UNITED NATIONS
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Mechanization Solutions for Improved Livestock Management and Prevention & Control of Zoonotic Diseases

Centre for Sustainable Agricultural Mechanization
United Nations Economic and Social Commission for Asia and the Pacific

MECHANIZATION SOLUTIONS FOR IMPROVED LIVESTOCK MANAGEMENT AND PREVENTION AND CONTROL OF ZOONOTIC DISEASES

Executive Summary

Animal husbandry plays an important role in the agricultural industry. However, since the outbreak of the Coronavirus disease (COVID-19) pandemic which has become a global crisis affecting human health and economic and social development, increased attention has been devoted to zoonotic diseases and measures for their prevention and control. Due to various factors such as weaknesses in anti-epidemic measures and social and cultural contexts, the Asia-Pacific region has always been an area with a high incidence of zoonotic diseases, causing huge losses to the livestock farming industry, and threatening human health and safety as well as people's livelihood and food security.

About 60% of human infectious diseases originate from animals. The mechanization of livestock farming can play an important role in the prevention and control of zoonosis. Owing to its outstanding characteristics on procedural and standardized operation, mechanical equipment has better execution functionality in biological prevention and control, which can avoid failure of prevention and control caused by human factors to a great extent. Mechanized equipment kills pathogens more reliably and is more effective in blocking transmission routes. Mechanized prevention and control solutions thus offer key advantages. At the same time, many mechanical equipment used in production chains of large-scale livestock farming can improve the management of the livestock farming industry, improve labor productivity, increase farming efficiency, improve the quality of livestock products, and reduce the load on the environment. Its role is also vital to improve food and nutrition security and animal welfare. Overall, it has high relevance for various Sustainable Development Goals including Zero Hunger (SDG 2), Good Health and Well-being (SDG 3), and Sustainable Consumption and Production (SDG 12).

The paper points out that the main factors restricting the mechanized prevention and control include insufficient prevention and control capacity of epidemic diseases in overall dimensions, inadequate disease prevention and control in small-scale and individual smallholder farms, inadequate research and application system of mechanized disease prevention and control, and insufficient role of specialized service organizations in livestock farming industry. Meanwhile, apart from challenges, mechanized prevention and control is also looking at a new range of opportunities. With the rapid development of the agricultural machinery industry and information technology, mechanization can play a greater role in prevention and control. In response to the African swine fever and COVID-19 outbreaks, lessons have been learned with regard to inadequate prevention and control measures, and a great deal of experience has been accumulated in the Asia-Pacific region. There is consensus on the need to improve both the software and hardware facilities for epidemic prevention and control in the livestock industry. Moreover, large-scale livestock farming and individual smallholder farming will continue to co-exist for the foreseeable future and therefore efforts need to be undertaken for the overall scale development of the livestock farming industry. In addition, attention needs to be accorded to the integration of mechanization with farming technologies and medical

technologies in the process of disease prevention and control.prevention and control.

Countries in the Asia-Pacific should draw lessons from each other's development experience based on their national conditions, formulate development plans and practical action plans, and endeavor to improve the scale, mechanization and intelligence level of livestock farming industry on an ongoing basis. This study puts forward the following six suggestions at the technical and policy level for the development of livestock farming mechanization in the Asia-Pacific region：

Firstly, it is necessary to strengthen scientific and technological innovation and new technology extension; improve the supply of green, safe and efficient animal husbandry machinery; and accelerate the application of new technologies such as automation, informatization, and intelligent equipment.

Secondly, it is important to encourage appropriate-scale of livestock farming and standardized construction of livestock farms, achieve sound development of livestock farming and planting industries in a harmonized way, and encourage the proper disposal of farming wastes locally or in nearby areas. It is critical to promote innovative modes, scientific planning, and mechanization-oriented design of livestock farming facilities, and strengthen technical guidance efforts on integrated large-scale as well as small scale farming facilities and equipment.

Thirdly, scientific prevention and control and the application of mechanization should be given more priority. Provisions for prevention and control of epidemic diseases should be enacted into laws and regulations in livestock farming management; guidelines on technical specifications for mechanized disinfection in livestock farms should be issued; and large scale farms (zones) as well as small scale farms should be equipped with facilities for resource utilization of livestock and poultry manure and appropriate and safe treatment of dead livestock and poultry.

Fourthly, greater importance should be attached to the role of market-oriented, socialized and specialized service organizations to promote the ‘company plus smallholder farmer (family farm)’ model and encourage social service organizations to carry out specialized services in the areas of resource utilization of manure, storage and transportation of livestock products, safety and decontamination, and epidemic prevention.

Fifthly, government support and financial insurance support should be upscaled. Governments should establish an incentive mechanism for the construction of large-scale farms, increase support for farms and farmers’ households to purchase livestock machinery and equipment; encourage financial institutions to carry out mortgage loans for procurement of livestock machinery and equipment; offer temporary loan discounts for investors; and improve the coverage of policy-driven insurance schemes.

Finally, it is imperative to implement training and education programmes for practitioners to engage in extensive international exchanges and cooperation; increase training opportunities for farm employees and improve the competency of practitioners in the livestock farming industry; strengthen the cooperation with relevant sectors/departments such as animal health, epidemic

control and environmental protection; and strengthen experience sharing and knowledge exchanges via close cooperation with the World Health Organization (WHO), World Organization for Animal Health (OIE), Food and Agriculture Organization of the United Nations (FAO) and other international organizations.

Introduction

Animal husbandry plays an important role in the agricultural industry. However, since the outbreak of the coronavirus disease 2019 (COVID-19) pandemic, which has become a global crisis affecting human health and economic and social development, increased attention has been devoted to zoonotic diseases and measures for their prevention and control. Due to various factors such as weaknesses in anti-epidemic prevention measures and social and cultural contexts, the Asia Pacific region has always been a high incidence area of zoonotic diseases, causing huge losses to the farming industry, and threatening health safety, people's livelihood security and food security.

