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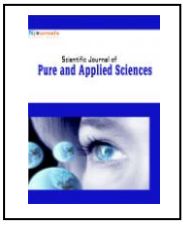

Review article

Importance of information and communication technology tools among livestock farmers: A review

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ABSTRACT

Agricultural extension services in most of the developing countries including India are usually designed around crop husbandry, while public sector initiatives towards animal husbandry are often dominated by animal breeding and health services (Morton and Matthewman 1996).ICT has been used in abroad widely for the study and improvement of various aspects of livestock production, research and education. Mainly the ICT is playing a greater role in livestock disease control, dairy herd management, livestock production and for marketing of livestock and livestock produce.

1. Introduction

Livestock sector plays a multi-faceted role in socio-economic development of rural households and contributes about 4.2 percent to the Gross Domestic Product and 25.6 percent to the Agricultural Gross Domestic Product in the country. Over the last three decades, livestock sector has grown at an annual rate of 7 percent, which is more than double the growth of the agriculture sector. Empirical evidences indicate that livestock is an important component of the agriculture system, providing an additional source of income and nutritional cover to a large section of the rural population, particularly the disadvantaged and poor households (Rao et al 2003; Birthal and Ali 2005; Ravikumar and Chander 2006, Singh et al 2007). The distribution of livestock, as a liquid asset to poor families, is more egalitarian as compared to land (Taneja and Birthal 2004; Ali 2007). However, the recent trend in livestock sector growth suggests that in order to meet the emerging demand for livestock based products, both in domestic and global markets, there is a need to reorient the production system by enhancing the efficiency and

creating quality consciousness. Verbeke (2001) argued that the consumer concerns about food safety of animal based products have led to an increased demand for information and transparency in food chains, and have acted as the major driver for the development of traceability systems. Adhiguru et al (2009) argued that farmers are not only looking for various information sources for carrying out their production and marketing tasks efficiently but also for ensuring delivery of safe and quality products to the consumers.

With the changing environment of food and agriculture sector including livestock based high value agriculture segment, information and knowledge has increasingly become an important factor of production for effective decision-making (Birkhaeuser et al 1991; Cash 2001; Galloway and Mochrie 2005; Adhiguru et al 2009). In most of the developing countries, information on improved agricultural technologies and practices are public goods and agricultural extension services are one of the most common means of public-sector knowledge dissemination (Birkhaeuser et al 1991; Dancey 1993; Umali and Schwartz 1994; Nirmala et al 1995; Dinar 1996; Umali-Deininger 1997, Anderson and Feder 2004). However, dissemination of information on livestock production has rarely been a priority for centralised extension services in developing countries (Morton and Matthewman 1996). Though veterinary services are being provided by the public sector in India, the financial constraints with most of the state governments have made it difficult to expand the reach of livestock services as well as to improve the quality of service delivery (Ahuja et al 2003; Bardhan 2010).

Information adoption among farming community is widely acknowledged as one of the critical factors for efficient and effective agricultural decision-making (Cash 2001, Galloway and Mochrie 2005, Rao 2006). Sasidhar and Sharma (2006) have emphasised that the use of Information and Communication Technology (ICT) tools has potential to change the economy of livestock, agriculture, and rural artisans in India. Tiwari et al (2010) argued that the livestock sector should come up with the need based, location specific and local language contents in the form of computer software's and other electronic material in regards to livestock disease control, dairy herd management, livestock production and for marketing of livestock and livestock produce. ICT based information delivery to livestock sector can significantly improve the quality of decision-making in livestock farming system. With intensification of crop/ livestock production systems and increased market demand of animal based products, the importance of information is growing in many developing countries (Morton and Matthewman 1996). In this process of structural change and potential growth in high value products (Gulati et al 2007), ICT based livestock advisory services for knowledge dissemination to the farming communities for better and informed decision-making at the farm level, have become essential.

2. Sources of information on animal husbandry

Agricultural extension services in most of the developing countries including India are usually designed around crop husbandry, while public sector initiatives towards animal husbandry are often dominated by animal breeding and health services (Morton and Matthewman 1996). Several argue that the concentration of government focus on livestock health is justified as farmers gain confidence that diseases are under control and are thereby prepared to invest more on livestock production (de Haan and Bekure 1991; Morton and Matthewman 1996). However, the changes in Indian livestock production have necessitated the provisions of delivering seamless information on various aspects of animal husbandry including processing and market linkage for animal based products.

