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Review on Livestock Innovation and Extension: Implication for Precision Livestock Farming in Ethiopia

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Abstract

The main aim of this review is to sum up innovation and extension approaches in Ethiopian livestock sector. Livestock sector holds large share of contribution to the economy and overall food production by increasing crop productivity through manure and animal traction power supply. Although livestock has a vital role in the household and national economy, its current contribution is below the potential due to various factors. Integrating livestock sector development into the circular bio-economy can be enhanced by increasing not only the food products and direct services from livestock but also share of by-products and wastes that human being could not utilize directly by recycling and treating. In the era of knowledge based economy precision livestock farming (PLF) is found to be the most powerful avenues for development interventions in the livestock sector in particulars as well as the national development at large amongst a number of interesting new and emerging technologies that have the potential to modernize the livestock industry. It is used to boost farm profitability, efficiency and sustainability by improving the breeding, nutritional, housing, environmental and other management aspects of various livestock species. Even though that much surpass the adoption and utilization of different livestock production innovation and technologies is pointed out as there is better progress especially in intensified and commercial farms to precisely manage the whole system of livestock production and productivity without compromising the environmental balance. The challenge and the success of farming lie in how precisely we can intensify our farming practices in the long run.

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Introduction

Ethiopia is developing country in which major proportion of the people wellbeing is dependent on agricultural activities. It is widely argued that, achieving agricultural production and productivity growth will not be possible without developing and disseminating improved agricultural innovation and technologies that can increase productivity to smallholder agriculture farm

(Asfaw *et al.*, 2012). Ethiopia has large livestock population with diverse genetic resources, and suitable agro-ecologies for different species of livestock production. The total livestock population for the country is estimated to be about 59.5 millions of cattle, 30.2 million goats, 30.7 million sheep, 2.16 million horses, 8.44 million donkeys, 0.41 million mules, and about 1.21 million camels. Out of 59.5 million female cattle constitute about 55.5 percent and the remaining 44.5

percent are male cattle. From the total cattle in the country, 98.20 percent are local breeds and the remaining 1.62 percent and 0.18 percent are hybrid and exotic breeds, respectively (CSA, 2016). The country produces over 3.8 billion litres of milk and ~1 million tonnes of beef per year valued at USD 2.5 billion and USD 5.1 billion, respectively (FAO, 2018). In proportion to size of the livestock population there is little production and productivity potential. Low productivity of indigenous livestock is attributed to poor genetic potential for productive traits, inadequate feeding source both in quality and quantity, health problems, and poor management practice (Mihret *et al.*, 2017). The country has been earning foreign currency by exporting meat and live animals mainly cattle, sheep, camels and goats (Asfaw *et al.*, 2011). However, the gain of foreign currency through the export of meat, live animals and hide and skin to different parts of world is not that much significant due to traditional management and poor husbandry practices.

Innovation and technical change still remain potentially critical drivers of social and economic transformation in the agriculture-based economies of many developing countries like, Ethiopia (UNIDO, 2001). Livestock production in Ethiopia has been mainly smallholder subsistence farming with animals having multipurpose use and being managed in a traditional way (MoA, 2013). The country's livestock sector is increasingly challenged by limited availability of land and water resources, and climate change. Livestock contribute to improve the nutritional status and income generation of the people by providing meat, milk, eggs, cheese, butter and other commodities, such as live animals, hides and skins for home use and export; and avert risks in times of crop failures (Gebre Mariam *et al.*, 2013). Despite the huge numbers, the current contribution of livestock to the producers and to the national economy at large is limited in proportion to its size. It has increasingly been unable to meet the increasing demands of livestock originated food products for the rapidly growing population (Asresie and Zemedu, 2015).

Agricultural productivity and improved livelihood remained low as a result not only because of lack of appropriate technologies and their accessibility, production inputs, credit and access to markets and basic infrastructure, but also because of gaps in information and skills that prevented rural producers from effectively utilizing and adopting technologies (Miriam *et al.*, 2011). The livestock industry plays very important economic, social and cultural roles for households to improve

income and wellbeing of the farm family. Keeping livestock is an important risk reduction strategy for vulnerable communities, as animals can act as insurance in times of need and provide a means of income diversification to help deal with times of stress (Thornton, 2010). The economic contribution of the livestock sector could be improved substantially if the sector better integrated into improved technologies and innovative approaches. The development of advanced technologies and their use in animal husbandry, which has given rise to precision livestock farming and appears to be a possible means for the sustainable development of livestock farming systems (Berckman, 2014). Sources of agricultural knowledge include scientific research and indigenous knowledge. The main aim of this review is to summarize the innovation capacities, generation and utilization of technologies, capacities and entrepreneurship skills of livestock value chain actors with implication of popularize future scenario of precision livestock production in line with the digital era.