About 60% of human infectious diseases originate from animals. The mechanization of livestock farming can play an important role in the prevention and control of zoonosis. Owing to its outstanding characteristics on procedural and standardized operation, mechanical equipment has better execution functionality in biological prevention and control, which can avoid failure of prevention and control caused by human factors to a great extent. Mechanized equipment kills pathogens more reliably and is more effective in blocking transmission routes. Mechanized prevention and control solutions thus offer key advantages. At the same time, many mechanical equipment used in production chains of large-scale livestock farming can improve the management of the livestock farming industry, improve labor productivity, increase farming efficiency, improve the quality of livestock products, and reduce the load on the environment. Its role is also vital to improve food and nutrition security and animal welfare. Overall, it has high relevance for various Sustainable Development Goals including Zero Hunger (SDG 2), Good Health and Well-being (SDG 3), and Sustainable Consumption and Production (SDG 12).

According to the statistics released by the Food and Agriculture Organization of the United Nations (FAO), the cattle population in Asia accounted for 30.5% of the global total, chickens accounted for 57.5%, sheep accounted for 42.6%, goats for 52.5% and pigs for 57.2% in 2018. The pig stocks in some Asia-Pacific countries are shown in Table 1.

Table 1 Pig Stocks in Some Asia Pacific Countries in 2018

(Unit: 10,000 heads)

Country	China	Vietnam	Russia	Korea	Japan	Indonesia	India	Thailand	Malaysia
Inventory	44158	2815	2307	1133	918	854	848	790	165

Source: FAOSTAT.

Pig farming industry is important to national economy and people's livelihood. The Asia-Pacific region is dominated by pork consumption, and pig production is of relevant to economic development and people's livelihood. Statistics shows that the total global consumption of pork was

110.588 million tons in 2017, of which 54.935 million tons consumed by China, which was half of the world consumption.

The development of livestock industry varied among countries in Asia-Pacific region. China, Japan, Thailand, South Korea and Taiwan of China have witnessed relatively rapid development. The scale-up rate of livestock farming* in China in 2018 was 60.5%. However, the decentralized farming run by smallholder farmers still accounts for the majority of the industry in general. The level of farming management by small and medium-sized farms (households) is not high, the level of farming mechanization is low, and epidemic diseases occur frequently.

1. Application and Development Trend of Pig Farming Machinery

Pig farming machinery mainly includes fence, slatted floor, feeding equipment, disinfection equipment, environmental control equipment, waste recycling equipment and harmless treatment equipment for dead pigs. Large and medium-sized farms have outstanding characteristics with complete-set of machinery equipment and systematic machinery application while in small householder and small-scale farms, single machine operation are predominantly adopted, and machineries are used only in a few segments of the whole processing chain.

1.1 Fence and slatted Floor

The pig fence sets restrictions on the activity space of pigs and convenience for pig farming management such as herd transfer, feeding and body condition monitoring. According to different classifications, there are many categories of pig fences which are shown in Table 2. According to the object, scale and cost of farming, appropriate pig fence can be selected.

Table 2 Classification of Pig Fence

Classification Basis	Type of Pig Fence
By feeding group	Boar fence, Mating Fence, Sow Fence, Gestation Fence, Farrowing Fence, Nursery Fence , Finishing Fence, Fattening Fence
By feeding quantity	Single Fence, Group Fence
By structural type	Entity Pig Fence, Fenced Pig Fence, Integrated Pig Fence and Assembled Pig Fence
By Daily Usage	Big Fence, Gestation Crate, Farrowing Fence, Nursery Fence

The use of slatted floor can reduce the inputs of man power for cleaning, and it is easy to remove pig manure and urine, and it is convenient to keep fence sanitized. Slated floor can be made of different materials which include cement concrete, metal woven mesh, engineering plastics, cast iron, ceramics and new composite materials.

*Scale rate of livestock and poultry farming: the comprehensive level of the scale-up rate of major livestock species, that is, the proportion of more than 500 live pigs per year in the total number of stocks, the proportion of more than 2000 laying hens in the total number of stocks, the proportion of more than 10000 broilers in the total

number of stocks, the proportion of more than 100 cows in the total number of stocks, and the proportion of more than 50 meat cattle in the total number of stocks Comprehensive level. [2]

The application of pig fence is usually used together with slatted floor in pig house. The delivery bar, which is very tipical and also known as delivery bed, is shown in Fig.1. It integrates pig fence, slatted floor and feeding trough, which consists bottom bed, fence, sow position fence and piglet heat preservation area. It is convenient for sows to be fed, lie down and arise; keep the sows and piglets' activity area dry and hygienic to reduce the occurrence of diseases. It also prevents the sows from trampling, lying pressure and other accidental injuries to piglets so as to avoid the piglets from piling up when sucking, affecting piglets' feeding.

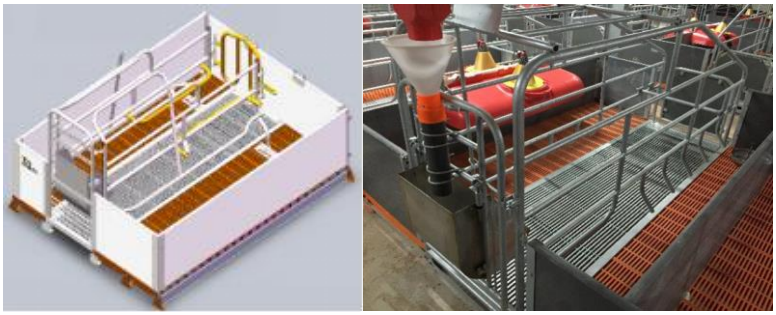
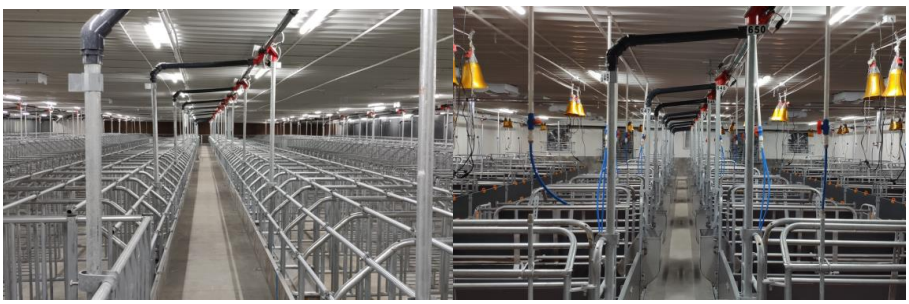


Figure 1 Delivery Bar

(Photo Source: Guangdong Nanmu Machinery Equipment Co., Ltd.)