A Situation Assessment Survey of Farmers by the National Sample Survey Organization (NSSO) on Access to Modern Technology for Farming indicates that only 5.1 percent of the households access information on animal husbandry (NSSO 2005). Figure 1 provides details of types of information used by the famers for livestock decision-making in India, most of the farmers seek information on production related activities such as health care, breeding and feeding, while information on livestock management is being used by only 9 percent households. In case of Uttar Pradesh, the use of information becomes even more skewed towards livestock production system where about 70 percent households use information on livestock health care followed by breeding and feeding (Figure 2). The dominance of production related information does not mean that farmers do not require information on livestock management, prices and market linkages; rather this may be due to the supply constraints of livestock extension services.

A closer look on the type of livestock extension services delivered clearly indicates that health and breeding information has been given more attention by the policy planners and agricultural extension organizations, whereas value addition aspects have been largely neglected. The importance of information for livestock based

processing, product prices and marketing has significantly increased in the present market-driven high value food economy, demanding reorientation in livestock information delivery by the public as well as private agencies

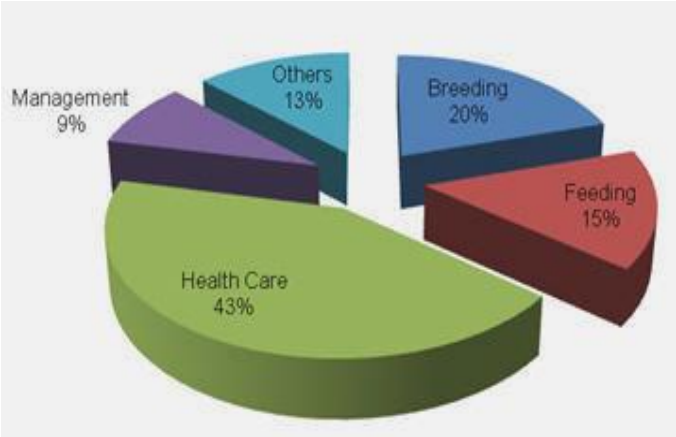

Fig. 1. Distribution of households by types of information on animal husbandry – India.

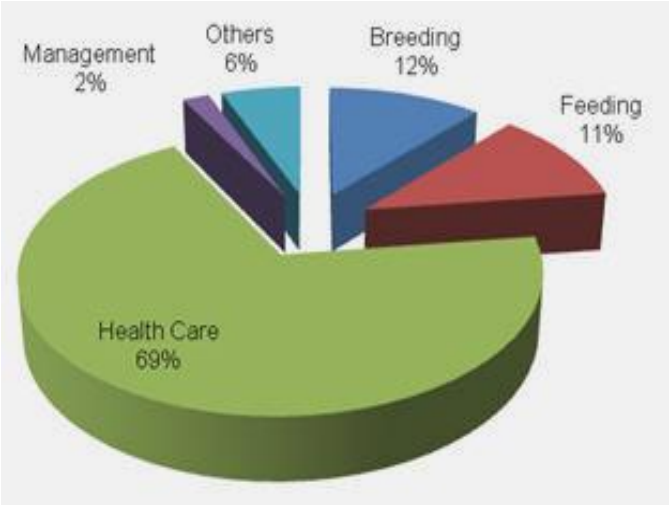

Fig. 2. Distribution of households by types of information on animal husbandry – Uttar Pradesh.
Source: Report No. 499(59/33/2), Access to Modern Technology for Farming, NSSO, GOI, 2005

3. Use of ICT for livestock development in abroad

ICT has been used in abroad widely for the study and improvement of various aspects of livestock production, research and education. Mainly the ICT is playing a greater role in livestock disease control, dairy herd management, livestock production and for marketing of livestock and livestock produce.

Ryan and Wilson (1991) reported that, the 'National Disease Control Information System' (NDCIS) of New Zealand, consists of a set of independent computers database on animal diseases such as tuberculosis and brucellosis, which is a good example of possible applications of ICT in improving the animal health. A decision support system for managing a foot-and-mouth disease epidemic is being developed at Massey University on behalf of the New Zealand Ministry of Agriculture and Fisheries. The system will comprise a database management system, a geographic information system, a spatial simulation model of foot-and-mouth disease and a number of expert systems (Sanson *et al.* 1991).