Overview of precision livestock farming

Ethiopia has a comparative advantage in live animals and meat export due to its large livestock population and suitable geographical location. However, the sector remains small in volume and earning when compared to the country's resource potential and other investment driving opportunities in the sector. Precision livestock farming is the aspect of precision agriculture that focuses on improving livestock farming operation through the drafting and development of various software and hardware technologies for automated tracking, monitoring, disease detection, record keeping, feed management, and other livestock farming operation (Lima *et al.*, 2018). It is defined as the use of information and communication technologies for improved control of fine-scale animal and physical resource variability to optimize economic, social, and environmental aspect of farm performance (Eastwood *et al.*, 2012). It gives hand to have better food quality and hygiene, traceability, welfare and environmental benefits (Banhazi *et al.*, 2012). Now a day, there is great advancement of various technologies and knowledge base of technical expertise those can make easy and precise the management aspect of livestock production while maintaining productivity and profitability of the farm.

Agricultural innovation involves interaction among multiple actors along the commodity value chain and beyond (Sumberg, 2005). The interaction of various chain actors and stakeholders in the livestock industry

facilitate the utilization of modern technologies to create better linkage among them and add values of livestock products. Current advancements in science and technology play great role in promoting the livestock sector (Enyew, 2011). ICT tools found to have lots of potential for driving innovation in livestock sector through the interaction and sharing of digital information by multiple stakeholders (Jespersen *et al.*, 2014). The shift in national policy towards more market-based economy facilitate private entrepreneurs to respond to the increasing demand of livestock products and services through increased investment in livestock production and product processing operations. Organized training programs on precision farming and digital technologies would raise awareness of precision agriculture with farmers and equip farmers with the digital skills required to access digital resources (Roberts and McIntosh, 2012).

Precision livestock farming technologies can help farmers to improve livestock production potential and quality of product in a sustainable manner. Computerized management system allows us to have all sorts of unbiased and real time data that will get summarized into meaningful, actionable insights. Data-driven decision making leads to better, more efficient, and timely decisions that will advance the productivity of livestock herds. Artificial insemination is recognized as the best biotechnological technique for increasing reproductive capacity. However, due to numerous technical, financial, infrastructural and managerial problems its applicability in Africa has not yet matched that of its success in the developed countries (Van, 2011). Improvements of the quantitative as well as qualitative value of livestock products need high potential for adoption technologies by enhancing the potential for investment in the sector through public private partnership and promotion of appropriate policies for value addition. Artificial insemination and preservation of semen are the main technologies that are used extensively. Reproductive technologies can also be used to control reproductive diseases if procedures and protocols are accurately followed (Madan, 2005). Application of advanced technologies and philosophy of digital culture in livestock production are useful for more rational use of resources, higher profit and greater productivity in every production sector of agriculture. The use of digital tools and instruments can enhance the sustainability of livestock sector development through rational use of chemical inputs and the consequent reduction of their impacts on social, cultural, economical and environmental system of the large public.