1.2 Feeding Machinery

Feeding machineries in pig farm include: dry feed feeding system, wet feed feeding system, dry and wet feed feeding equipment and drinking water system. The dry feed system is composed of feed bin, conveying pipe, scraper chain (or spring screw), driving device, corner device and discharging mechanism. The dry feed system is widely used, which is the basic equipment for large-scale farming. The wet feed system is equipped with water conveying, mixing and wet feeding mechanisms on the basis of the dry feed system. The below shown Fig. 2, (a) is the wet feed system of the distribution room, (b) is the wet feeding system of the delivery room. The dry and wet material trough make the dry material and water automatically fall into the trough through the pigs' arch moving the discharge pipe and water dispenser to be fed after mixing. With technical progress, precision control feeding equipment such as intelligent dry and liquid feeder, breeder pig measurement system, sow group feeding system has been gradually applied.



(a) Wet feed feeding system of distribution room (b) Wet feeding system of delivery room

Figure 2 Wet feeding system

(Photo source: Guangdong Nanmu Machinery Equipment Co., Ltd.)

Large-scale pig farms generally adopt pressure water supply, and the water supply system is mainly composed of water pipe, filter, pressure reducing valve and automatic drinking water device. Water supply system includes duck beak type, nipple type and cup type (bowl type pig water dispenser) of the automatic drinking water device. Duck beak type pig automatic water dispenser is simple structural design, good sealing performance, low flow rate and pressure drop when water flows out; nipple type water dispenser is also a simple structure with good trafficability, poor sealing performance and high water flow speed, therefore, it needs to be used at a reduced pressure; bowl type pig drinking water dispenser can save water, which can avoid water directly flowing to the ground and lead to pig house humidity.

1.3 Disinfection and Anti-Epidemic Equipment

The disinfection and epidemic prevention machineries used in pig farms mainly include washing machines, sprayers, duster and flame sterilizer. The sprayer is the core machinery of mechanized disinfection. The effiects of disinfection mainly depend on its atomization performance, including droplet size, droplet range, suspension time, atomization volume and atomization rate. The duster is used for spraying powder disinfectant. The foam cleaning machine can more efficiently and thoroughly remove biofilms and contaminants attached to the enclosure environment and equipment than the high-pressure water guns. Others, such as hot water washing machine, special foaming machine, have also been applied. The flame thrower can spray high temperature above 1000℃ through liquefied gas combustion, which can kill bacteria, viruses and insect eggs in pig houses, pig fence, and food trough.

In practical application, various kinds of disinfection and epidemic prevention machinery are mostly combined, such as vehicle decontamination center, personnel (material) disinfection channel, etc. The vehicle decontamination center integrates high pressure washing, foaming, spraying and fan device. It has the functions of high pressure cleaning, foam cleaning, atomizing disinfection, cold air drying and so on, which can comprehensively disinfect the vehicles entering and leaving the area. According to the different objects of washing and decontamination, the vehicle decontamination center can be divided into open type, semi closed type and closed type, and the drying room can also be combined for using according to the situation. The operation of vehicle decontamination center needs to be equipped with wastewater collection and treatment equipment to avoid environmental pollution and the spread of pathogens (viruses). Figure 3 shows the closed vehicle decontamination center (a) and drying room (b).

(a) Closed vehicle decontamination center (b) Drying room

Figure 3 Vehicle decontamination center
(Photo source: Qingdao Shangfang Environmental Technology Co., Ltd.)

Spray equipment, including centrifugal atomization, ultrasonic atomization and two fluid atomization, are widely applied in the disinfection channels on personnel (materials) in pig farms, which requires stable spraying, good atomization effects and longer time suspension of droplet in the air. Automatic access control is often used in disinfection channels in order to prevent personnel from escaping from disinfection and ensure effectiveness on disinfection time.

1.4 In-House Environment Conditioning Equipment

The in-house environment factors in pig farms include temperature, humidity, harmful gases, dust, and etc. The equipment used includes fans, cooling pad, rolling curtains, ventilation windows, heating equipment, etc, which can realize the functions of ventilation, cooling, heating of pig houses respectively, and these equipment can be used with different combinations upon different purposes and objects. The system control is generally realized in large-scale pig farms. Figure 4 shows the physical architecture of the farming resource system.

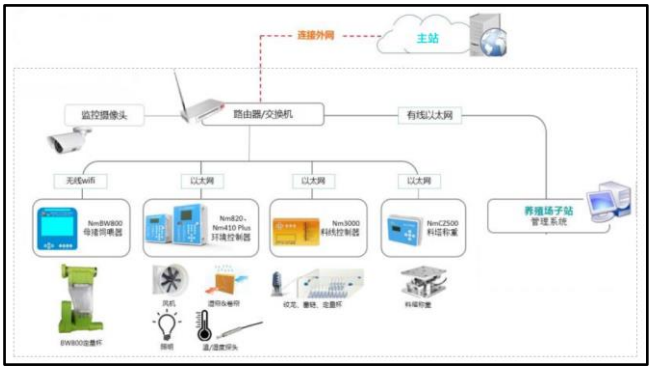
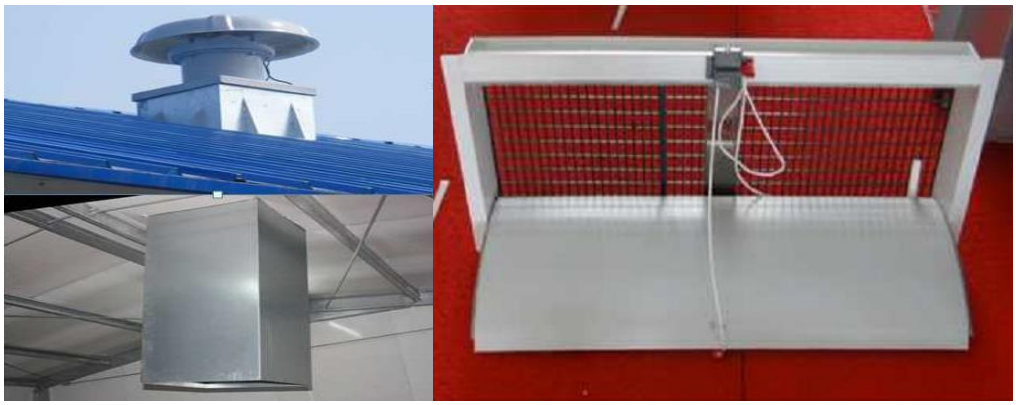