Jalvingh *et al.* (1995) and Sanson *et al.* (1999) reported that, because of their economic importance, contagious animal disease outbreaks require rapid identification and elimination of all virus sources. For managing the vast amount of data and for help in setting the correct priorities, the use of computerized decision support

systems (DSS) seems to be promising. EpiMAN of New Zealand is the first decision support system for controlling of foot-and-mouth disease (FMD) outbreaks. The system was initially developed to control FMD but now has been progressively expanded to manage other exotic and endemic diseases. Santos (2002) reported that, the National FMD Task Force of Philippines uses an information system in managing data regarding disease situation, vaccination, and animal movement, which gives accurate information on the animal disease situation of an area at the quickest possible time. In Italy to control the blue tongue disease in cattle effectively, a surveillance system was established that included clinical, entomological and serological surveillance elements. The National Reference Centre for Veterinary Epidemiology developed a Web-based National Information System (NIS) and a Geographical Information System (GIS) to collect and manage data from Veterinary Services across Italy. Surveillance data are displayed to the user in different ways: reports, tables and interactive maps (Conte *et al.* 2005). Garner *et al.* (2005) reported that Department of Agriculture, Fisheries and Forestry, Australia, developed a sophisticated spatial model (AusSpread) for foot-and-mouth disease control that operates within a geographic information system framework. The model allows for interactions between herds or flocks of different animal species and production type, and considers the role that such interactions are likely to play in the epidemiology of a regional outbreak of foot-and-mouth disease. The user can choose mitigations and eradication strategies from those that are currently described in Australia's Veterinary Emergency Plan. The model also allows the user to evaluate the impact of constraints on the availability of resources for mitigations or eradication measures. Outputs include a range of maps and tabulated outbreak statistics describing the geographic extent of the outbreak and its duration, the numbers of affected, slaughtered, and, as relevant, vaccinated herds or flocks, and the cost of control and eradication. To get rid of various animal diseases in Tanzania, a strategic approach is proposed that involves the collection of animal health information using active surveillance techniques and the introduction of a geographic information system. Assessment of the Tanzanian animal health information system revealed two major problems: firstly, the absence of disease information that accurately reflects the health status of the source population, and secondly, an inefficient information management system, which is unable to provide useful information on the spatial component of animal health (Kivaria and Kapaga 2005).

3. Status of use of ICT in India

The new information and communication technology (ICT) is the most powerful tool among the driving forces of globalization. ICT through internet, CDs and mobile phones have become a powerful tool to contribute in the development process. Similarly ICT has brought enormous changes in the service delivery in many sector saving resources, time and money. Through internal computerization of small and medium businesses on-line buying has already begun in the larger cities, with notable gains in efficiency. E-learning has paved the way to share the knowledge across the country through educational satellite such as EDUSAT. Similarly Telemedicine is an emerging sector where ICT have provided the urban medical facilities to remote rural areas in cost effective manner. ICT has repeatedly demonstrated its potential for alleviating poverty in developing countries. In many instances, poor people have experienced benefits in the form of increased income; better health care; improved education and training; access to job opportunities; engagement with government services; contacts with family and friends; enterprise development opportunities; increased agricultural productivity, and so on.

4. Use of ICT for livestock development in India

The ICT is being used in the country in many ways for animal health management, disease control, feeding of livestock, herd management, and for marketing of milk.

5. Animal health management and disease control using ICT

Livestock are an asset for the landless farmers in India. Improvement in the health of the cattle goes a long way in exploiting their production potential helping cattle owners in coming out of the poverty. In the post-WTO global scenario and World Trade Organization's SPS Agreement, the country is facing several constraints in international trade owing to the presence of various contagious and infectious diseases of livestock like FMD in animals, which acts as a non-tariff barrier. Chaouhan (1994) colleted data from 100 farmers of Kangra district of Himachal Pradesh and reported that economic losses due to various diseases per year/farm by small, medium,