Innovation and Extension in Ethiopian livestock sector

Livestock production is considered to be an important pathway out of poverty for the rural poor in developing countries. Livestock producers encounter various management problems such as diseases, poor feed resources and shortage of grazing lands. Innovation System refers to the network of organizations, enterprises and individuals focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect the systems' behavior and performance (Hall *et al.*, 2006). According to (Madan, 2011), innovation is a process by which new ideas and methods are transformed into practices. It is also defined as the act that endows resources with a new capacity to create wealth (Drucker, 2014; Fagerberg *et al.*, 2006), describe invention as the first occurrence of an idea for a new product or process, while innovation is the first attempt to put the invention into practice and commercialization. Le Gal *et al.*, 2011, noted that knowing how an innovation can be generated and diffused to the large mass of the public (commercialization) is recognized to be another key factor in the success or failure of the innovation. For innovation thinkers, innovation of different kinds (technical, institutional, etc.) follows a cyclic process and uses multiple sources of knowledge from different sources. Sustainable intensification is generally defined as producing more output from existing resources while minimizing pressure on the environment (Pretty *et al.* 2011). The innovation approach assumes that learning in networks leads to learning by all individual chain actors. The more diverse the actors better the opportunities to combine complementary capabilities. Interaction and learning depend on actors' physical distance, the institutional environment that shapes trust-based relationships, and actors' capacity to absorb new ideas. Extension is an instrument to facilitate development and it ranges from transfer of technology to participatory problem solving educational approaches, which aim at reducing poverty and enhancing community involvement in the processes of development (Rivera and Qamar, 2003). Livestock extension involves systematic and organized communication of expertise with livestock owners with a view to helping them through the identification of problems and dissemination of improved animal production inputs, tools, techniques and principles found from research and innovation to boost the production and productivity.

Inclusive livestock value chain development scenario

Innovation approach focuses on knowledge generation and use at a particular stage of a value chain, while the value-chain approach is more about value creation and market opportunities and linkages throughout the a chain. Livestock value chain is understood to include all the actors and activities from production to consumption, and the dynamic interaction between actors involved in a livestock value chain (Rich *et al.*, 2011). This encompasses the two most important approaches these are inclusiveness – ensuring economic and social inclusion for all food systems actors, including smallholder farms, women and youth and sustainability – minimizing negative environmental impacts, conserving scarce natural resources, saving biodiversity loss and strengthening resiliency against future shocks. Recent studies of agricultural innovation depicted the utility of the value-chain concept as unit of analysis and focus of interventions aimed at stimulating innovation and developing innovation capacity (World Bank, 2007). Currently, innovation and technology diffusion highly influenced by weak coordination between the actors at different segments of the technology sources and users. Livestock innovations imply improving processes and products from the holistic knowledge of the system. In the livestock sector, innovation is the successful deployment of good ideas and techniques into practice on farms. Relevant innovation capacities reside in networks and partnerships, in organizations, and in individuals (Ayele and Wiled, 2005). Farmers need to innovate in their system; governments need to innovate in the specific policies they implement to support family farming; producers' organizations need to innovate for a better response to the needs of family farmers; the researchers and extension advisors need to innovate shifting from a research driven process predominantly based on technology transfer to an approach that enables and rewards innovation done by smallholders themselves.

Innovative livestock production and producer's livelihood

The new emerging technology have allowed people to incorporate modern and advanced solutions that not only improve the productivity of the agricultural sector but also reduce costs, save time, improve the health and safety of the producer, increase product quality, and reduce losses within and out of the field. Livestock contribute to food security and nutrition, livelihoods, national economic development and the overall well-

being of people. Technologies in animal husbandry make the production more cost-effective, socially and environmentally friendly and sustainable (Almeida *et al.*, 2017). Accelerating and scaling up innovation in livestock sector can trigger the transformation needed to respond to feeding a growing and increasingly population, climate change impacts and achieve the sustainable development (FAO, 2018). The growing demand for animal source foods will provide major business opportunities for cattle farmers, who will invest to increase herd sizes and improve productivity. Livestock goods and services also credited as important and intermediate inputs into activities such as manufacturing and transport provision within Ethiopia. The livestock sector has an enormous contribution to national economy and generating income to farmers, creating job opportunities, ensuring food security, providing services, contributing as asset, social, cultural and environmental values, and sustain livelihoods (Solomon, 2003; Sintayehu *et al.*, 2010). Food security is becoming an increasingly important issue in Ethiopia. Livestock helps on food supply, family nutrition, family income, asset savings, soil productivity, livelihoods, transport, agricultural traction, agricultural diversification and sustainable agricultural production, family and community employment, ritual purposes and social status (Moyo and Swanepoel, 2010). Household income from livestock activities has not changed notably with respect to today for smallholders, agro pastoralists and pastoralists, because of the weak economy and significant challenges in accessing productive inputs.