Figure 4 Physical Structure of Farming Resources System
(Photo Source: Guangdong Nanmu Machinery Equipment Co., Ltd.)

To achieve the purposes of longitudinal, transverse and vertical ventilation, the axial fan, variable speed fan, side wall ventilation windows, roof ventilation windows, roof exhaust system, roof air supply pipeline system, ventilation ceiling, upper and lower active windows, ceiling ventilation windows, rolling shutter, spray system and their combinations are usually applied in pig house. Figure 5 shows ceiling ventilation window (a) and side wall ventilation window (b) in pig house.



(a) Ceiling ventilation window (b) Side wall ventilation window

Figure 5 Ventilation window

(Photo source: Guangzhou South China Animal Husbandry Equipment Co., Ltd.)

The cooling supply for pig house mainly depends on the combination of cooling devices such as wet curtain and spray with fans. Based on the principle of evaporative cooling, the outdoor air flows through the interior to cool the indoor air. The wet curtain system is composed of wet curtain paper, wet curtain frame, water circulation system and filtration system. It can achieve the best ventilation and cooling effect when combined with fan. Fig. 6 shows the cooling system combined with fan and wet curtain.

(a) Axial fan (b) Wet curtain

Figure 6 Cooling System Assembly

(Photo source: Guangdong Nanmu Machinery Equipment Co., Ltd.)

The heat preservation equipment in pig farms includes gas furnace, air energy and water heating, heat preservation lamp, heat preservation pad, etc. Gas furnace is a kind of space heater, which usually has independent temperature control function, and can automatically adjust the starting frequency according to the set temperature; The air can be heated by water, and the water medium in the circulation system is heated by the heat pump principle to get efficient water heating. Compared with the traditional electric heating system, the energy efficiency ratio of this equipment is higher and more economical; the heat preservation lamp and heat preservation pad are territorial radiation type heat preservation, which are mainly used for drying, heating and keeping warm of newborn piglets.

1.5 Waste Treatment Machineries in Pig Farming

The waste treatment machineries in pig farming include the manure recycling equipment and the harmless treatment equipment of sick and dead pigs. In terms of resource utilization from pig manure, most of the farms in Japan and China adopt the mode of solid-liquid separation, dry manure fermentation and returning of manure to the field, and the biogas residue and biogas slurry produced from sewage by biogas engineering treatment are used for recycling purposes in agriculture. The equipment used in the collection, treatment and utilization of manure mainly includes scraper type excrement remover, solid-liquid separator, tipper, aerobic fermentation tank, biogas residue and biogas slurry pumping and discharging equipment, fertilizer spreader, and etc.

Scraper type excrement remover is divided into plate type and V-type plate type, which are shown in Figure 7. Its structure is simple and performance is stable, safe and reliable, which can greatly

reduce the cost of manure remove by manual. The solid-liquid separator can be divided into spiral extrusion type, inclined screen type, circular screen type and horizontal centrifugal type, which can greatly reduce the moisture of livestock and poultry manure (from 80% ~ 90% to 40% ~ 50%). Aerobic fermentation tank and turnovers are mainly used to treat dry manure, which can be used as organic fertilizer base material or directly returned to the field after aerobic fermentation. The aerobic fermentation tank is divided into separate type and horizontal type. The turnover has slot type, self-propelled type and other types. The dumper includes trough type and self-propelled type, and the power can also be selected from internal combustion engine or electric motor according to needs. The sewage after solid-liquid separation needs to be returned to the field after anaerobic and aerobic treatment. Biogas engineering is one of the main modes of sewage treatment, and anaerobic fermentation tank has been applied in anaerobic operation. The organic fertilizer produced by the treatment of manure can be returned to field by using of biogas residue and biogas slurry pumping equipment and fertilizer spreader.

(a) Plate type (b) V plate

Figure 7 Scraper type excrement cleaning machine

(Photo source: Guangzhou South China Animal Husbandry Equipment Co., Ltd.)

The harmless treatment equipment for sick and dead pigs mainly includes: degradator, incinerator and chemical machine. Biological bacteria and sawdust and other auxiliary materials should be added during the operation of the degradator. The cutting, grinding, fermentation, sterilization and drying of the carcass of livestock and poultry are completed in a closed cabin. Under normal pressure which is no higher than 72℃ (different due to different biological bacteria) and within 10 hours (due to the different humidity of the processed materials), the biodegradation of the rotten animal corpses by the biological bacteria generates biological heat, after that, the high temperature treatment of 120℃ can be achieved by external auxiliary heating, which can effectively kill viruses with no emission of smoke, odor or blood water. After treatment, the materials are transformed into harmless powdery organic fertilizer raw materials. Flue gas will be generated in the incinerator due to incineration, and dioxin will be released during incomplete combustion, so it must be fully burned again. The equipment for harmless treatment of corpses is usually equipped with waste gas or waste water treatment devices. During the operation of the chemical machine, the carcasses of livestock are digested in the reaction tank under high temperature and high pressure, and then transformed into sterile aqueous solution and dry matter bone slag, and the pathogenic microorganisms are completely killed. Based on whether the hot steam gas is in contacts of carcass of livestock or not, the chemical machine can be divided into humidification method and drying method. The humidifier is used more often. The humidifier is widely used. The fat and bone meal can be used as biodiesel raw material, and the bone meal can be processed to produce organic fertilizer.

