Chapter 6

Effects of Disasters and Climate Change on Livestock Sector and Implications for ASEAN Food Security

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CHAPTER 6

Effects of Disasters and Climate Change on the Livestock Sector and Implications for ASEAN Food Security

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6.1 Introduction

With the effects of climate change already being felt, we are facing major challenges: food security and climate change adaptation. According to the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has risen 0.74°C (0.56°C–0.92°C) over the past 100 years (Kim, 2011). The third report of the IPCC uses complex climate models which forecast global mean surface temperatures to rise by 1.4°C–5.8°C by the end of 2100. Global warming – the increase in average global temperatures – is the reason for climate change. Agriculture is vulnerable to disasters and climate change, in terms of economic resources as well as food security (Otte, 2014). Favourable weather and climate are the key to success in agriculture, but global warming and climate change affect the agriculture sector throughout the world. With increasing impacts of climate change and natural disasters, the yields and profits of agricultural systems have been declining. Soil scientists, agricultural engineers, and integrated crop and livestock farmers are making significant efforts to reduce the losses caused by disasters and climate change. The impacts of climate change on present day agriculture are essential in making a new vision for future agriculture policies (Kim, 2011). In the last 30 years, climate change has reduced global agricultural production by 1% to 5% per decade (Thornton, Boone, and Ramirez-Villegas, 2015).

6.1.1 Climate Change in the Republic of Korea

The Republic of Korea (henceforth, Korea), located in the northern hemisphere, belongs to a temperate climate zone with four distinct seasons. The average temperature of Korea has increased by 1.5°C over the last 100 years (Korea Rural Economic Institute (KREI), 2010). This is much greater than the global temperature rise of 0.7°C. Korea's average temperatures are expected to increase by a minimum of 2°C from 2000 to 2050 (when simulated under the IPCC's Climate Change Scenario A1B). Seawater surface temperature is estimated to increase by about 1.3°C by 2050 and 2.9°C by 2100.

Precipitation in Korea has risen by 19% over the last 100 years (Myeong, 2012). Increased instances of extreme rainfall in the summer and prolonged droughts in the winter are also expected. Scientists predict a further rise of 9.5 centimetres by 2050 and 20.9 centimetres by 2100.

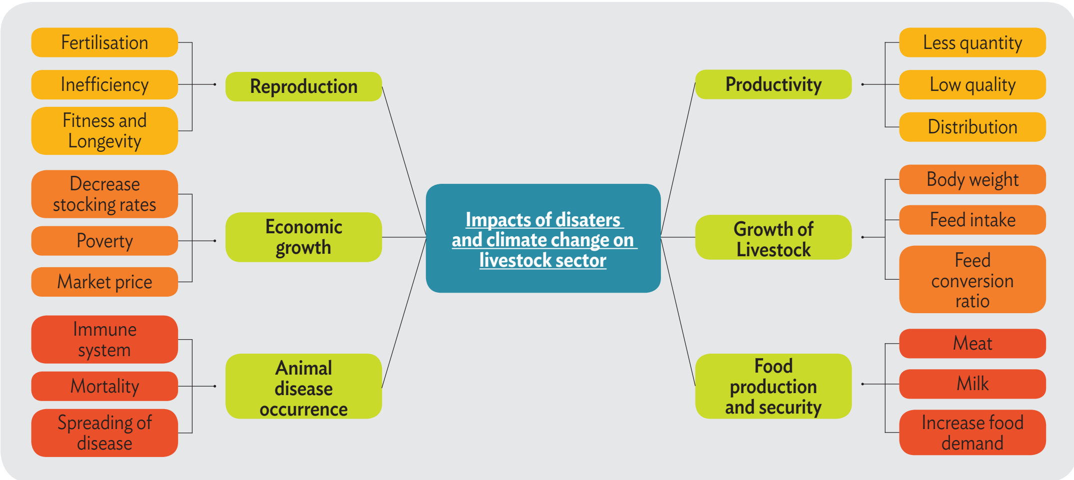
6.2 Climate Change Impacts on Livestock Production

Farming is a source of livelihood for one-third of the world's population, and about 60% own livestock. Nearly 800 million livestock owners live on less than $2 a day (Food and Agriculture Organization of the United Nations (FAO), 2011). Livestock is a rapidly growing subsector, with 40% of the global agricultural gross domestic product, and it is key to food security in all regions. Meat and milk consumption have increased significantly and are projected to rise in gross terms by 70%–80% over current levels by 2050 (Herrero et al., 2015). Demand for livestock production has increased because of the rise in the world's population. However, climate change affects livestock systems in several ways. It impacts livestock production and causes biological changes in livestock, such as fertilisation and breeding.

