

# LIVESTOCK PRODUCTION IN KOREA: RECENT TREND AND FUTURE PROSPECTS OF ICT TECHNOLOGY

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## ABSTRACT

*Currently, livestock is one of the fastest-growing agricultural subsectors in developing countries. However, in Korea, livestock production is likely to be increasingly affected by many of external factors including, incorporation of the global economy, a dramatic decrease in population, decrease in a number of committed farmers, ageing society, climate change and distance between rural and urban areas. It is also affected by the continent of the country which is surrounded by more than 70% of the area is a mountain and by the four distinguished seasons. So, a certain level of livestock product and grain self-sufficiency is not easy to maintenance due to the above factors. Conversely, smart livestock farming can guarantee a balanced high annual income, maintain rural society, regenerate the rural economy as well as keep livestock product self-sufficiency at a secured level. In recent years, various kinds of information communication technologies (ICT) have developed and used in the fields of sensing, monitoring, housing environment control, mechanization, automation, and education of livestock production. Particularly, livestock productivity has been improved by smart livestock management technology via breeding, nutrition, optimal environmental control, reduced maintenance loads, and so on. Therefore, the aim of the research was to achieve more productive, efficient and sustainable farm operations based on the effective use of ICT technology in smart livestock farming by big data, deep learning, and artificial intelligence.*

**Keyword:** Livestock industry, scenario, development, sustainability, economy growth

## INTRODUCTION

Livestock systems hold about 30% of the world's ice-free surface, providing a large variety of goods and services, and using different animal species and resources, in a wide range of agro-ecological and socio-economic conditions (Steinfeld *et al.* 2006). The livestock sector is increasingly offered employment of at least 1.3 billion people worldwide and directly support the income of 600 million poor smallholder farmers in the developing countries (Thornton *et al.* 2006). Livestock also plays an important function in risk reduction policy for vulnerable communities, and livestock is an important supplier of nutrients and traction for growing crops in smallholder systems. Livestock products supply 17% to kilocalorie consumption and 33% to protein consumption globally, but it depends upon the wealth of the nations (Rosegrant *et al.* 2009).

Among the developed countries for agriculture, the Netherlands has developed advanced agricultural technologies such as automation livestock house and facilities to resolve the various problems. Israel has secured the production competitiveness of the livestock industry by developing and integrating cutting-edge IT technologies in facilities for livestock (NIA, 2014). In Japan, technology development and application are carried out focusing on convenience and improvement of farmers' profits to solve the labour shortage caused by ageing. Also, these countries are actively promoting the use of IT convergence technology for practical effects such as environmental management, alleviate production cost, improve product quality, and upgrade work efficiency. The application of cutting-edge technology (IT, ICT, IoT) to resolve problems such as lack of manpower faced by the rural communities and environmental control of facilities is receiving positive attention.

By applying cutting-edge information technology to the livestock farms, farm managers can achieve significant animal growth-related data, which not only minimizes ambiguity of environmental control but also reduces the labour force through automatic control systemization (Blackmore, 2000). Therefore, the Korean government plans to strengthen livestock production by using ICT infrastructures and energy-saving smart livestock farming technologies. However, the diversity and connectivity of monitoring and control in livestock house have been insufficient. Based on the automated controlled livestock house, the development of a field-oriented type Internet-based smart farm for the intelligent systematization of livestock production process utilizing hybrid algorithms for diagnosis and various monitoring and control through livestock growth and livestock house internal environment monitoring is required.

Airflow is invisible and unpredictable while the airflow is the main mechanism of generation and dispersion of aero-characteristics such as heat, humidity, gas, dust, and so on. So, the aero-environment in livestock house has been difficult to approach more engineering and connect to ICT technologies. Therefore, this paper explains the situation faced by domestic and foreign countries related to agriculture and introduces the necessity of high-end agricultural facilities to promote food security and rural economy. In addition, domestic and foreign efforts related to ICT application in agriculture will be introduced. Finally, an overview of the researches on ICT related to aerodynamics and energy engineering in the livestock industry will be presented.