large farmer and overall calculated to be Rs. 2652, 2195, 2172 and 2509 respectively. Economic losses due to morbidity were Rs. 1192 and mortality was Rs. 1317. Saxena (1994) reported that nearly 3508 million liters milk is lost due to foot- and-mouth disease (FMD) in buffaloes and cattle in India, a direct loss of milk due to reduction in yield, reduction in milk due to delayed conception and reduction owing to abortions in pregnant animals. Similarly Singh *et al.* (1997) estimated an economic loss in dairy cattle due to mastitis was Rs. 1607.2 crore which included Rs. 889.51 crore for cows and Rs. 717.69 crore for buffaloes. The reasons are poor health facilities, lack of awareness and inadequate vaccination cover etc. ICT tools can play important role for awareness. The existing information kiosks and SMS service of mobile phone network can be used for the information dissemination. Similarly with the help of computer based Information system and Expert system such as "Animal Health Information System" (AHIS) and 'Poultry Expert System' (PES) farmers can be enabled for tentative diagnosis of animal diseases at their level so that they can understand the seriousness of the situation and seek veterinarian help as early as possible. They can also try appropriate first -aid measures with the help of such software. For the easy access of computer, to these cattle owners the existing network of computerized milk collection center can play important role. Since such softwares are being developed in India the same can be made available to these centers. Two interactive softwares, one for the Para Veterinarians and stockman entitled "Animal Health Information System" (AHIS) in English and another for the farmers of Maharashtra entitled "Health information system for dairy animals" in Marathi, have been developed at the Indian Veterinary Research Institute, Izatnagar, for animal health management particularly for animal disease diagnosis (Phand *et al.* 2009)

Ramkumar *et al*. (2003) reported that, demand-led information deliveries through the Touch Screen Information kiosk installed in Veterinary institution of Pondicherry helped farmers in preventing diseases and improving health of animals, saving time, labour and money for this disadvantaged group. They further reported changes in adoption practices including different steps in clean milk production especially washing of udder with dilute potassium permanganate solution and washing of hands by the milker after obtaining information through Touch Screen Information kiosk at Puducherry.

The ICT has already proven its worth for animal health care systems and for disseminating its information to the livestock owners in an effective manner. Various other such information system softwares and expert system could be developed based on the needs of different clients and locale. Further these may be made language specific for the clientele to cater in a more effective and precise manner. Researches are in the way to develop such systems in the various parts of the country.

6. Dissemination of livestock related information

Fast and efficient dissemination of suitable technological information from the Research Station to the farmers in the field and reporting of farmers' feedback to the research system is one of the critical inputs in Transfer of Agricultural and animal husbandry Technology. The extension personnel have been disseminating the technological messages to the farmers manually. This approach has not been able to reach majority of the farmers who are spread across the whole country due to scarcity of expert human resource, especially in terms of manpower. This gap remains a challenge for the extension system even today. To reach over 110 million farmers, spread over 500 districts and over 6000 blocks is an uphill task. The diversity of agro-ecological situations adds to this challenge further.

Modern communication technologies can apply to conditions in rural areas, which will help improve communication, increase participation, and disseminate information and share knowledge and skills. It is being said that "Cyber Extension" would be the major form of technology dissemination in the near future. However it is observed that the rural population still has difficulty in accessing crucial information in order to make timely decisions. It is essential that information availability is demand driven rather than supply driven. The challenge is not only to improve the accessibility of communication technology to the rural population but also to improve its relevance to local development. Next to the radio and television the mobile phone users are increasing rapidly in India particularly in rural areas, creating platform for information dissemination through value added services like Short Message Service (SMS).

According to the latest report released by Telecom Regulatory Authority of India (TRAI, 2011), India had 851.70 million mobile phone subscribers at the end of June 2011. Out of which 538.38 million were Urban Subscribers while 267.74 million rural subscribers. The mobile growth in rural areas is higher at 3.07% as compared to urban which was about 2.06% in January. The share of Urban Subscriber has declined to 66.79% from 67%

where as share of Rural Subscribers has increased from 33% to 33.21%. With this, the overall Tele-density in India reaches 67.67 percent**.** As the fastest growing telecommunications market in the world, India is projected to have 1.159 billion mobile subscribers by 2013. Several leading global consultancies estimate that India will become the world's largest mobile phone market by subscriptions by 2013. The mobile phone looks like today's most likely access device for information dissemination. The livestock related information such as vaccination alert can be delivered through mobile service provider before monsoon. Internet possibly a very effective and low cost medium for reaching the masses, these community information centres can motivate the local people into starting entrepreneurial ventures. According to I-Cube 2008, a survey conducted jointly by IMRB International and Internet and Mobile Association of India (IAMAI), regarding internet users in India, there are 45.3 million "active" internet users (who have used the internet at least once in the last one month) and 62.2 million "claimed" internet users (who have used the internet sometime but not in the last one month). Among them urban users continue to dominate internet use contributing to 42 million. Moreover the recent report by LiveMint and Komli estimates that India will have 80 million internet users by 2010.