Extreme weather events (e.g. heatwaves, floods, and droughts) cause livestock productivity losses and deaths (Gaughan and Cawsell-Smith, 2015). Some animals can survive in hot conditions, but it will limit livestock production. It is generally accepted that an increase in temperature has negative effects on livestock feed intake, reproduction, and performance (Porter et al., 2014). More research is needed on the impacts of climate change on livestock since most of the work to date has focused on crops. The impacts on livestock systems will be measured through reduced feed quantity and quality, changes in pest and disease prevalence, and direct impairment of production caused by physiological stress. Growth and meat, egg, and milk yield and quality decrease as temperatures exceed 30°C because of reduced feed intake (Thornton and Gerber, 2010).

Directs impacts of climate change on livestock production include heat stress, humidity, wind, drought, frost, and floods – leading to a decrease in milk production, meat production, reproduction, animal health, and behavioural performance. Indirect impacts include nonavailability of food resources because climate change affects the livestock pasture pattern as well as rangeland vegetation patterns. Future impacts of climate change on livestock production are likely to be direct via productivity losses (physiological stress) owing to temperature increases; and indirect through changes in the availability, quality, and prices of inputs such as fodder, energy, disease management, housing, and water (Thornton, 2010). The impacts of disasters and climate change on the livestock sector are illustrated in Figure 6.1.

Figure 6.1: Impacts of Disasters and Climate Change on the Livestock Sector



Source: Author.

The major impacts of climate change on livestock and human diseases have been on vector-borne diseases. Increasing temperatures have supported the expansion of vector populations into cooler areas – higher altitude systems (e.g. malaria and livestock tick-borne diseases) or more temperate zones. Changes in rainfall patterns can also influence an expansion of vectors during wetter years. Variations in temperature and rainfall are the most significant climatic variables affecting livestock disease outbreaks. Many rapidly emerging diseases continue to spread over large areas. Warmer and wetter weather increases the risk of animal disease, which can damage the immune systems of livestock, cause mortality, and raise the risk of spreading disease (e.g. foot-and-mouth disease (FMD) and flu virus). Outbreaks of diseases such as FMD or avian influenza affect large numbers of animals and contribute to further degradation of the environment and surrounding communities' health and livelihoods. Outbreaks of FMD caused by the serotype O virus occur in cattle and pigs. Korea did not have an outbreak from 2000 until November 2010, when a widely extended outbreak last 5 months. The outbreak was extremely detrimental to the domestic food supply chain, resulting in economic losses of about $1.7 billion. Market prices were increased to help resolve the issue. The use of technology, improvements in breeds, more intensive production systems, and market opportunities at the local, national, and international levels were implemented to control and manage the situation. The government sector imposed quarantines, initiated a vaccination campaign targeting 9 million pigs and 3 million head of cattle, and culled 2.2 million livestock, with an overall cost estimated at around $1.6 billion. Nearly 74% of hogs and 99% of cattle were vaccinated and culled, and the number of daily FMD cases gradually decreased (Park et al., 2013). Currently in Korea, in 150,000 head of cattle, accounting for about 5% of the total head; and 34% of the total pig inventory affected by FMD, the Ministry of Agriculture, Food and Rural affairs confirmed FMD decreased because of appropriate vaccination.

Disasters and climate change can adversely affect productivity, resulting in less and lower quality production and affecting the distribution of livestock products. Decreased productivity causes food production to decline – including meat and milk – and demand for food to increase. The reproductive system of livestock is also affected by thermal stress, associated with climate change, through inefficiency in embryo development and fertilisation. To analyse how and to what extent the change in temperature and precipitation accompanying global warming affects the livestock sector, various experiments, simulations, and research have been carried out both in laboratories and in the field (Rojas-Downing et al., 2017).

Disasters and climate change also affect economic growth in the livestock sector. They cause poverty if the livestock of an area is damaged by disasters, the stocking rates of an area decrease, and the market price of certain types of livestock increases because of lower availability. Livestock systems have both positive and negative effects on the natural resource base, public health, social equity, and economic growth (World Bank, 2009). They make up 33% of the agricultural gross domestic product, and this share is increasing rapidly. This growth is driven by the rapidly increasing demand for livestock products, while the demand is driven by population growth, urbanisation, and increasing incomes in developing countries (Delgado, 2005).