## **Trends on Korean agriculture**

Since 2018, 1,425 livestock production farms (6.2%) of the total number of 23,000 farms were made by livestock smart farm technology in Korea. The livestock sector has been increased through improved facilities. However, the Korean livestock sector is continuously facing several challenges such as integration of global economy, a dramatic decrease in population in some places leading to decrease in a number of dedicated farmers, ageing society, climate change and the increasing gap between rural and urban areas, environmental pollution and infectious livestock disease. Therefore, a new paradigm shift from traditional farming methods is needed to solve problems in a steady decline in the rural labour force and in the reduction in livestock productivity (KISTEP, 2015).

The Korean agriculture sector has been extensively increased since last 40 years. The production, processing, and utilization of knowledge and information have been a key to achieving the development. In recent days, new and innovative knowledge is constantly required to find more and better information, and its creatively using are also very important. There are a variety of distinctive keywords used in current livestock research and development such as ICT, smart farm, rural competitiveness, global weather change, ageing, 6<sup>th</sup> primary industry, animal welfare, food safety, FTA/globalization, Mechanization/automation, and so on. Based on these typical keywords, we have categorized the trends in Korean Agriculture sector. The incorporation of the global economy is a threat to accelerate the opening of the WTO/FTA livestock products market and increasing the import of livestock products. It is not stable enough for the domestic market, because its economic structure depends on exports/ imports in Korea. As a result, there is a tendency to open up agricultural markets to export non-agricultural high technology products which leads to increase the cheaper imported agricultural products, and this situation is considered a major threatening to domestic farmers' income and rural economic development.

Agriculture is a representative industry that requires a lot of human resources. In recent years, mechanization and automation have been interestingly increased in various fields of agriculture, which leads to failure to create employment in rural areas. Particularly, the agriculture population ageing is a particularly serious concern in Korea while compared to other nations. The domestic agriculture population is 4.6% of the total Korean population, the number of elderly people aged 65 or older has risen sharply to reach 44.7% of the total agriculture population. This may lead to a decrease in the strength, economics of rural communities, reduction in the efficiency of the agricultural labour force, using advanced technologies, and the shortage of human resources in rural areas. On the other hands, the government recognizes the need to create a job opportunity in the rural area for increasing population and improving the strength of rural communities, and it has continuously developed and promoted various support programs to prevent population decline in the rural areas. In order to encourage people to move to the rural area and join farming, the government has made great effort to improve the convenience of culture, education and medical care in rural areas as well as to increase employment in rural area. Conflicting efforts seem to be simultaneously occurring.

Climate change has an adverse effect on livestock system, and farmers have to manage this changing natural environment. In order to global warming, the farmers have a response to the changing natural environment, and as well as have to learn and develop new technologies to change it. Due to the

population growth, the global food demand is projected to increase by 50% by 2030, and thus the food productions need to double in 2050. Korea has grain and food self-sufficiency rates of 24% and 53%, respectively, and resulting in that Korean food security index is only 32, very low compared to the other countries. At recent days, consumers are becoming aware of eco-friendly livestock products and food safety. Therefore, the government needs to develop the rural industry for food production and for the development of the rural economy. In addition, the development of infrastructure, culture, tourism, and education, can be a positive impact on the revitalization of the rural economy with more job opportunity.

### The importance of smart livestock farming

A decrease in agriculture population and aging are dramatic threats to the sustainability of agriculture and livestock production. The imbalance between supply and demand for agricultural products, price and consumer certainty are persistent. Owing to the emerging of the global market economy, the FTA, Korea and other major countries will expand, leading to an increase in agricultural imports/ exports. It will lead to the weakness of domestic agriculture competitiveness. For this reason, the share of agriculture in the national economy is steadily declining. Although, livestock accounts for a large share of agricultural production, labor-intensive and underdeveloped facilities and production structures to future sustainability, climate change, livestock disease, and changes in rural population. Korea's agricultural productivity has been progressively increasing, but the gap is still bigger than that of countries with higher productivity globally.

To resolve this problem, the Korean government has invested huge money on agricultural facilities since the early 1990s. And since the 2000s, enormous efforts have been made to apply ICT technology, including automation and mechanization. With this, researches actively responded to the decline of the labour force in rural areas, and have laid the foundations for producing high-quality livestock products. The intention of this is to increase the income of the farm household and rural development. These representative agricultural facilities can be characterized by controlled horticulture and livestock farming.

