07/2009				-
IN.MH.BGC6861	KIRAN.VIJAY.CHOUGULE	4	1	10/07/2008	09/08/2008				-
IN.MH.BGC6864	KIRAN.VIJAY.CHOUGULE	5	1	03/10/2008	02/11/2008				-
IN.MH.BGC6865	KIRAN.VIJAY.CHOUGULE	3	1	14/08/2008	13/09/2008				-
IN.MH.BGC6891	TANAJI.HINDURAO.CHOHAN	4	1	05/12/2008	04/01/2009				-
IN.MH.BGC6893	TANAJI.HINDURAO.CHOHAN	5	1	16/06/2009	16/07/2009				-
IN.MH.BGC9954	SHANTIKUMAR.SHBHASH.NAWALE	3	1	18/06/2009	18/07/2009				-

Fig. 2. The 'Action List' for facilitating improvised services to the farmers.

animals. The data services to the farmers was however offered free of cost and the maintenance cost is being born by DNE.

2.4.1. *Setting up of secure animal data recording system*

The integrated system described here was primarily developed for dairy animals (cow and buffalo) suitable for both intensive and small-hold dairy farming systems. The validation was carried out in cluster of ten villages in Thanjavur district in the state of Tamil Nadu situated in southern India. The project was implemented by the IFMR Trust, an NGO involved in serving marginal communities through financial services. In the first phase it was planned to register 5000 animals owned predominantly by small and marginal farmers (average holding 2–3 animals). The system was devised to ensure (a) correct identification and registration of each animal for insurance and management purposes; (b) actual visits by the field VHW entrusted with the responsibility of providing routine services and periodic data recording; (c) reliable recording of periodic data with faithful transmission to the main server. The central data server was installed at the IFMR headquarters in Chennai, around 500 km north of the project site.

Initially the animals were identified by affixing RFID ear tags carrying unique identification number. The ID number was then read by taking the reader within the range to open animal registration and data entry format. Details such as owner name, species (cow or buffalo), breed, sex, age, parity (lactation number), current breeding status, last estrus, last calving date and milk production were entered in the entry format. The data was saved locally on the mini-laptop and transferred through the internet to the central server where the insurance policy number was auto-generated and the details transferred back via the internet and updated in the individual animal file on the mini-laptop. The VHW could subsequently take a print out and provide the policy document to the animal owner. Herdman-PDA has the capability to generate action lists daily in the morning so as to facilitate providing routine husbandry and veterinary services by the assigned VHW. The 'Action List' indicated the names of the farmer and the ID number of the animal for different management actions (Fig. 2).

The unique feature of the system is that the program permits new record entry only when the reader attached to mini-laptop is brought within the reading range. This unlocks and opens the animal's data entry form. The VHW can update the records which can be saved on the mini-laptop and also transferred to the central server through internet modem connected to the USB port (Fig. 3). This process ensures that the VHW indeed visited the farm for providing services and data collection and hence minimizes possibility of falsified data reporting. The data collected at the server can also be analyzed to generate performance reports for sharing with the participating farmers and the financing agencies.

3. Results

The present paper describes development and testing of an integrated RFID-based identification and animal data recording system in small-hold dairy set up in cluster of villages south of India. The project is being implemented by NGO, IFMR Trust, which basically works in the field of rural empowerment through providing of

Fig. 3. The RFID reader-mini-laptop used at the project site for secure data entry.

Table 1
Frequency of data collection for registered animals based on prediction of events in 'Action List'.

S. no.	Record type	Frequency of recording
1	Breeding service	Every 21 days till pregnancy
2	Pregnancy test result	60 days after the last non-return service
3	Calving	Once in parity
4	Milk records	Once every 30 days during lactation
5	Drying off	After drying off
6	Body Weight	Every month in case of calves
7	Treatment	Every sickness episode
8	Insurance	At the time of insurance and claims

financial services (www.ifmr.co.in). Initial system tests revealed minor problems related to data synchronization and pre-saving validation. These problems were rectified before the integrated system was commissioned. The project started with insuring cattle belonging to selected poor farmers against mortality but could also be extended to productivity losses. The claim-settlements require the cattle owners to prove that the animals were optimally managed and that there was no negligence in bringing the animals to productivity. In the event of non-availability of dynamic management records, the insurance company takes months to investigate the claim authenticity. In many cases even though apparently the claims are fraudulent due to political and social pressure the companies are forced to settle the claim in favor of farmers. In the long run, this negatively impacts farmers because of increased premiums. One way of preventing such instances is to link insurance with service providing since in the present case the veterinarian is visiting the animal at least four times and during these visits the production and breeding records of the animal can also be collected. This strategy has been found to address many adverse issues confronting cattle insurance business (Sharma et al., 2010).