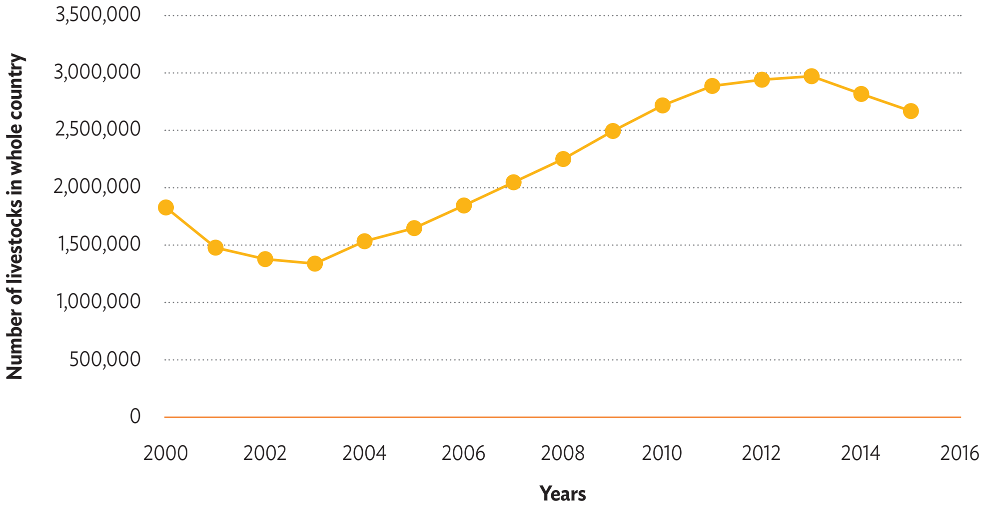
Climate change will have severely deleterious impacts in many tropical and subtropical zones, even with small increases in average temperatures. This is in contrast to many parts of the temperate zone where agricultural productivity is likely to increase slightly at mid- to high latitudes, with local mean temperature increases of 1°C–3°C (Parry et al., 2007).

Several options are available for livestock management, including grazing and manure management. Global agriculture could offset 5%–14% (with a potential maximum of 20%) of total annual carbon dioxide (CO_2) emissions at prices ranging from $20 to $100 per ton of CO_2 equivalent (tCO_2eq) (Smith et al., 2008). The increase in temperature also has negative impacts on forage quality, which is connected to livestock productivity (Thornton, Boone, and Ramirez-Villegas, 2015).

6.3 Status of Korean Livestock Production

Korea's livestock industry underwent rapid transformation as the production of poultry and pig farming expanded dramatically in the late 1970s and 1980s. In 1989, the domestic feed production for livestock was 10 million tons (Chung et al., 2014). Korean livestock demand increased with the growing population from 1995 to 2013. Per capita consumption grew 2.4% annually from 27.5 kilogrammes (kg) in 1995 to 42.8 kg in 2013, while meat production rose 2.2% per year from 1.057 million tons to 1.587 million tons over the same period. Meat imports also increased with rising consumption (KREI, 2015). Per capita pork consumption grew from 14.8 kg in 1995 to 20.9 kg in 2013. Imports increased because of the shortfall in pork production over demand, as self-sufficiency rates fell from 92.4% in 1995 to 81.1% in 2013 (KREI, 2015).

Figure 6.2: Annual Livestock Production in Rep. of Korea, 2000–2016

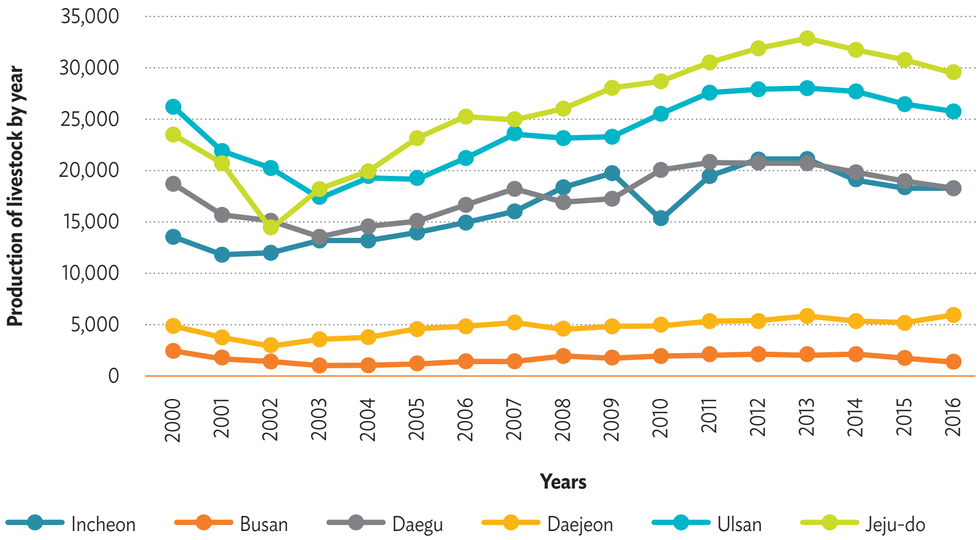


Source: Korean Statistical Information Service (KOSIS).

Korea's livestock industry is facing problems because of animal disease and the impacts of climate change. The planting of crops that are used to manufacture animal food is being delayed because of the temperature rise, which is causing a decrease in the productivity and quality of livestock products. Figure 6.2 shows the annual livestock production in Korea from 2000 to 2016. The lowest number of livestock was recorded during 2000–2004 because of heat stress, as the highest temperatures and lowest precipitation rates were recorded in 2001. High temperatures were also recorded in 2015, causing a decreasing trend. Therefore, heat stress directly affects the production of livestock.