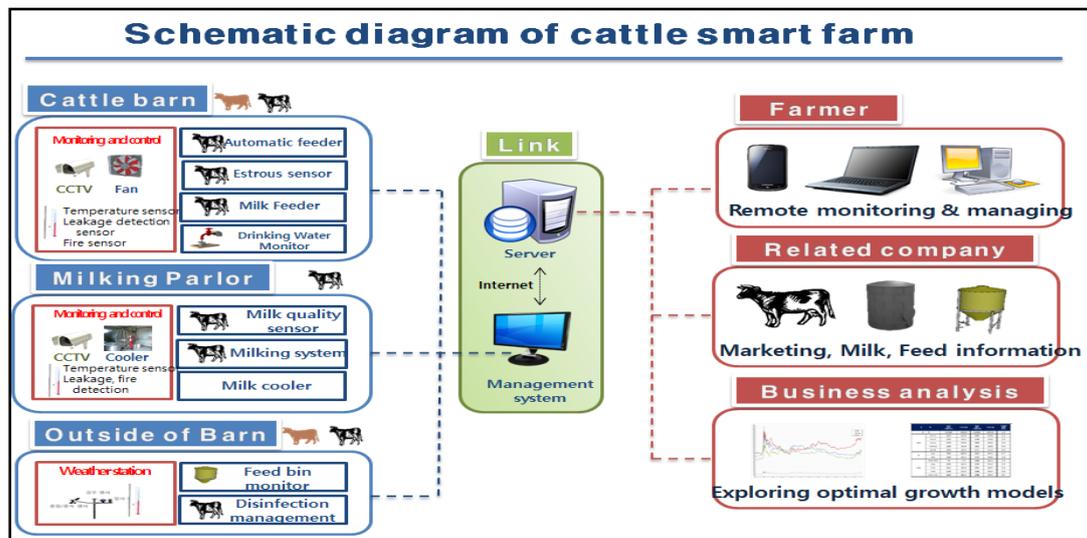


Figure 1. ICT integrated livestock house considering sensing, monitoring, and controlling as well as automation/ mechanization and energy saving

However, it is still believed that productivity using agricultural facilities is lower in Korea than that of developed countries like the Netherlands. It might be due to four distinct seasons, while the annual air temperature range is over than 60 °C and the highest air temperature was higher than 40 °C in 2018. It is a great challenge to maintain optimal growth conditions for each of the four seasons showing very distinctive characteristics. Particularly, the farmers are increasingly troubled with energy and labour costs, which account for a large portion of production costs. But, recently many efforts have been carried out to improve productivity with increasing environmental control efficiency, reduce energy load, forecast disease problems, mechanize/ automate by smart livestock farming.

At present, ICT/ smart farm technologies are being actively developed and used to resolve various agricultural issues, to improve their performance in the livestock farm. In the mid-1990s, there was tremendous investment and development in livestock house and automation of management. But, since 2014, the developed smart livestock farming has been used to sensing, monitoring, control, automation/mechanization, and housing environment observation through the development of ICT, smart farm, IoT. At recently, researchers have more attention to the smart farm keyword that implements ICT technology in rural areas of Korea. Therefore, the aim of smart livestock farm development is to increase the productivity and efficiency of livestock production and develop agriculture into high value-added industries which will dramatically improve climate change, rural population decline, income, and environmental conditions.

## **What is smart livestock farming?**

### ***Origin of smart livestock farming (SLF)***

In '70s and '80s of the last century, smart livestock farming are originated from the USA. The development and implementation of precision agriculture have been made possible by combining the global position signal (GPS). This technology can be used in real-time data collection with accurate position information. This technology based applications in precision farming are being used for farm planning, observing the vegetation of plants and some basic soil characteristics. In the USA, corn and soy are mostly cultivating, and this GPS based application can be used farmers to work during low visibility field conditions such as rain, dust, fog and darkness. Until now these remote plant and soil observation, location information, data analytics and techniques to treat management zones more precise are the basics of current developments in precision agriculture for arable farming systems (Kees Lokhorst, 2018).