To meet the information needs of the livestock farmers, latest advances in Information and Communication Technologies (ICTs) have provided conducive environment for adopting new technologies and making the method of instructions more effective and interactive.

Mobile telephony is growing manifold when comparing to other Information Communication Technologies (ICTs) in rural areas. Mobile phones are the success story of bridging the rural digital divide bringing tangible economic benefits and acting as agents of social mobilization through improved communication. According to Waverman *et al*. (2005) of the London Business School, ten extra phones per hundred inhabitants can lead to 0.59 per cent extra annual growth in a typical low income country like India. Dissemination of information through mobile phones is a newly emerging concept in agriculture and allied sector. According to a recent research, introduction of mobile phones to Kerala fishermen could decrease price dispersion and wastage by facilitating the spread of information which made the markets more efficient by decreasing risk and uncertainty (Jensen, 2007; Abraham

2007). Recent ICRIER study (Mittal and Tripathi, 2009) among farmers highlights the key role played by mobile phones in lowering transaction costs and raising the income-levels of farmers, by efficiently addressing their immediate agricultural information requirements and also farmers emphasized that timing of precise information is central to minimizing wastage and therefore increasing efficiency. Mittal *et al.* (2010) conducted a study on impact of mobile phones on the crop sector and, in particular on small farmers in India. The key finding of this research was that mobile phones can act as a catalyst to rejuvenate the extension services in the country.

Recent survey among farmers of UP, Rajasthan and Maharashtra revealed that farmers were confident of the utility of the mobile phone in reducing costs and enhancing earnings. Farmers can bridge or alleviate the information gap by the use of mobile phones (Mittal and Tripathi, 2009). Mobile phones along with the mobile enabled services provide lot of hope to improve the extension system. British Department for International Development (DFID) found that people perceived mobile phones to have greater impact on social networking and for reducing vulnerability but only have a mixed economical value (Myhr and Nordstrom, 2006).

Information through mobile phone has a major impact on the overall farm output in areas where biotic and abiotic conditions are not so favourable for cultivation. Timely intervention through right kind of prescriptions can help increase yields by 10.00-25.00 per cent (Gupta, 2009). Evidences are now gradually increasing about the use of mobiles for dissemination of agricultural information among farmers. But, the relation between livestock owners and mobile phones has not been explored much except a scanty coverage by newspapers with little scientific reports based on empirical data on this group especially in context of India. As such, the Animal husbandry field is the new arena for research to explore the role of mobile phones in delivery of livestock related information among livestock owners.

7. Use of mobile phones by the livestock owners

Mobile phones were used by majority of livestock owners to seek the information and service related to animal husbandry and agriculture compared to other ICT tools and mass media sources like television and radio. Therefore, mobile phones can play a pivotal role in dissemination of livestock related information among livestock owners. The veterinarians and farmers if provided with ICT enabled mobile facility; they would act as powerful tool to empower the livestock owners. The social and economic benefits obtained from mobile phones by the livestock

owners were useful for their endeavour. Majority livestock owners perceived medium level of satisfaction in overall respondents. So, the service delivery may be improved furthermore to attain high level of satisfaction (Gensis Ingo, 2010). The farmers were spending money on mobile phone calls to call or seek information related to animal husbandry to veterinarians. It shows their willingness to pay for the service they received. Most of the livestock owners from rural areas perceived language and network coverage as main constraints than in peri-urban areas. Hence, providing mobile enabled services either by text messages or voice messages according to the literacy rate of that area specific in local language may mitigate this constraint. Moreover, infrastructure with the mobile service provider should be improved to cover remote rural villages so that, benefit of information can be extended to vast majority of farmers including in remote areas.

References

Abraham, R., 2007. Mobile phones and economic development: Evidence from the fishing industry in India. MIT Press; 4(1) , 5–17.

Adhiguru, P., Birthal, P.S., Ganesh-Kumar, B., 2009. Strengthening Pluralistic Agricultural Information Delivery Systems in India. Agricultural Economics Research Review 22 (1), 71-79.