Implementation of the project required careful planning and coordination between all the stakeholders and this was the single most important challenge. We found that many farmers were aware of benefits of livestock insurance but the discouraging factors were long time taken by the insurance companies for issuing policy and inordinate delays in claim settlement. When the insurance company explained the entire process and assured transparency and speed the farmers readily agreed to participate. The next challenge was to train the veterinary staff in handling mini-laptop as they were not well versed with computer operations, especially the herd health management software. A training program for them was organized for three days wherein the operation of the integrated system was taught to them. Their learning capacity was found to be extremely good and within one month they were found to operate mini-laptop-based herd management program satisfactorily. RFID-tagging and animal registration was carried out in batches and it took around three months to create the animal database. With the integrated system it was possible to issue the policies on the day of registration itself. The VHW provided on-farm vaccination and deworming services on the scheduled days. The production and breeding status data was also collected at the time of visit. A procedure similar to that described earlier was followed to unlock and access the data entry form for the identified animal which enabled data entry, saving on the mini-laptop and transfer of the records to the central server via internet modem. Herdman-PDA also has facility to generate 'Action List' comprising of animals due for estrus check and AI, pregnancy check, milk yield recording, calving, vaccination, etc. (Table 1).

Cross validation of data proved that the system provided sufficient security and credibility. The dynamic data therefore can be used by the insurance company to authenticate the mortality claims (for example, by confirming that the animal was vaccinated against common infectious diseases) or permanent disability claims (by validating that every possible management care was taken) from the available records. For registered farmers the major benefits were substantial discount on insurance premium, instant policy issuance, faster claim settlement and built in preventive health services. For the insurance company the direct benefit was saving due to prevention of fraudulent claims. The project is still on-going and many more farmers are joining the scheme.

4. Discussion

Implementing animal identification and data recording (I & R) programs in small-hold dairy farming system offers logistic and economic challenges. In this paper we have described a simple economic I & R integrated system that is cost effective to implement. Contrary to general belief, we have proved that an RFID-based system could be of considerable benefit even in a rural small-hold set up. In situations where the farmers own 2–3 animals and are scattered over a wide geographical area, the major challenge is to put up an organizational delivery structure so as to address critical issues, such as, who will fund, set up and sustain data recording system and how RFID and insurance will be financed so that poor farmers are not burdened. The novel insurance product around which the data recording system was implemented and the delivery system involving the consortium of agencies (Sharma et al., 2010) addressed these constraints. The data recording system for long term use was supported by DNE, the cost of RFID was built in insurance product whereas the insurance premium was given as loan by KGFC recoverable in easy monthly installments The integrated herd data management system enables instant registration of animals for insurance and immediate issuance of insurance certificates to the farmers. The system could also be used for performance recording of animals in a cost-effective way since this was done by the service provider and no separate data recording agency was needed. The novel system of unlocking of data entry form only after detecting the RFID tag ensured that the VHW actually visited the farm and undertook the management task. The dynamic animal record database so generated has high credibility and could be used to settle insurance claims in genuine cases expeditiously.

Small and marginal dairy farmers are prone to commit mistakes in animal observations for events such as estrus and impending pregnancy testing, calving or dry-off. The immediate advantage to the farmer is availability of uninterrupted protocol-based extension and veterinary services based on data analysis. The VHW could use the information for arranging services as well collect, record and transfer the periodic data to the mini-laptop as well as central server. The data built up could also be used to understand and evaluate impact and benefits of the welfare schemes implemented for the poor farmers. In addition, the I & R system described in the paper has potential to offer other benefits to the participating farmers: (a) the database so created can be interfaced with Herdman-mobile so as to send SMS alerts to farmers about animals due for estrus, pregnancy, calving, milk records and drying off; (b) Herdman software also provides facility of sickness and treatment records which after analysis can provide insight into types and factors associated with different diseases in the area so as to evolve preventive strategies; (c) the data on AI and sire usage can be utilized to understand the sire fertility and progeny performance; (d) the individual animal records can be used for identifying superior genetics animals and lastly (e) animals when marketed with records would fetch higher prices to the farmers.

In cases where the animal is insured for life or permanent productivity loss, the server assigns a unique insurance number which is then transmitted and updated on the PDA or laptop at the next synchronization operation and a soft copy of the insurance policy is transmitted to the mini-laptop, which can be printed and

Table 2
Cost–benefit analysis of the secured identification and recording system for small-hold dairy farmers.