In '80s and '90s of the last century, this precision agriculture development was initiated from Europe. The scientific developments in arable farming motivated researchers to work on the new concept of precision livestock farming (PLF). Inspired by the potential new engineering concepts in sensing, data management, decision support, control theory and the concept of precision agriculture, they desired to create new applications in order to support the management of livestock farmers. Where the satellite was the key in the development of precision agriculture, the development and large scale introduction of electronic identification systems (radio frequency identification tags, RFID) was the key for the development of PLF. Suddenly farmers were able to identify individual cows that were part of a group, and we could also treat them individually by giving them concentrates. Together with the ability to measure the milk yield of individual cows, automatically the basic elements of PLF were introduced. These elements stimulated developments in sensor technology, decision support and in milking, feeding and housing systems. Group housing of sows and aviary systems for laying hens could be developed with the knowledge that data about the livestock in the barn was available and could be used to treat individuals or smaller groups (on pen level instead of compartment level). In conclusion, we could say that PLF was focused on the support of the management of production animals. On individual level for dairy cows and breeding sows and on subgroup level for finishing pigs and all sort of poultry production (broilers, laying hens). This last group can also be seen as management zones as applied to zones of a field in precision agriculture. Within the PLF community, regular discussions were held about the name. Precision Livestock Farming is an abstract concept. Even now the name is still under discussion which leads to alternative names popping up. Development and differentiation of the definition can be seen. For example, in the term '**precision**' we see differentiations such as 'precision feeding', 'precision breeding', 'precision health' and 'precision grassland management'. The term precision then means 'more precise actions that are based on high-resolution data that can enhance the processes on the farm.' Another development can be seen around the term '**SMART**'. Smart farming and smart livestock farming are examples where decisions of stakeholders that are related to a farmer are influenced by the general management of the farm processes. So when using the term 'Smart' the farm is also seen as a part of a complex and dynamic production chain. It is interesting to see that the acronym of the SMART-principle is hardly used. In time we see people using different terminology. For the terminology of Smart Livestock Farming is being used. Be aware that SLF, in essence, is a subset of Precision Livestock Farming and that it is based on the same principles as those of Precision Agriculture (Kees Lokhorst, 2018).

## ***SLF definition***

Although there are quite some different definitions, we see that the following two definitions fit smart livestock farming.

Daniel Berckmans defines the Precision Livestock Farming as “*Management of livestock farming by automatic real-time monitoring/controlling of production, reproduction, health and welfare of livestock*”.

The EIP- focus group ‘Mainstreaming Precision Farming’ uses the definition: “*Precision Farming refers to a management concept focusing on (near-real-time) observation, measurement and responses to inter- and intra-variability in crops, fields and animals.*” These definitions include a few important elements that should be taken into account when we talk about Smart Livestock Farming.

These are Livestock farming, Management, Inter- and intra-variability, (Near) real-time, Automatic observation/monitoring/controlling, (Re) production, welfare and health of animals, crops and fields. To be able to read these signals, the farmer needs tools to register, monitor and interpret them. The aspect of why the potential benefits may include increasing animal performance, cost reduction and optimization of process input, all of which would increase profitability, is included. Smart farming shall reduce environmental impacts and contribute to the better welfare of animals in agriculture and farming practices. Another aspect that is not defined back in this argumentation, but that is nonetheless relevant for smart farming is the role of humans with respect for the quality of labour, labour time, the social aspects of labour, the costs of production and the developments in ICT solutions (Kees Lokhorst, 2018).

## ***Definition of Smart Livestock Farming (SLF) in Korea***

Definition of smart livestock farming (SLF) in Korea is a connecting farming system which is oriented more intelligence and high efficiency merged with network and automation technology by monitoring and controlling a livestock housing environment, feeding and health condition, remotely to release time and place limitation and improve the rural life. Smart farm technologies cover a wide range, from production, distribution and up to the consumption of agricultural products.