Ahuja, V., Umali-Deininger, D., de-Haan, C., 2003 Market structure and the demand for veterinary services in India. Agricultural Economics 29 (1), 27-42.

Ali, J., 2007. Livestock, common property resources and rural smallholders in India. International Journal of Agricultural Sustainability 5 (4), 265–268.

Anderson, J.R., Feder, G., 2004. Agricultural Extension: Good Intentions and Hard Realities. The World Bank Research Observer 19 (1), 41-60.

Bardhan, D., 2010. Factors influencing farmers' willingness to pay for animal health services and preference for private veterinary practitioners. Indian Journal of Animal Sciences 80 (8), 790–797

Birkhaeuser, D., Evenson, R.E., Feder, G., 1991. The Economic Impact of Agricultural Extension: A Review. Economic Development and Cultural Change 39 (3): 607-650.

Birthal, P.S., Ali, J., 2005. Potential of livestock sector in rural transformation. In: Rural Transformation in India: The Role of Non-farm Sector (Rohini Nayyar and A.N. Sharma, eds): Institute for Human Development and Manohar Publishers and Distributors, New Delhi.

Cash, D.W., 2001. In Order to Aid in Diffusing Useful and Practical Information: Agricultural Extension and Boundary Organizations. Science Technology and Human Values 26 (4): 431-453.

Chaouhan S K and Sharma R K. 1994. Economic losses due to diseases and constraints for dairy development in kangra district of Himachal Pradesh. Indian Journal of Animal Sciences 64 (1): 62–65.

Conte, A., Colangeli, P., Ippoliti, C., Paladini, C., Ambrosini, M., Savini, L., Acqua, D., Calistri, P., 2005. The use of a web-based interactive geographical information system for the surveillance of bluetongue in Italy. Revue-Scientifique-et-Technique-Office-International-des-Epizooties 24 (3), 857–68.

Dancey, R.J., 1993. The evolution of agricultural extension in England and Wales. Journal of Agricultural Economics 44 (3), 375-393.

Dinar, A., 1996. Extension Commercialization: How Much to Charge for Extension Services? American Journal of Agricultural Economics 78 (1), 1-12.

Galloway, L., Mochrie, R., 2005. The use of ICT in rural firms: a policy-orientated literature review. The Journal of Policy, Regulation and Strategy for Telecommunications 7 (1), 33-46.

Garner, M.G., Beckett, S.D., 2005. Modeling the spread of footand- mouth disease in Australia. Australian Veterinary Journal 83(12), 758–66.

Gensis, A.V., 2010. Potential of Mobile Phones in Utilization of Livestock Related Information – An Exploratory Study in Erode District of Tamil Nadu. M.V.Sc. Thesis, IVRI, Izatnagar, Bareilly, India.

Gulati, A., Minot, N., Delgado, C., Bora, S., 2007. Growth in high-value agriculture in Asia and the emergence of vertical links with farmers. In: J.F.M. Swinnen, Editor, Global Supply Chains, Standards and the Poor: How the Globalization of Food Systems and Standards Affects Rural Development and Poverty, CABI, Wallingford, UK (2007), 91–108.

Gupta, A., 2009. A noble prescription. Business India, Dec 13, pp.114-116.

Jalvingh, A.W., Nielen, M., Dijkhuizen, A.A., Morris, R.S., 1995. A computerized decision support system for contagious animal disease control. Pig News Information 16 (1), 9–12.

Jensen, R., 2007. The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries Sector. The Quarterly Journal of Economics, 122(3), 879-924.

Kivaria, F.M., Kapaga, A.M., 2006. Review of current problems and shortcomings in the Tanzanian animal health information system with suggestions on improvement. Journal of Veterinary Research 69 (4), 305–14.

Mittal, S., Tripathi, G., 2009. Role of mobile phone technology in improving small farm productivity. Agricultural Economics Research Review, 22, 451- 459.

Mittal, S., Gandhi, S., Tripathi, G., 2010. Socio-economic impact of mobile phones on Indian agriculture. Available at: http://www.comminit.com/en/node/

Morton, J., Matthewman, R., 1996. Improving livestock production through extension: information needs, institutions and opportunities. Natural Resource Perspectives 12, Overseas Development Institute, London, UK.