1.6 Application and Development Trend of Livestock Farming Machinery

The application trend of livestock farming machinery is highlighted in the transformation and upgrading of traditional machinery by automation, information and intelligent technology. Machinery replaces labor in all links of farming industry, and intelligent equipment replaces manpower in key links of the process. Taking pig farming for an example, intelligent equipment based on intelligent recognition and big data operation has been applied in modern farms through the following four aspects.

Pig intelligent recognition and big data algorithm: through ear mark recognition or pig face recognition, voice recognition and infrared technology application, accurate, real-time and objective farming big data can be obtained. Combined with big data algorithm, pigs' weight, growth, exercise and eating health status can be observed and recorded to realize the precision of pig feeding management, growth curve analysis, epidemic prevention and control, environmental control and cluster management.

Precise and customized feeding：through the remote control of the Internet of Things, according to the feeding curve set by the system, intelligent feeding and precise feeding can be carried out for group and individual pig, and the optimal feed conversion ratio of each pig can be accurately controlled to reduce feed waste and feed cost. When a pig goes to the feeder for feeding, the file information of the pig can be retrieved through the pig face recognition to determine the amount of food that the pig can eat, and automatically feed. Pig can take food many times. When the sum of the feeding amount reaches the set upper limit, the feeder will not feed anymore to realize the accurate feeding of pigs.

Intelligent inspection of pig farm：pig farm inspection robot can accurately estimate the weight of the fattening and reserve pigs that are eating through the camera, and analyze the fat condition of the pregnant pigs that are eating; collect the sound of each fence through the sound collection device, and analyze the abnormality by using the algorithm model, carry out disease warning so as to respond in time; collect the temperature data of pigs in each fence through the infrared thermometer to detect whether the pig is in good condition, if there is a fever, timely warning should be given in time. Through a great number of farming data accumulation, inspection robot algorithm is constantly modified, and the solution provided to managers is more effective, which can greatly improve the standardization of farming process, and improve the automation level of pig farm production management.

Intelligent environment conditioning：The intelligent control system of pig house environment makes use of sensor, computer, internet and automatic control technology to realize data acquisition, storage, analysis and automatic control output. By setting intelligent environment control rules and controlling the automatic operation of environmental control equipment (such as fans, rolling shutters, ceiling windows, and etc.) under specific conditions, the environment (temperature, humidity, air quality) in the piggery can be maintained for a longer time. The high level and comfortable farming environment can greatly improve the production efficiency and reduce the production cost.

2. The Improvement of Farming Management by Mechanization

2.1 Mechanization Promotes Large-scale Farming

The extensive application of mechanization is the basis for large-scale farming. The scale and standardization of farming provide conditions for systematic application of mechanical equipment. In Asia, Japanses pig farms are established in accordance with the European and American models with high mechanization rate and complete-sets of automatic environmental control, feeding and fecal cleaning equipment. In 2012, pig farms of over 2000 heads stocks accounted for 66% of the total in Japan, of which 54.6% holds over 3000 pigs. The scale of pig industry is also accelerating in Thailand, and equipment and facilities have been rapidly applied. In 2015, the number of pig houses with the scale of more than 1000 heads reached 70% of the total. In China, industrialized pig farming started in 1980s, and gradually developed from traditional decentralized farming to industrialized and large-scale farming operations. According to the data of *China Animal Husbandry and Veterinary Statistics 2019*, the proportion of pig farms with scale of more than 500 pigs in 2018 increased to 49.1%, which was very close to the target of 52% of the pig farming scale in 2020 set in *The National Pig Production Development Plan (2016-2020)* issued by the Ministry of Agriculture and Rural Affairs of China. According to the analysis of China Agricultural Mechanization Association, the overall mechanization level of large-scale pig farming has reached 45%, of which the mechanization rate in feeding and environmental control systems is more than 60%.

2.2 Mechanization Improves Pig Farming Efficiency and Benefit

The number of pigs managed by per capita management personnel in an efficient mechanized pig farm can be 4-5 times higher than that of the traditional fattening farm which can reach 2000-3000 heads. Some studies have shown that the application of machineries makes the large-scale pig farms advantageous in reducing the cost compared with the smallholder investors, and the cost in the pig growth and fattening stage has more obvious negative correlation with the scale of farming. Table 3 shows the comparison of land use and scale of breeder pig farms of China's Wenshi Food Group Co. Ltd. in different developing stage and the efficiency of pig farms has been greatly improved with the upgrading of construction mode and mechanization level. Taking pig farm with annual production of 130,000 pigs in China as an example, through mechanization upgrading and application of precision feeding equipment, intelligent temperature control, automatic production performance monitoring, automatic water-saving equipment and sewage treatment system, the number of personnel raising 10,000 pigs has been reduced by one tenth, water consumption of pigs is reduced by 28%, feed efficiency reduced by 3%, and survival rate of nursery and fattening increased by 1% ~ 2%. The sows mating delivery rate is increased by nearly 7% reaching 86.53%, and the average qualified number of weaned piglets delivered by per sow is increased by 9% reaching 25.6 piglets on annual basis. At the same time, the mode of "leading enterprises + farming cooperatives + small household farms" gives impetus to the development of farming, promotion of structural adjustment in agricultural industrialization, and improvement of farmers' income which helps achieve good economic and social benefits.