In order to overcome the limitation of small-size farmlands and secure the global competitiveness of Korean agriculture, capital and technology-intensive farms can be a good way as the next generation of smart agricultural production systems. In addition, South Korea-oriented smart farm, namely, Smart Korean farm plays the most realistic alternative to overcome the growth limitation and accelerate the 6<sup>th</sup> industrialization of agriculture in the worldwide. The 6<sup>th</sup> industrialization covers 1<sup>st</sup> production, 2<sup>nd</sup> processing and 3<sup>rd</sup> pleasantness. Therefore, this is the time to jump, crash, and convergence smart technologies for the future of agriculture. The smart farms with ICT technology will bring agricultural innovation. We are transforming from agriculture centered on productivity and efficiency to safe and environmentally friendly agriculture in the future like from experiential and subjective knowledge-based agriculture to data-based, objective knowledge-based agriculture. Future agriculture will be transformed from a government-dependent small-scale industry to a core industry that will be a growth engine.

## ***Development of smart livestock farming***

The aim of the first, second and third generations of smart livestock farming is to improve the convenience on farming, income and make global products and service.

The 1<sup>st</sup> generation smart livestock farm model consists of network, sensor node, control node and visual monitor. It enables to enhance precision farming and improve farmer’s benefits. The environmental conditions within a livestock farm are monitored and controlled remotely by using farmer’s smartphone, which is capable of enhancing precision farming and improving farmer’s benefits. Also, it is used to monitor the feed intake, drinking water and environment conditions.

The 2<sup>nd</sup> generation of smart livestock farming is progressed from the 1<sup>st</sup> generation. On top of the outcome from the 1<sup>st</sup> generation of smart farm model, this model adds two more components, which are complex environment control and big data cloud service. In the 2<sup>nd</sup> generation model, automatic control of housing environment can be achievable, which improves livestock productivity and quality. Enormous data can be removed from the collected big data. The animal growth and production model based on the Big Data will be made. Using environmental information and growth & production models, we can be able to provide environmental control conditions, optimal decision-making, and security services to farmers. The agricultural cloud system is a key component of the second generation smart farm. The cloud platform consists of data collection - storage - analysis - services. The

environment, growth, visual information, etc. are collected from livestock farms, and the collected data is analyzed by artificial intelligence. The results of the analysis are used to provide services related to decision making, such as environmental control, growth control, and failure prediction. When the collected information of IoT based data is transferred to the cloud, artificial intelligence analyzes the situation and decide to control AI itself.

On the basis of the 2<sup>nd</sup> generation, complex energy management and agricultural smart work were added in the 3<sup>rd</sup> generation. The 3<sup>rd</sup> generation model, optimal energy management and full automation of robotic farming will become possible and smart farm technologies will drive the growth of the agricultural industry.