FMD is another factor in the reduction of Korea's livestock sector. A serious outbreak of FMD occurred in Korea in 2010–2011, leading to the culling of hundreds of thousands of pigs (in January 2011) in an effort to contain it. The outbreak began in November 2010 in pig farms in Andong, Gyeongsangbuk-do and spread rapidly throughout the country. Figure 6.3 shows the livestock production in major cities of Korea from 2000 to 2016.

Figure 6.3: Livestock Production in Major Cities of Rep. of Korea, 2000–2016



Source: Korean Statistical Information Service (KOSIS).

6.4 Food Insecurity

Climate-related disasters cause food insecurity in their immediate aftermath and the long run. Drought is the main driver of food insecurity, which has negative impacts on nutrition. Floods and storms also cause food insecurity, destroying and changing livelihood assets. The factors to determine food security are food production, prices, demand, and supply. The effects of climate change on our ecosystems are already severe and widespread. Ensuring food security in the face of climate change is amongst the most daunting challenges facing humankind. While some of the problems associated with climate change are emerging gradually, action is urgently needed to allow enough time to build resilience into agricultural production systems to combat them (FAO, 2015). From 2011 to 2013, about 842 million people went hungry as they did not receive enough food to maintain an active and healthy life (FAO, International Fund for Agricultural Development, and World Food Programme, 2013). Livestock contributes greatly to food security because it (i) supplies calories, protein, and nutrients; (ii) mostly eats feed that is not appropriate for human consumption; and (iii) provides manure for crop production, which is rich in nutrients (FAO, 2011). Sustainable livestock production needs more research, extension, and demonstration.

It is also important to maintain efficient conversion of natural resources to human food to sustain a neutral food balance (FAO, 2011). Food balance can be accomplished through the efficient production of protein from livestock (FAO, International Fund for Agricultural Development, and World Food Programme, 2013). However, climate change will influence this conversion by affecting the nutritional content of livestock products (Harvell et al., 2002; Patz et al., 2000) and reducing livestock production (Hatfield et al., 2008). Animal source foods provide high-quality protein and a variety of micronutrients that are difficult to obtain in adequate quantities from foods of plant origin alone. Animal source foods provide 15% of total food energy and 25% of total dietary protein (Rojas-Downing et al., 2017). Currently, the livestock sector’s best approach to food security is by addressing the primacy of food balance (FAO, International Fund for Agricultural Development, and World Food Programme, 2013; FAO, 2011).

6.4.1 ASEAN Livestock Production and Food Security

With limited arable land for growing crops and raising livestock, continuous human population growth, climate change, rising demand for fossil fuels, and so forth, we face unique challenges in ensuring food security for our people. Growing incomes in the region have caused demand for food to rise rapidly, and we face the challenge of meeting this demand with limited and sometimes declining natural resources. Since food security includes good nutrition, meeting true food security requires educating people on the nutritional value of foods and good eating habits, as imbalanced diets or malnutrition can cause a number of non-infectious diseases. These include obesity, micronutrient and/or trace element deficiencies, diabetes, cardiovascular disease, and cancer.

Table 6.1: Status of Livestock Production in ASEAN Countries, 2014

ASEAN countries	Buffalo	Goat	Cattle	Duck	Chicken	Pig
Brunei Darussalam	102	40	604	250	28,040	30
Cambodia	9,723	–	69,205	9,142	17,556	1,04,195
Indonesia	35,236	65,142	497,669	37,985	1,939,225	7,58,999
Lao PDR	19,750	1,923	30,131	4,550	25,234	68,443
Malaysia	3,477	1,670	27,462	157,279	14,15,515	2,17,558
Myanmar	46,914	66,356	232,804	129,005	1,389,207	834,000
Philippines	100,078	55,323	201,390	29,767	1,114,881	1,690,692
Singapore	0	12	46	5,000	90,000	18,542
Thailand	28,306	1,868	163,264	56,178	1,756,536	948,901
Viet Nam	94,420	8,085	292,501	102,646	633,334	3,330,590

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: All livestock values are in tonnes.

Source: Food and Agriculture Organization Statistics (2014).

The Association of Southeast Asian Nations (ASEAN) is one of the fastest growing regional economic communities, and its population of more than 600 million is larger than that of the European Union. Heterogeneity prevails, however, as ASEAN member countries are diverse in many aspects. Large disparities exist in population size, cultural background, economic structure and development, and level of disposable income. Likewise, there are large differences in the structure of the livestock sectors of ASEAN members and their respective levels of technology adoption. Large technology gaps in animal production practices exist between ASEAN countries and even within countries. It is thus necessary to clearly identify critical technology gaps and specify the rationale for attempting to bridge the gaps before embarking on major technology development/adaptation and dissemination programmes. This paper reviews these livestock sector developments with a 'sustainability lens' to produce recommendations on areas in which new technologies need to be deployed and/or developed. Table 6.1 shows the status of meat production of ASEAN countries.