Table 3 Comparison of Different Development Stages of Breeder Pig Farm

Order	Development stage	Construction mode	Area occupied by single pig /(m^2 / head)	Per capita efficiency (head / person)
First generation	Traditional pig farm	Layout 6-8 pig houses, brick and wood structure, open natural ventilation, traditional dry and clean manure, artificial feeding	6.8	40～50
Second generation	Large line pig farm	Layout of 5-8 pig houses, using steel structure + fully enclosed brick, semi-automatic mechanical ventilation control, semi-automatic manure cleaning, mechanical + manual feeding	6	60～70
Third generation	Industrialized pig farm	Layout of 5-8 pig houses, the use of large-span steel structure + fully enclosed brick, semi-automatic mechanical ventilation, mechanical cleaning mode, mechanical feeding	5.5	100～120
Forth generation	Storied house pig farm	It adopts reinforced concrete floor structure, with precise ventilation, automatic excrement cleaning and automatic feeding to realize automatic, information and intelligent feeding	5.3	200

2.3 Mechanization Improves Welfare of Human and Pig

With the application of automation equipment, precise management of pig farm can be realized, and the breeders can have more time to observe and manage pigs to achieve early detection of epidemic disease occurrence and treatment, and significantly reduce the mortality rate. The application of new materials and design technologies on the floor rack makes the activity and rest area of pigs more comfortable and cleaner at different growth stages, and the probability of accidental injury and bacterial infection of pigs can be greatly reduced. The automatic feeding system can reduce the contact between human and livestock, avoid the stress on pigs, reduce the feed loss, and the closed pipeline can avoid the pollution made by rat and insect vectors. The application of environmental control system and fecal cleaning system can greatly improve the environmental indicators such as ammonia, carbon dioxide, wind speed, temperature and humidity, and further create a comfortable and healthy environment for the growth of pigs to improve the health of pigs. The air filtration system can effectively filter out more than 99.5% of the 0.3-micron particles, which can block the aerosol and micro particles carrying virus or bacteria outside the pig house and cut off the transmission path, which can effectively prevent the infection of pathogenic microorganisms such as foot-and-mouth disease and asthma. The application of disinfection equipment, waste recycling equipment and dead carcass harmless treatment equipment reduce the probability of pigs and

personnel infected by epidemic diseases to achieve healthier environment for pigs and employees.

2.4 Mechanization Improves Human Living Environment

Livestock and poultry industry have great impacts on environment. Livestock and poultry farming wastes include feces, urine, shed flushing sewage, dead livestock and poultry, farming bedding materials, livestock placenta and waste gas, and etc., of which, feces, urine and shed flushing sewage are the main contaminants. According to the data released by the first pollution sources census in China in 2007, the amount of chemical oxygen demand (COD), total nitrogen (TN) and total phosphorus (TP) of livestock and poultry farming industry accounted for 41.9%, 21.7% and 37.9% of the total emissions respectively. Livestock and poultry farming pollution source ranks the third largest pollution source following industrial pollution, domestic sewage and garbage pollution. [3] In recent years, the Chinese government has been committed to improving the environment and pollution control, encouraging the improvement of farming technologies, including, using dry and clean manure instead of water to flush manure; using water-saving water dispensers to increase source emission reduction; encouraging the resource utilization of livestock and poultry manure and the harmless treatment of dead livestock and poultry carcasses; providing policy support to improve the rate of equipped machineries and comprehensive utilization rate of livestock and poultry manure treatment facilities.

The analytical results of China's second pollution sources census data show that: the emission intensity of COD, TN and TP has decreased by 55.5%, 67.2% and 57.9% respectively compared with the statistics as of 2007; water flushing of manure has been replaced by dry and clean mode, and the daily sewage reduction rate has reached 60%; in 2017, the proportion of China's large-scale pig farms adopting dry and clean manure process has reached 81%, and the proportion of water flushing manure has decreased to 9%, which greatly increases the collection rate of solid manure promote the resource utilization of manure and reduce the emission of pollutants. [3] According to the statistics generated by the Ministry of Agriculture and Rural Affairs of China, the comprehensive utilization rate of livestock and poultry manure and the rate of equipped facilities on manure treatment reached 74% nationwide in 2018, and 86% in large-scale farms. At the same time, large-scale farms basically realized the harmless treatment of the dead livestock and poultry, and centralized treatment on dead livestock and poultry from small-scale farms was adopted. The utilization of manure resources and the application of harmless treatment equipment for dead pigs can avoid soil pollution caused by feces which contain a great number of bacteria and insect eggs. The application of mechanization has greatly promoted the disposal efficiency of livestock and poultry farming waste, effectively reduced the pollution discharge, improved the living environment, and laid foundation for the sustainable development for livestock industry.

3. Mechanized Solutions for Prevention and Control of Zoonosis

3.1 Role of Mechanization in Prevention and Control of Zoonosis

Mechanization plays an important role in improving the disinfection efficiency, which can greatly enhance the capacity of farms to deal with zoonosis and effectively improve the health level of pigs

and farming practitioners. The prevention and control measures for zoonosis in farms are mainly to kill pathogens and biological vectors, block transmission routes, and isolate susceptible human and livestock. Personnel, vehicles, pigs, materials, feed, water, waste, vector pests (mosquitoes, flies, mice, birds, etc.) involved in the farming process, as well as the air and facilities in the house, are the objects of prevention and control. The prevention and control areas include the inside and outside of the farm and its associated environment. Among them, the mechanized disinfection mainly includes the disinfection of personnel, vehicles and materials, and the disinfection of production areas, living management areas and isolation areas, and the harmless treatment and disinfection of livestock and poultry corpses. Farms need to implement the rule of "overall prevention and control, human and livestock prevention together".

The function of mechanized prevention and control not only depends on the scientific and targeted design of disinfection and control program, overall consideration on the whole process and key linkages, but also depends on the integrated connection of mechanical facilities, farming technologies and anti-epidemic drugs. These measures also need to be strictly implemented in accordance with the prevention and control regulations. The main links of mechanized prevention and control include: user friendly design of machineries, the sanitary guarantee of feed, water and air by mechanization, and the mechanized disinfection.