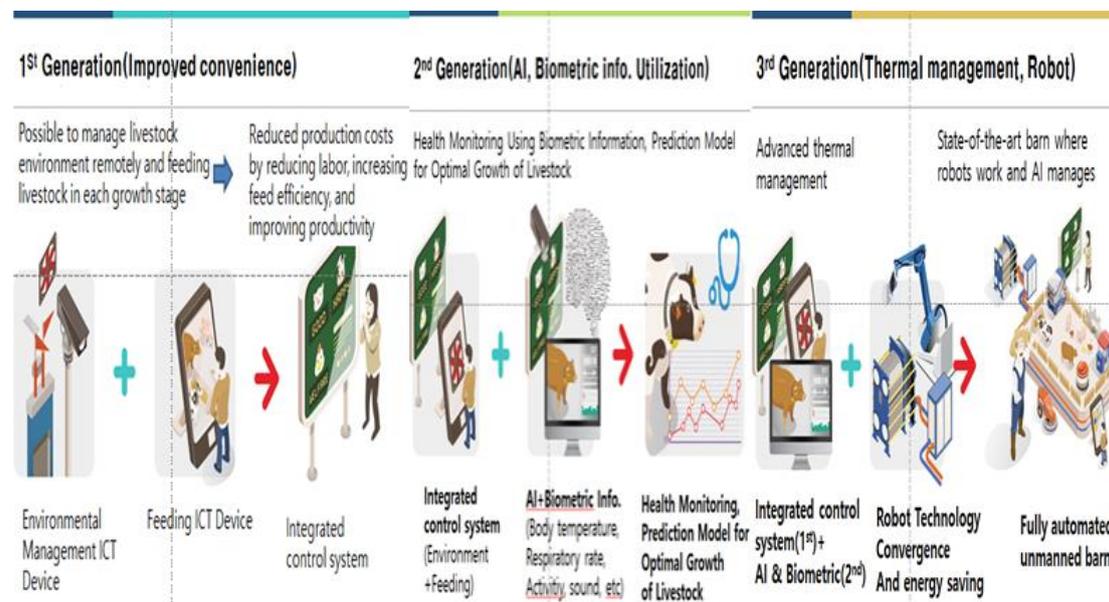


Figure 2. Development stage of each generation of smart livestock farming

### ***Adaptation of ICT based technology in Korean livestock farm***

At present, not only the national institutions but also the private company is developing and commercializing ICT-based smart farm technology for poultry, pigs, beef cattle and dairy cows. The ICT equipment selection and classification items for smart farm configuration are outlined below, respectively.

- Environmental management: Temperature, humidity, ammonia, carbon dioxide, short circuit (power failure) detection, wind direction, wind speed, rainfall, illumination, fire detection, ventilation fan etc.

- Livestock management: Heat stress detectors, automatic feeders, feed bin management, water controllers, pig sorting machine, robot milking machines, etc.

- Management information: marketing management, cost management, disease management, milking management, etc.

Livestock farmers adopting smart livestock farm-based technology are mostly used in the 1<sup>st</sup> or 1.5 generation level, and various technology development research projects related to 2<sup>nd</sup> and 3<sup>rd</sup> generation are currently being pursued. After the adaptation of the 1<sup>st</sup> generation livestock smart farm technology, it is being investigated that the productivity, income and cost reduction.

For example, pig farmers have improved their PSY (Pig per Sow per Year) and MSY (Market pigs per Sow per Year) rates by 5.7% and 9.3%, and the feed efficiency has improved by 9.3%. As for cost reduction point of view, the price of 2,534 won (2.3USD) per head for breeding stocks and 8,534won (7.8USD) per head for farms with integrated farms were found to be positive for the introduction of smart farms. The effect of introducing the 1<sup>st</sup> generation of smart duck technology was also found to be 0.13 kg (3.55 to 3.68 kg) of body weight improvement and 9% of production index (444.2 to 484.8). However, most of the livestock biometric information collection devices used to develop the 2<sup>nd</sup> generation livestock smart farm model depends on the overseas imported products. Therefore, there is a demand for the development of domestic technologies.

In Korea, smart livestock model was developed for pig, laying hen, broiler, duck, Hanwoo (Korean beef), and dairy cows. We proposed animal ICT devices (19 kinds of environmental sensors, 25 kinds of livestock management equipment) for standardization. The standardized device is an essential element to achieving the improved smart farm and strengthening the post-management, thereby leading to market expansion based on the trust of farmers. According to the farmers survey on adaption, 53.8% of farmer's answered installation fee and maintenance is too high, difficulty in using ICT technology (16.7%), anxiety about performance (12.8%), mistrust of companies and technology (11.2%), lack of infrastructure such as internet availability in remote area (5.5%). To promote smart farm technology, smart farm technology development (34.3%) > strengthening funding and support for facilities (30.2%) > (21.4%), and provide training opportunities (9.8%) > strengthened the publicity of smart farms (4.3%) is needed. Also, it is very important to improve the quality of the equipment itself, to establish reliability, management, government support. Therefore, manufacturers have to focus on low production cost for the development of high-quality equipment and core technology. The convenience of use and after service can be achieved through the supply of customized system from the consumer. Hence, we have developed standards for core components and equipment, verified compliance of each product with the standard, guideline, and post-management.