ASEAN countries are facing food security problems as a result of natural disasters. The ASEAN region is home to 2.6 billion chickens, 225 million ducks, 15 million buffalo, 47 million cattle, 71 million pigs, 26 million sheep, and 12 million goats to feed more than 620 million inhabitants. Although livestock production is growing rapidly, the average meat consumption in ASEAN countries is still low when compared with industrialised countries; and food insecurity problems arise in many ASEAN countries, especially after disasters and extreme climate events.

6.4.2 Korea Begins Work to Improve Food Security in ASEAN

Korea will help improve food security in Southeast Asian countries, using its advanced technology to provide detailed information on regional and global food conditions. A collaboration project for 'Improving the Resilience of the Agriculture Sector to Climate Change Impacts' in the Lao People's Democratic Republic (Lao PDR) will help set up a real-time agricultural information system, according to the Ministry of Agriculture, Food and Rural Affairs in 2015 (International Food Policy Research Institute, 2016). Under the agreement, Korea will build a national system in the Lao PDR that shows food supply conditions in the Southeast Asian region and throughout the world. Such information will be shared by Korea with all 10 ASEAN Member States, helping them to prepare for possible food shortages or price hikes. The Lao PDR project is part of Korea's official development aid programme for ASEAN countries, which seeks to help establish the ASEAN Food Security Information System (International Food Policy Research Institute, 2016). Korea plans to spend up to $2 million to help set up the information system in six other countries: Cambodia, Indonesia, Myanmar, Philippines, Thailand, and Viet Nam.

6.5 Adaptation to Climate Change and Food Security

Adaptation contributes to reducing the negative risks associated with climate change and provides opportunities to use climate change for positive effects. It plays an important role in mitigating the impacts of climate change – including actions to mitigate damage from climate change and enhance future adaptive capacity both directly and indirectly. Evaluation of the impact of, as well as the vulnerability and adaptation to, climate change in Korea has ceased to remain in the theoretical and academic domain and is being used to formulate policies and action plans to address its problematic effects. Research-based observation can be the user guide in the formulation of action plans which will yield scientific and thus effective results. Decision-making stakeholders require a wide range of information to develop policies responsive to climate change. This includes (i) the locations where damage from climate change is expected, (ii) the predicted impact range caused by climate change, (iii) the climate change impact projections, (iv) the potential and inevitable impacts, (v) an analytical evaluation, (vi) the probability of the occurrence of various risk factors related to climate change, and (vii) an assessment of the reduction of vulnerability in response to future adaptation strategies.

6.5.1 Korean Adaptation Measures to Climate Change and Food Security

Korean adaptation measures for climate change and food security access current and future impacts of climate change, analyse the adaptive ability of each region to identify the key vulnerability, and thereby establish annual implementation strategies to reduce damage caused by climate change. Adaptation measures require extensive experience and many professionals, as they must predict the impact of climate change on health, agriculture, ecosystems, and various other areas; and prepare appropriate measures. The new adaptation measures include the following:

(i) precision livestock smart farming (PLSF);
(ii) the application of information and communication technology (ICT);
(iii) policies and strategies for adaptation; and
(iv) the role of institutions.

(i) Precision Livestock Smart Farming

Farmers are facing an unprecedented increase in animal and livestock disease outbreaks because of globalisation and climate change. This affects productivity, causes low production of meat and milk, and takes its toll on the economy. According to the FAO, International Fund for Agricultural Development, and World Food Programme (2013), technology solutions in agricultural and livestock production systems will play a key role in addressing this challenge and ensuring adequate food supply. While increasing production, it will be important to find ways to minimise the environmental footprint of livestock farming and ensure high levels of health and welfare for animals. Such solutions should enable farmers to manage a large number of animals in an adequate and profitable manner. PLSF systems offer solutions to all of the above challenges, as they help farmers to increase the quantity and quality of livestock production in a sustainable manner; offer tailored care for animals in terms of feeding, milking, and housing; and make many of the farmers' daily tasks much easier to handle. This system includes precision feeding systems, which allow farmers to feed their cows accurately, precisely, and with minimal human intervention. Precision milking robots or automatic milking machines are a good example of the large-scale adoption of PLSF systems. These robotic systems can handle up to 65 cows an average of 2.7 times per day. Stable and farm management systems also showcase the application of PLSF through support and monitoring systems which use cameras and microphones to act as the eyes and ears of the farmer at all times.