S. no.	Item	Investment cost (US$)		
		Unit cost	Units	Cost/benefit[a]
1	RFID ear tag with visual duplicate tag	1.03	5000	5150
2	RFID reader with interface to mini-laptop	40	5	200
3	Mini-laptop for veterinary health worker	270	5	1350
4	Local Server along with web-server space	600	One	600
5	Software for mini-laptop and data server	–	–	7100
6	Internet connectivity to all the VHWs	100	5	500
	Total			14,900

[a] Considering the cost of each fraudulent claim as US$ 500, the cost can be recovered if 30 such claims are prevented which is 0.6% of the insured animals.

handed over to the farmer. Since the agency also provides services to the farmers, data (breeding, production and health) is collected by the VHW on every visit (Table 1) and transmitted to the server via USB internet connection provided to the VHW. The project area has dependable broadband connection but to tackle the eventuality of connection failure the Herdman-PDA has facility of storing the new records as temporary file which is transferred whenever the internet connection is established. Thus, there is no chance of loss of data due to data transfer failure. The novelties of the system are: (a) the veterinary worker has to visit the animal, read the RFID tag to access the records of the associated animal in the hand-held device which ensures authenticity of the records and (b) animal data is captured without incurring extra cost hence cost-effective for resource-poor farmers' organizations.

Whenever an animal dies or becomes permanently incapable of production, the farmers file appropriate claims with the insurance company. Conventionally claims settlement is a long-drawn process, which may take months largely due to non-availability of records to prove that there was no negligence on the part of the farmers. As a result the affected farmers cannot buy and introduce replacement stock to continue with livelihood activity and hence defeats the very purpose of public-funded insurance scheme. The proposed I & R system, however, would solve the problems since with access to animal records the claims would be evaluated and settled within three to five days and frauds would be avoided.

In order to deploy such a system, investment in infrastructure and maintenance is necessary. It will be pertinent to consider this cost and the anticipated benefits over a period of time. In order to keep the investment costs to a minimum, locally manufactured but ICAR-compliant RFID ear tags and reader were used. Table 2 describes the investment cost for setting up of a system for 5000 animals. It is therefore evident that even if 32 (less than 1% of 5000) fraudulent claims are prevented due to availability of data, the cost of investment can be recovered. The cost of maintenance of the system can be met from the improved services that would enhance productivity, minimize losses due to management errors and enhanced market price of the animals due to availability of data.

An important limitation of the external ear tag is that it could be severed and fraudulently removed by the farmer. In that case the conniving VHW could read the tag away from the animal and a false claim for death could be filed. But such fraud would be detectable since once cut, the RFID tag cannot be re-tagged to any other animal. Secondly in case of claims for death, the VHW is required to provide a photograph of the animal depicting fixed tag hence this possibility would be remote. Thirdly, in order for the farmer to evade detection of this fraud he must implicate the VHW as well as the supervising veterinarian who are franchisee of the insurance company. Thus there is a remote possibility that very few farmers might still cheat but their proportion would be negligible. The RFID inject bolus could however be an ideal alternative as these cannot be manipulated but there are still constraints to their widespread use, such as high cost, low reading range, migration and administration. The integrated system implementation entails stake-holding of a cattle insurance company, local veterinary service providers and other beneficiaries such as milk processors and input suppliers. The proposed system therefore can only be implemented in organized dairy cooperatives or private milk processing companies who collect milk from these farmers and also provide veterinary and extension services. In such cases the data recording system can be owned and sustained by the milk processing entity, whereas the insurance company can partly finance RFID and provide discounted insurance coverage in exchange for access to the animal data.

5. Conclusions

It can be concluded that the use of RFID-based identification and recording system in small-hold dairy units offers value-added benefit of data security and would prevent settlement of fraudulent insurance-related records. The integrated system can be effectively used in providing protocol-based veterinary and animal husbandry services to the farmers and can be used as a cost-effective animal performance recording service. From the economic analysis of the project it is evident that the cost of investment can be recovered in one year whereas the fee received from the improved services would make the system sustainable on long term. Although RFID technology for animal identification has been commercially available since the early 1980s (Geers, 1994), their economic impact on overall integrated operations has been being quantified only recently (Saatkamp et al., 1995; Saatkamp et al., 1997; Nebel et al., 2000; O'Connor, 2009). The system described here for preventing livestock insurance-related irregularities in small-hold farming system adds a new dimension to employing of RFID technology. It is evident that the implementation of RFID-based data recording systems would be of economic benefit to farmers, insurance companies, veterinary service providers and the government departments financing welfare schemes.

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