### ***Pig***

In smart pig farm, the development of 1<sup>st</sup> generation model is completed, and farming technology dissemination is being carried out, and continuous monitoring is carried out for the productivity enhancement through the demonstration of the field and the effect of improving the convenience of operation. It is possible to control and monitor the inside information of facility and management for each object in real-time through the user's PC and mobile device. Also, the platform construction has been completed to enable control of the ventilation fan and lighting device when necessary. In feed bin, the load cell and various gas sensors are installed to confirm the total feed amount and the degree of deterioration of the feed-in real-time, and the farmer can manage the convenience of management regarding the purchase of feed etc. The feed companies can provide a delivery plan of feed for each farmhouse at the right time. RFID (Radio Frequency Identification) tag, which is attached to each sow, and real-time feed and water intake management can be performed for each sow individual. In addition, it is one of the preferred ICT specification equipment for farmed sows to automatically control the feeding rate based on sow age, parity, and BCS (Body Condition Score). The very big advantage of ICT technology is reducing feed loss and labour saving. By using the pig shipment selector, the weight of the individual of the finishing pigs is automatically measured to select only the finishing pigs, which reached the target weight. This uniformed marketing can save money by ICT technology, because, if it is no uniform and farmer need to pay the penalty, and shipment work of the existing 2 hours can be shortened to within 30 minutes. So the convenience of work and prevention of accident can be prevented. According to the banning of the stall in the European country since 2013, Animal welfare group feeding device for pregnant sow was developed in various countries, including Korea. It can improve the accuracy of feeding and promoting leg health, decreasing the reheat rate after insemination by 5%, preventing feed loss, and shortening of delivery time, and so on. Recently, researches on the development of prediction model of pigs through monitoring and analysis of biometric information and precise control on the internal environment of pigs based on sensing information have been conducted for the 2<sup>nd</sup> and third 3rd smart farm development.



### ***Beef and dairy cattle***

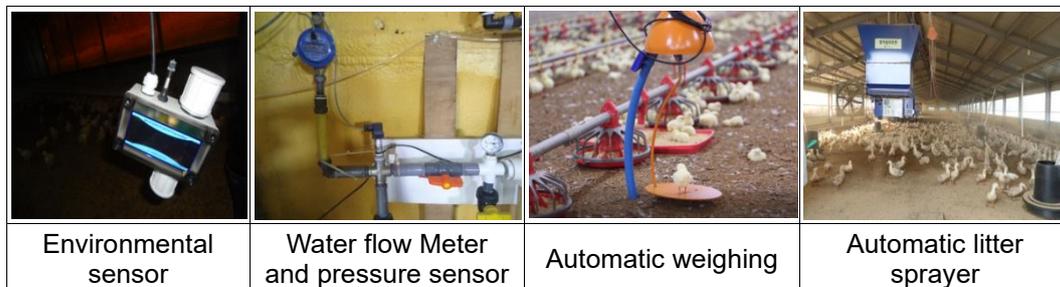
In smart dairy and Hanwoo cows farms, 1<sup>st</sup> generation model has been developed like smart pig farm as we mentioned above, and continuous monitoring is being conducted on the improvement effects of

field demonstrations. A smart air blowing fan that is operated in order to improve the uniformity of various housing environments inside, the facility has been developed in conjunction with the wind velocity and wind direction of the outside air. We have developed an automatic milk feeder to manage individual precise specifications for young calves. Currently, a variety of biometric information monitoring devices, models and robots are being developed for the 2<sup>nd</sup> and 3<sup>rd</sup> generation model. Also, we developed mobile smart monitoring system for the measurement of body temperature and activity and can be used early warning of the health and reproduction-related conditions such as hoof disease, heat generation. The research and development of Korea are being developed robotic milking machines, and also, the developed Individual recognition and automatic feeding system using RFID are commercialized. 3D Depth camera and machine learning technique to develop 3D body shape measurement and weight estimation algorithm for non-contact type for Hanwoo, dairy cow and horse is under investigation.