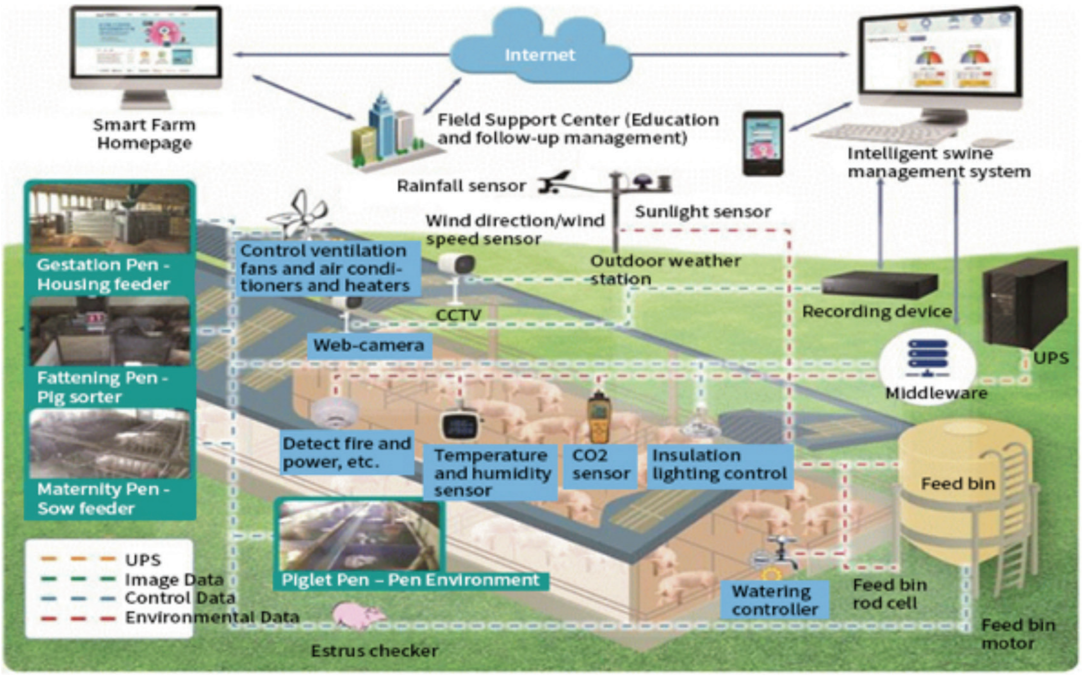
The Internet of Things (IoT) provides another platform for PLSF, as it can provide real-time data to the farm authorities. Data are collected through sensors installed at certain locations on a farm to create basic information for use in determining the optimal environment for livestock production. This information is easily transmitted on a wireless network and is automatically stored in the IoT server in real time. Farmers can receive the information on demand via a smartphone or personal computer. In addition, meteorological information pertaining to weather or predicted disasters can use an IoT system, with the aim of increasing the efficiency of livestock production.

(ii) Application of ICT

ICT plays a role in both supply chain and farm management. It uses information on climatic trends, enabling the use of environmentally friendly and sustainable practices to cope with threats to productivity. The application of ICT has been accepted as beneficial in relation to achieving sustainable agricultural production to increase livestock production and profits. However, small farm holdings require considerable investment to implement ICT systems.

To determine the environmental conditions and performance of each system, with the aim of controlling livestock farm temperatures, a number of factors are involved in implementing ICT. Such factors need to be estimated before applying or installing ICT to enable efficient management. Korea has been seriously affected by rising temperatures and altered rainfall patterns since 1981, which have had a strong indirect impact on increasing outbreaks of insects and FMD since 2000 (Park et al., 2013). Since 1995, the development trend of the ICT industry in Korea has been increasingly related to the agriculture, forestry, and fisheries sector (Lee and Kang, 1997). Figure 6.4 shows how ICT could be applied to optimize livestock farms.

Figure 6.4: Research on ICT Application in Livestock Farms

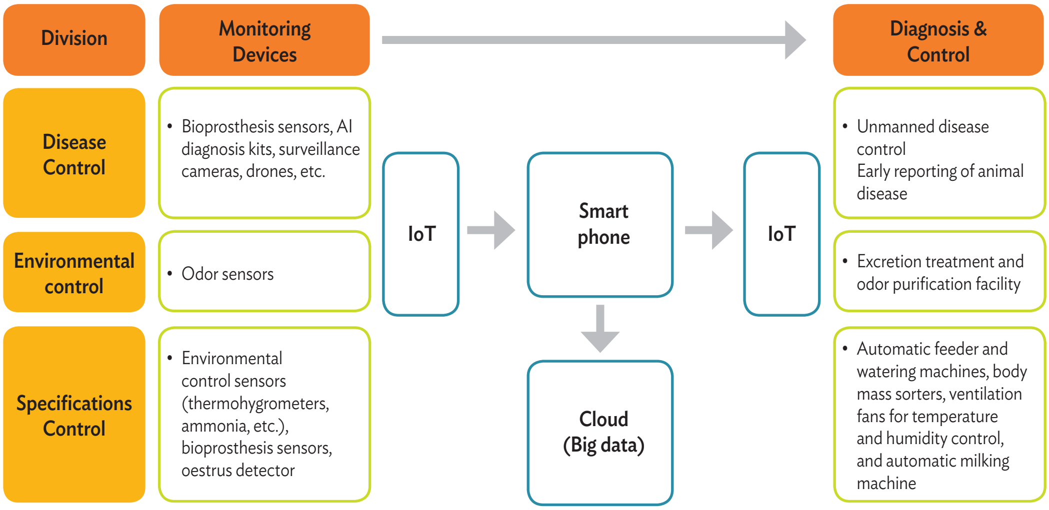


CO_2 = carbon dioxide, ICT = information and communication technology.