3.2 User Friendly Design on Farm Mechanization

The installation and construction of mechanical facilities should be fully considered in the farm planning to facilitate the operation of machinery and facilitate the implementation of epidemic prevention and control measures. The construction land for vehicle washing and decontamination center should be reserved at the vehicle entrance of pig farm, and the construction land for silo of feed transit center and transit pig house should be reserved for large and medium-sized pig farms. The pig farm should be laid out by the production area, the living management area and the isolation area, and should be separated by walls or isolation belts. In the production area, pig breeder houses, sports grounds, delivery house, nursery houses, grown houses, fattening houses and relevant auxiliary facilities shall be constructed in forward direction. The layout of pig house should meet the requirements of epidemic prevention, production, passage and sewage discharge. The site area and design should meet the requirement of the installation and use of pigsty, floor facilities, feeding, environmental control and disinfection equipment. The living management area should be equipped with personnel washing channel and material disinfection channel, and the doors and windows should be provided to prevent mosquito, fly, mouse, bird and other vector biological intrusion. The roads in the site shall be divided into clean roads and sewage roads, and cross use of roads should be prohibited. Light and dark isolation ditches should be built to discharge sewage and rainwater which also play a role for isolation in the field. In the isolation area, pig houses and farming waste facilities should be built and used as the distribution center of organic fertilizer.

3.3 Sanitation on Feed, Water and Air

Farm can achieve health and sanitation purposes on feed, drinking water and air through equipped facilitations with automatic feeding system, automatic drinking water system, meditation system

and air filtration system. The closed feed pipeline can isolate the contacts between biological vectors and feed to a greater extent and further block the transmission path of diseases. The automatic drinking water and medicine system provide clean water for pigs by filtering and sterilizing the drinking water. The air filtration system can remove harmful gases, dust and pathogens in the environment, and ensure the fresh and clean air in the pig house.

3.4 Mechanized Disinfection in Farms

3.4.1 Disinfection of Vehicles, Personnel and Materials

According to the actual needs, farms should set up reasonable disinfecting facilities and equipment. Large and medium-sized farms should be equipped with relatively comprehensive disinfecting facilities and equipment. Small farms can adopt more flexible disinfecting methods. Please refer to Table 4 for configuration. Taking pig farms for an example, large and medium-sized pig farms are suitable for the construction of comprehensive disinfecting stations, which are generally 1-3 kilometers away from the production area. The disinfecting station consists of vehicle disinfection center, personnel disinfection channel and material disinfection room, which has the functions of disinfecting external vehicles, personnel and materials. The vehicle disinfection center should meet the requirements on daily frequency of entering vehicles and vehicle body length. In order to reduce the construction cost and improve the utilization efficiency of facilities and equipment, it is more appropriate to jointly establish disinfection center with several small scale farms which are located closely to each other. At the same time, distributed disinfecting equipment should be given full play and personnel disinfection channel should be established.

Table 4 Reference Configuration of Disinfecting Facilities and Equipment in Livestock Farms

Scale	Facilities and equipment
Large scale	Personnel disinfection channel, vehicle disinfection center (automatic cleaning drying system), vehicle disinfection channel, material disinfection room
Medium scale	Personnel disinfection channel, vehicle disinfection center (automatic cleaning drying system), vehicle disinfection channel, material disinfection room
Small scale	Personnel disinfection channel, vehicle disinfection center (equipped with multiple farms) or equipped with mobile high-pressure foam cleaning machine, electric ultra low volume sprayer.

Disinfection on in-coming vehicle includes disinfecting on car surface and driver's cab. Vehicle body surface disinfecting includes pre-cleaning, foam cleaning, deep cleaning, spray disinfecting, high temperature drying and disinfecting. After the vehicle body surface is disinfected, the driver's cab should be disinfected by spray. The droplet diameter is 20~50μm and 10~20μm respectively each time, and the spray duration should be 1~5 minutes (shown in the Table 5). After the 5-minutes is finished, the driver can be allowed to enter the cab.

Table 5 Parameters Recommended Values and Disinfecting Equipment for Vehicles Entering the Site [4]

Segment		Equipment name	Parameter name	Recommended value
Vehicle body surface disinfecting	Pre cleaning	Automatic vehicle cleaning equipment or high pressure cleaning machine	Pressure	16~18Mpa
			Flow	20~25L/min
	Foam cleaning	Automatic foaming equipment (or high pressure cleaning machine with foaming function)	Pressure	6~8Mpa
			Flow	70~90L/min
			Soaking time	10~15min
	Deep cleaning	Automatic vehicle cleaning equipment or high pressure cleaning machine	Pressure	16~18Mpa
			Flow	20~25L/min
	Spray disinfecting	Automatic spray disinfectant device or electric ultra low volume sprayer	Droplet size	80~150μm
	High temperature drying	High temperature drying equipment	Temperature	65℃
			Duration	20~30min
Cab disinfecting		Electric ultra low volume sprayer	Droplet size	20~50μm
				10~20μm
			Duration	1~5min

Disinfection on personnel includes body surface disinfection, hand disinfection, sole disinfection and upper respiratory tract disinfection. The body surface disinfection uses spray equipment, the sole and the hand may use the disinfection basin, the disinfection pool and so on. The choice of spray disinfectant is very important and must be safe and efficient. Attention should be paid to the effectiveness of personnel disinfection to avoid malicious escaping from disinfection. If necessary, automatic control access control system can be used to ensure disinfection time. When disinfecting the materials entering the site, special attention should be paid to the chemical characteristics of the materials, and the disinfectant should be selected carefully to avoid chemical reaction between the disinfectant and the materials. Medical materials need to be sterilized by special medical high pressure sterilizer. The recommended equipment and parameters of personnel and materials disinfection are shown in Table 6.

Table 6 The Recommended Equipment and Parameters of Personnel and Materials Disinfection [4]

Segment	Equipment	Parameter	Recommended value
Disinfection of personnel entering the site	Automatic spray disinfectant device or electric ultra low volume sprayer	Droplet size	40~60μm
		Duration	1~5min
Materials enter the field to disinfect	Automatic spray disinfectant device or electric ultra low volume sprayer	Droplet size	5~10μm
		Duration	10~15min

3.4.2 Disinfection on Production Management Area

Spray disinfection should be carried out on the periphery of key areas such as toilets, canteens, garbage stations and other areas with dense population or more pollution sources. Through the establishment of rat bait station, fly trap, trap lamp, bird repellent lamp and other facilities, the infection routes of mice, mosquitoes and birds can be controlled. The disinfectant should not be sprayed on the surface of food or tableware. The recommended equipment and values of their parameters in production management area disinfection are shown in Table 7.