### ***Poultry***

In the case of the 1<sup>st</sup> generation basic model, environmental monitoring sensors and CCTVs are used to monitor and control the environment inside the poultry house. Early detecting and warning ICT equipment for safety management such as fire and power outage is adapted. Integrated ICT equipment (feed bin management, water management, automatic feeding, etc.) used to supply appropriate nutrients for each stage of poultry. The respiration rate, pulse, body temperature, distribution, and behaviour of poultry are controlling by using small biometric information sensors, thermal imaging devices, vision sensors, vocal sensors, etc., research is underlying. Light is important because of poultry feed and laying an egg by the light stimulus. An LED lighting device is a controller having a dimming function is used to prevent stress at the time of turning on and off. The dimming is in the range of 0 to 100% and the dimming time must be controllable. Weight management is very important for layer, broiler and breeder. Broiler chickens are regularly monitored for normal growth management and release decisions, the weight management of the breeding period is very important to improve productivity and hatching rate during the breeding season. Previously, a chicken was caught and measured by a manual scale, but a device for measuring weight automatically using a load cell is being utilized. Remote monitoring and automatic spraying model for litter have been developed and applied to duck farms. Automatically detecting and classifying eggs based on image processing and CNN based on egg production, egg weight, egg coloring, broken egg, and decolorization was developed. WiFi, Bluetooth, Zigbee, CDMA, LTE, LoRa, etc. are used for wireless communication in the livestock house. Communication module should be selected according to the communication distance, communication speed and installation environment.



### ***Future prospects of ICT technology***

The agriculture and livestock market has become increasingly sophisticated and smart in the world. The development of ICT technology, smart farm component parts and infrastructure are used to expand their business in these areas. Smart farm technology is an increase in its necessity, importance, and effectiveness of smart farms worldwide. It is necessary to develop an integrated smart farm model for the livestock sector, to invest in relevant element technology and infrastructure technology at the government level. The development of 2<sup>nd</sup> generation smart farm core technology is under progress, but there is inadequate research on customized optimization and empirical studies, and local area for developing standard model, and this technology needed to be strengthened. At present, domestic technology is an emergent to promote the field demonstration of 2<sup>nd</sup> generation technology. The collection of Smart farm big data is increasing due to the increasing of Smart farm. However, since it is only a few items to be used for production, it is necessary to upgrade the Big Data Analysis and Utilization model and to expand the application items. Also, it is necessary to improve productivity through smart farm technology centered on convenience, through precise production management focused on growth information and conversion of an unmanned and automated technology. In order to nurture smart farm as a new growth engine of the nation, so, it is necessary to induce new industries to develop convergence technologies with other fields such as information and communication and energy. In future, we will develop and increase the smart farm convergence and source technology based on cutting-edge convergence technology with global competitiveness. Therefore, this sustainable enrichment industry will be implemented, and global competitiveness will be enhanced.

Table 1. Short and long term development plan of each generation of smart livestock farming

Item	1 <sup>st</sup> Generation	2 <sup>nd</sup> Generation	3 <sup>rd</sup> Generation
Target year	Present	2025	2030
Effect	Enhance convenience 'More comfortable'	Increase productivity 'Less input, more output'	Improve sustainability 'High production / quality by anyone'
Main function	Remote facility control	Precise growth management	Full-cycle intelligence. Automatic management
Core information	Environmental Information	Environmental information, growth information	Environmental information, growth information, production information
Core technology	Communication technology	Communication technology, big data / AI	Communication technology, big data / AI, robot
Decision / control	Human	Human/PC	PC(AI)
R&D product	Smartphone house control system	Data based growth management software	Intelligent robot farm

### **CONCLUSION**

The development of controlled livestock smart farm has importance to overcome various issues in the future. Though great efforts are being made to enhance the productivity of controlled environment in various related areas, especially further studies are needed on "aerodynamics and energy engineering", "ICT/Smart farm technologies" and "unmanned automation using robot technology". Therefore, the balanced efforts and cooperation in scientific and engineering approaches are needed. For this purpose, a solid cooperative system of farmer, industry and academia should be done. Although various attempts have been made recently on ICT / Smart farm, one concern is "building big data". Big data with sufficient reliability should be constructed, which requires long-term research and support for achieving deep learning or artificial intelligence (DL or AI), the ultimate goal of ICT / Smart farm. These big data constructions and data analysis do not work of ICT experts, but who know most about this field and can

do various studies. We should always take pride in knowing how our major and experience are playing an important role in reaching ICT.

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