Source: Ministry of Agriculture, Food and Rural Affairs, Korea.

ICT is also used on livestock and aquaculture farms (Mana et al., 2015). In this decade, ICT has assumed increased importance in Korea. The policies of central and state governments are in favour of the use of ICT as a tool for agriculture extension activities. The spread of ICT-based information centres and the quality of rural connectivity is increasing. ICT shows considerable promise as a channel for the delivery of extension services. However, the success of ICT applications in livestock extension or allied sectors depends on various issues such as farmers' adoption of ICT, the political and policy environment, farmers' educational status, ICT penetration rates, ICT infrastructure (such as connectivity), and rural information models. Consequently, the use of IoT technology provides a platform for automatically controlling factors. To meet the growing appetite for meat and livestock derived products, livestock farms are increasing in size. Therefore, farmers must find greater integration of ICT into their production processes so that their farming knowledge can be exploited to better effect. In a new era where all things are digitally connected, ICT – including IoT – can raise productivity and bring innovation to traditional industries.

Figure 6.5: Structure of the Proposed ICT System in Farms



AI = artificial intelligence, ICT = information and communication technology, IoT = Internet of Things.

Source: Ministry of Agriculture, Food and Rural Affairs, Korea.

Korea's current livestock industry is competing with the livestock industry of advanced countries, but problems like climate change and disasters cause livestock diseases such as FMD and artificial intelligence, which lead to mortality and financial damages. To solve such problems, livestock farms need to create an optimal breeding environment using scientific technology and integration systems. ICT systems provide an optimal breeding environment to collect real-time environmental information. The installation of environmental sensors in livestock farms generally gives information on temperature, gas emissions, and humidity. This technology also provides information such as oestrus detection and delivery times. Therefore, it reduces labour requirements and operates livestock farms systematically. The use of these techniques is one way to increase the quantity and quality of livestock production and overcome food security in the country.

(iii) Policies and Strategies for Adaptation

As adaptation contributes to reducing the negative risks of climate change and provides opportunities to use the climate for positive effects, policies play an important role in mitigating the impacts of climate change. The effective implementation of adaptation measures should be encouraged, and the most suitable adaptation measures should be selected through the assessment of available adaptation measures. To determine the priorities for application of adaptation measures to climate change, efficiency, effectiveness, feasibility, and acceptance are set as assessment criteria. Adaptation and mitigation can make significant impacts if they become part of national and regional policies (FAO, 2009). The following regional policies are designed to provide adaptation and mitigation practices.

Flash Flood Forecasting System

The National Disaster Management Institute has established a plan to minimise damage from flash floods by operating an early warning system 20–40 minutes before floods.

Typhoon Committee Disaster Information System

During the 38th session of the United Nations Typhoon Committee in 2005, the members of the Working Group on Disaster Risk Reduction agreed to establish an efficient data sharing tool for various tropical cyclone-related disasters. Korea has actively engaged in collecting data and developing ways to strengthen its functions.

Storm and Flood Insurance

Storm and flood insurance is controlled by the National Emergency Management Agency and operated by a private insurance company. Central and local governments support part of the insurance premiums for customers so that they can cope with unexpected storms and floods.

Agriculture and Fishery Disaster Insurance

The Agriculture and Fishery Disaster Insurance Act was enacted in 2010 to compensate for crop, aqua-cultural product, livestock, and facility damages caused by agriculture and fishery disasters. Agriculture and fishery disaster insurance is controlled by the government to enhance the stability of agriculture and fisheries and to increase production. It aims to contribute to the balanced development of the national economy.

In the basic framework of climate change adaptation and food security related to livestock, the following additional support facilities should be included:

(a) Food sustainability
- Sustainability in livestock productivity
- Long-term food security responses

(b) Development of real-time application-oriented technology
- Livestock smart farm development
- Breed technology development
- Weather station development

(c) Supporting facilities
- Expansion of agriculture disaster insurance
- Expansion of disaster-resilient facilities
- Early warning systems
- Technology application in disaster risk reduction
- Promotion of savings and insurance schemes

(d) Sustainable management
- Animal waste management process
- Livestock disease management
- Land and water resource management
- Low-carbon agriculture technology
- Knowledge management and sharing across sectors
- Partnerships with other humanitarian, development, and environmental organisations; research institutions; governments; and the private sector to identify practical and effective responses to climate change and food insecurity.