Myhr, J., Nordstrom, L., 2006. Livelihood changes enabled by mobile phones the case of Tanzanian fishermen. Bachelor thesis, Uppsala University- Sweden.

Nirmala, L., Ravichandran, V., Rathakrishnan, T., 1995. Information sources utilization influencing knowledge and adoption of biofertilizers. Journal of Extensión Educación 6 (1), 1071-1074.

NSSO, 2005. Access to Modern Technology for Farming, Report No. 499(59/33/2), National Sample Survey Organization, Ministry of Statistics and Program Implementation, Government of India.

Phand, S., Tiwari, R., Sharma, M.C., 2009. Development of need based Animal Health Information System (AHIS) for veterinary professionals and students. Indian Veterinary Research Institute, Izatnagar (Submitted for copyright).

Ramkumar, S., Garforth, C., Rao, S.V.N., 2003. Information kiosk for dissemination of cattle health knowledge: evaluation report based on preliminary findings of research (http://wwwdfidahporg).

Rao, K.P.C., Bantilan, M.C.S., Rao, Y.M., Chopde, V.K., 2003. Strategic Assessments and Development Pathways for Agriculture in the Semi-Arid Tropics. Policy Brief No. 4, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India

Rao, N.H., 2006. A framework for implementing information and communication technologies in agricultural development in India. Technological Forecasting and Social Change 74 (4), 491-518.

Ravikumar, R.K., Mahesh, C., 2006. Extension educational efforts by State Department of Animal Husbandry (SDAH), Tamil Nadu: SWOT analysis. Livestock Research for Rural Development. Volume 18, Article #126. Retrieved February 15, 2011, from http://www.lrrd.org/lrrd18/9/ravi18126.htm

Ryan, T.J., Wilson, D.A., 1991. Future development of the national disease control database. Symposium on tuberculosis, pp. 245–50. April 1991. Palmerston North Massey University, New Zealand.

Sanson, R.L., Morris, R.S., Stern, M.W., 1999. EpiMAN-FMD: A decision support system for managing epidemics of vesicular disease. Revue-Scientifique-et-Technique-Office-Internationaldes- Epizooties 18 (3), 593–605.

Santos, I.J., 2002. FMD information management system as a disease surveillance tool in FMD control and eradication program in the Philippines. Special Research Journal Edition 6 (10), 108–115.

Sasidhar, P.V.K., Sharma, V.P., 2006. Cyber livestock outreach services in India: a model framework. Livestock Research for Rural Development. Volume 18, Article #2. Retrieved February 15, 2011, from http://www.lrrd.org/lrrd18/1/sasi18002.htm

Singh, J., Erenstein, O., Thorpe, W., Varma, A., 2007. Crop–livestock interactions and livelihoods in the Gangetic Plains of Uttar Pradesh, India. Crop–livestock interactions scoping study - Report 2. Research Report 11. ILRI (International Livestock Research Institute), Nairobi, Kenya. 88 pp.

Singh, R., Tiwari, C.B., Kumar, D., 1997. Statistical model for estimating losses due to foot and mouth disease in India. Indian Journal of Animal Sciences 67 (5), 41–44 small farm productivity. Agricultural Economics Research Review, 22, 451

Tanjea, V.K., Birthal, P.S., 2004. Role of Buffalo in Food Security in Asia, Asian Buffalo Magazine 1: 4-13. The Vodafone Policy Paper Series, 3, 10-23.

Tiwari, R., Phand, S., Sharma, M.C., 2010. Status and scope of information and communication technology for livestock and poultry production in India– A review. Indian Journal of Animal Sciences 80 (12), 1235–1242.

Umali, D.L., Schwartz, L., 1994. Public and Private Agricultural Extension: Beyond Traditional Frontiers. World Bank Discussion Paper No.236. Washington D.C.: World Bank.

Umali-Deininger, D., 1997. Public and Private Agricultural Extension: Partners or Rivals? The World Bank Research Observer 12 (2), 203-224.

Verbeke, W., 2001. The emerging role of traceability and information in demand-oriented livestock production. Outlook on Agriculture 30 (4), 249-255.

Waverman, L., Meloria, M., Fuss, M., 2005. The impact of telecoms on economic growth in developing nations. In Africa: The impact of mobile phones.The Vodafone Policy Paper Series, 3, 10-23.