Determinants to livestock production technology diffusion and adoption

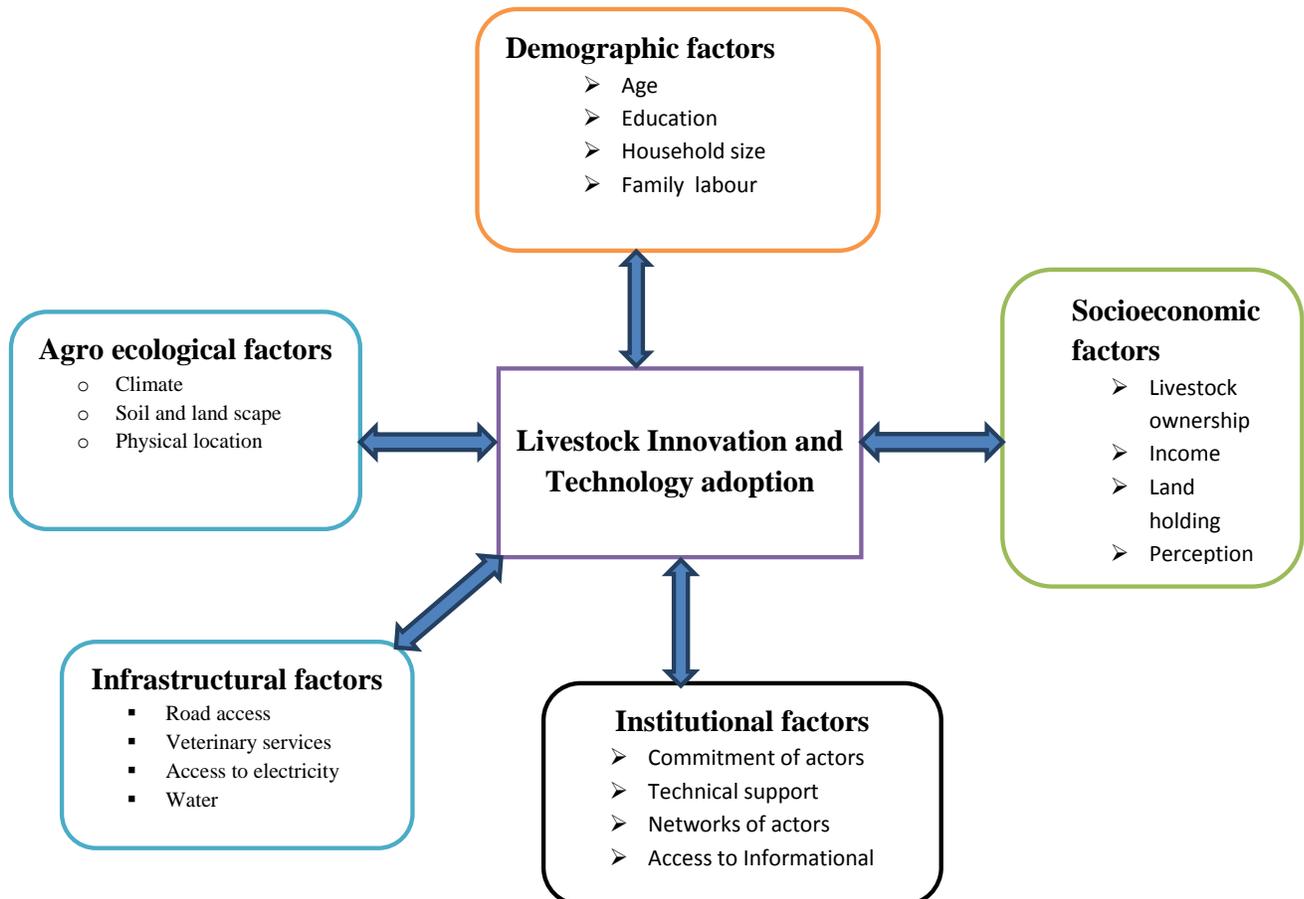
Regarding innovation diffusion model Feder *et al.*, (1985) pointed out that adoption is an integration of an innovation in to farmers' farming practices for a period of time, in aspect farmers may not sustain the adoption process because of different constraints like institutional personal and social reason. Technological developments provide more efficient, cost effective and fast solutions for producers to get on time process using management and direct manipulation possibilities in the animal farming. Some of the technologies are electronic recording, milking, heat detection, auto-weighing, genetic improvement, feeding, barn optimization, and health issue monitoring and recording keeping. Understanding the emergence of innovation systems is at the heart of research analyzing technological change (Hekkert and Negro, 2009). Technologies need to be understandable and user friendly to achieve widespread

utilization and adoption by all of farming households. The automation of animal husbandry and integration of on-farm systems and processes have a key role to play in facilitating the process of meeting each of important challenges for competitive market. In this era of digital culture, advanced information management is increasingly an essential component of profitable livestock production to operate market driven livestock production to be competent and better bargaining power in the market. This is realized through various measures like effective disease projection, rapid and accurate disease treatment, modern livestock management systems, modern financial management system (FAO, 2013). After the creation, sourcing or accumulation of knowledge, the knowledge has to be disseminated to users to support the innovation process.