(iv) Role of institutions in adaptation to climate change and disasters

For adaptation to climate change, it is important to understand how the private sector and government institutions can respond effectively to adaptation with appropriate institutional mechanisms and incentive structures – driving behavioural change. Institutions should (a) make disaster risk reduction a priority, (b) improve risk information and early warning systems, (c) build a culture of safety and resilience, (d) reduce the risks in key sectors, and (e) strengthen response preparedness.

6.6 Government Support for Disaster Prevention and Restoration

The Korean government decided to redirect investment from restoration to prevention to minimise damage and reduce the burden of restoration. Using the stability assessment for vulnerable areas and facilities, the government sets priorities according to the degree of danger and the urgency to increase the effectiveness of investments. The three main goals of the Korean government's disaster management and prevention are to

- establish a comprehensive response system against natural disasters, focusing on preventive countermeasures;
- establish a disaster prevention information system and science-based disaster prevention strategies and policies; and
- promote international cooperation and prepare for the unification of Korea.

6.7 Adaptation Programmes by Institutions in Korea

Following a comprehensive review of domestic and foreign adaptation measures, Table 6.2 shows the programmes applicable to the Korean agricultural sector. These 19 adaptation programmes include five for research and development, three for infrastructure management, one for economic adaptation, three for legal and institutional improvement, two for education and training, one for monitoring, and four for technology and management measures applicable to farm households.

Table 6.2: Adaptation Programmes by Institutions in Korea

Category	Detailed adaptation programmes
R&D	1. Breeding 2. Production technology development 3. Base technology development 4. Resource technology development 5. Climate information system
Infrastructure management	6. Farmland management 7. Agriculture water management 8. Agriculture facility management
Economic means	9. Provision of grants
Legal and institutional improvement	10. Expansion of insurance system 11. Resource management system 12. Formulation of an adaptation measure
Education and training	13. Worker training 14. Education and public relations

Category	Detailed adaptation programmes
Monitoring	15. Assessment of adaptation and vulnerability
Technology and management	16. Production technology management 17. Soil management 18. Water supply management 19. Financial management

R&D = research and development.

Source: Korean Rural Economic Institute (KREI) (2010).

6.8 Recommendations for ASEAN Countries to Overcome Food Security

Climate change and natural disasters are a threat to livestock production, which can lead to food insecurity. ASEAN countries are also facing food insecurity problems because of climate change and disasters. Proper adaptation measures need to be followed to overcome these problems.

Korean adaptation measures against climate change impacts in the livestock sector are (i) PLSF, (ii) ICT application, (iii) policies and strategies for adaptation, and (iv) the role of institutions. These are the key to reducing losses from disasters in the agricultural sector in Korea.

- The recommended policies are as follows:
  - **Enhance** food security information systems (e.g. statistical baselines, livelihood profiles, and vulnerability and risk analysis)
  - **Improve** early warning systems and communication related to agricultural livelihoods and food security (e.g. crop forecasting, food price monitoring, monitoring of plant pests, animal diseases, fish diseases, biosecurity risks, and wildfires) and natural hazards (e.g. droughts, floods, and storms). Strengthen links between early warning, preparedness, and response mechanisms, including decision-making processes.
  - **Strengthen** the institutional mechanisms and legal and policy environments that enable and facilitate strategies and financial investments in risk reduction for the agricultural sector.
  - **Strengthen** the capacity of line ministries to deliver national legislation, policies, and strategies on disaster risk reduction through technical advice, human resources, expertise, training, practical tools, and services.

- Integrate disaster risk reduction into rural and agricultural development policies and plans.
- Develop agricultural sector-specific national strategies on disaster risk reduction across agriculture, fisheries and aquaculture, forestry, and natural resources management.
- Support policies, laws, and management systems that can improve the resilience of the agricultural sector in the future.
- Improve national and local preparedness planning in the agriculture, fisheries and aquaculture, livestock, and forestry sectors.
- Promote agricultural practices to strengthen preparedness at the national and local levels.
- Strengthen the capacity and capabilities of relevant ministries and departments in preparedness and planning for emergencies.
- Enhance the utilisation of local feed resources and balance feed needs with feed availability.
- Balance manure production with the absorption capacity of the agricultural land.
- Reduce the risk of disease emergence and spread.
- Reverse the widespread prevalence of antimicrobial resistance.
- Enhance the safety of animal source food.
- Utilise the livestock sector to raise rural incomes and living standards.
- Provide optimal environment for appropriate technology development/adoption.
- Enhance the nutrient content and/or digestibility of local feed resources, mainly agricultural by-products but also food waste.
- Improve the formulation of balanced rations, drawing on local feedstuffs.
- Breed for the capacity to digest lesser quality feeds.
- Promote cost-effective practices of manure management.
- Develop vaccines and other alternatives to antimicrobials to control diseases of intensification.
- Capitalise on advances in ICT in support of family farms.

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