Technology acceptance and uptake for precision livestock production is complex and influenced by a variety of factors such as socio-demographics (age, education), financial resources and farm size, with these variables having different effects on adoption. Livestock

production technology adoption is one of the mature areas of research in information system (Rajesh, 2016). The availability of household labour, household's education attainment, better endowment of physical assets, availability of financial capital and access to information facilitate adoption of agricultural technologies (Knowler and Bradshaw, 2007; Larson and Gurara, 2013). The type of technology influences adoption decisions as there are varying technical skill gap and costs associated factors with different technologies. Tey and Brindal studied the adoption factors for precision agriculture and classified the factors found into seven categories; socioeconomic factors, agro-ecological factors, institutional factors, information factors, perception factors, behavioral factors and technological factors (Tey and Brindal, 2012). In connection with this various empirical findings indicated. For instance, Obinne (1991), noted that education is an important factor influencing farm innovation uptake. As farmers literate more and more they can use more technologies that enable them to produce higher quantity and quality products from their farming operation.

(Reviewer): Summarized conceptualization of determinant factors for livestock production technology adoption



Livestock keepers need information on livestock diseases, nutrition, treatment and control of diseases, breeding techniques and markets for their products, among many other information needs. These information needs may be grouped into five headings: agricultural inputs; extension education; agricultural technology; agricultural credit; and marketing (Ozowa, 1995). Lemma *et al.*, (2012) revealed that, access to information like being exposed to mass media and farmers training on improved dairy breed technologies practice have a positive and significant relationship with the adoption of improved breeds practice. Limited adoption was attributed, among other factors, to farmers' limited knowledge of technologies and low technical support provided to them, low government priority given to fodder compared to staple crop technologies, and limited availability of fodder seeds (IFAD, 2006). Empowering farmers' to access and use quality information, training and products about improved livestock breed, forage production and veterinary services to enhance their farm production and productivity require great effort from development agents and practitioners. Hence, it is vital to increase the familiarity and ability of farmers to utilize different technologies in their farming practices. Based on the depicted empirical findings of different investigations I have summarized by conceptualized framework for determinant factors for livestock innovation and technology adoption as follows.

Conclusion and recommendations are as follows:

Livestock farming is playing a significant role supporting the livelihoods of smallholder farmers with multiple purposes. Innovation and extension are the main avenues to have sound precision livestock production enables to maximize the efficiency and effectiveness of livestock production while maintaining environmental friendly sustainability of the farm. There are minimal practices of innovation by smallholder livestock producers to enhance the production potential, product quality and product shelf life of animals determined by the implementation of biotechnological tools and techniques. Although there are various impeding factors the habit of advanced livestock production technology and packages adoption and utilization is in better progress importantly in intensive farming. The key challenges for practitioners to improve production and productivity in the livestock industry is to enhance the dissemination and adoption rate of innovations related livestock rearing technologies for farmers. The potential for improving livestock production through the provision of sector oriented up to date and valuable information is growing in Ethiopia.

However, the addressability to the large mass of the public is affected by different factors those emerged from various sources. Optimum production among livestock producers and tackling food shortage and increasing demand of livestock products, can be realized by enhancing innovation and extension approaches for commercial application and adoption of multipurpose livestock production technologies and principles. It is vital to improve the productivity, product quality, health and welfare of animals and to support traceability across the entire livestock production chain through the use of emerging livestock production innovation and technologies. Therefore, the following recommendations are forwarded for further action in the future.

Enhancing innovation and extension in the livestock industry through devoting synergies between diverse stakeholders to maximize its contribution to national economy has to be given great emphasis.

It is vital to exploit potential opportunities of the for inclusive and sustainable livelihood improvement through the use of emerging livestock production technologies in entire livestock value chain.

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