Table 7 The Recommended Equipment and Values of Parameters in Production Management Area Disinfection [4]

Content	Equipment	Parameter	Recommended value
Outdoor environment	Mobile spray disinfectant equipment	Droplet size	80~120μm
		Spray width	12~15m
		Frequency	1 times / day
	Rat bait station	Space	15~30m
	Automatic intelligent mousetrap	Coverage area	7.5 mu
	Laser bird repellent	Coverage area	12 mu
Indoor environment	Electric ultra low volume sprayer	Droplet size	60~80μm
		Frequency	1 times / 2 days
	Rat glue	Space	2 places /15 ㎡
	Insect trap lamp	Coverage area	1 places /（80~150 ㎡）

3.4.3 Disinfection on Production Area

Disinfecting in the production area includes the disinfection on the personnel entering the production area, the disinfection on houses with livestock and houses without livestock, and the disinfection on the external environment of the production area.

As the personnel entering the production area will move in the shed and get in touch with the staff in other areas, it is easy to carry and spread pathogens, therefore, necessary disinfection should be carried out before the personnel enters the farm. Personnel disinfection procedures include: body surface spray disinfection - bathing and changing clothes - body surface spray disinfection. The recommended parameters values and the disinfection equipment for personnel surface spray are shown in Table 6. The working clothes should be specially used by special personnel (disposable work clothes can also be configured), and comprehensive disinfection should be carried out after replacement. The frequency of disinfection depends on the number of people going back and forth between the production area and the production management area.

The disinfecting of the livestock house is divided into disinfecting with livestock and disinfecting on empty house. The disinfecting on the house with livestock is mainly carried out when the pigs

are in the period of low immunity, which is the period of high incidence of pig infectious diseases. It kills pathogenic microorganisms on the surface of pigs and the suspended solids in the air of pigs, reducing the risk of infection. An automatic spray disinfection system can be set up in a large and medium-sized pig farm. The system can operate according to the set-time procedure, and the scope of spray disinfection should cover every corner of the livestock houses. The pesticides used in farms should not cause damage to the respiratory tract of the livestock and breeders. Empty house disinfecting is an important means to stop the spread of disease in the farm in order to avoid the spread of diseases among generations of livestock. Empty house disinfecting generally include pre-cleaning, foam cleaning, deep cleaning, spray disinfecting and vector pest disinfecting. After cleaning the livestock, then cleaning the excrement and dirt in the houses which should avoid water rushing and prevent enlarging the pollution surface, and spray disinfection can be adopted. After cleaning up the houses, the empty houses are needed to be thoroughly sterilized. The ceiling, walls, pigsty, bed and drainage ditch should be sterilized according to the order from top to bottom. After spray disinfection, the air house is airtight fumigated and sterilized. After disinfection, the empty house should be completely sealed for more than 72 hours. For the contaminated house, the flame sterilizer can be used to disinfect the surface of non-combustible materials, facilities and equipment in the pigsty, such as pigsty, floor and trough to completely disinfect the pathogen. The recommended values of parameters and disinfectant spraying equipment of the pig housing are shown in Table 8.

Table 8 Recommended Values of Parameters and Disinfecting Spraying Equipment of the Pig Housing[4]

Link		Equipment	Parameter	Recommended value
Disinfecting with livestock		Automatic spray disinfectant device or electric ultra low volume sprayer	Droplet size	50~80μm
Empty house disinfection (after each house cleared)	Pre-cleaning	Centralized constant pressure cleaning equipment or high pressure cleaning machine	Pressure	16~18Mpa
			Flow	20~25L/min
	Foam cleaning	Automatic foaming equipment or high pressure cleaning machine with foaming function	Pressure	6~8Mpa
			Flow	70~90L/min
			Soaking time	10~15min
	Deep cleaning	Centralized constant pressure cleaning equipment or high pressure cleaning machine	Pressure	16~18Mpa
			Flow	20~25L/min
	Spray disinfecting	Automatic spray disinfectant device or electric ultra low volume sprayer	Droplet size	50~80μm

External environment of the production area include ground, house, equipment, roads, and spray disinfectant is usually adopted (as shown in Table 9). For the key epidemic prevention and control areas such as garbage station, septic tank, sewage channel, livestock and poultry products transfer area, silo, water tank etc., high-pressure cleaning machine can be used to carry out high-pressure

disinfectant. Facilities such as rat bait station, fly trap, trap lamp and bird repellent lamp can be set up in the production area whereas necessary.

Table 9 Recommended Values of Parameters and Disinfecting Equipment in External Environment [4]

Link	Equipment	Parameter	Recommended value
Spray disinfecting	Mobile spray disinfectant equipment	Spray width	12~15m
		Droplet size	80~120μm
		Frequency	1 times / day
High pressure disinfecting	High pressure cleaning machine	Pressure	16~18Mpa
		Flow	20~25L/min

3.4.4 Harmless Treatment on Dead Pigs

Treatment on dead pigs should strictly follow the principles of pollution control, environmental protection and human safety. When dead pigs are found in the process of pig farming, they should be isolated as soon as possible. Professionals should check in the designated area of the farm, and harmless treatment equipment for dead pigs should be used or transported to the designated place by professional institutions for treatment. Dead pigs caused by anthrax and other zoonotic infectious diseases should be treated with mortars. Special transport vehicles or refrigerated transport vehicles should be used to transport livestock carcasses. Attention should be paid to the protection to avoid the spread of pollution. If the epidemic situation is suspected, it shall be reported and handled in time according to the relevant national regulations. During this period, fungicide should be appropriately selected according to the type of epidemic disease and disinfecting should be reinforced in the production area. The parameters of temperature, time and pressure should be strictly controlled according to the operation instructions to ensure the effect of body treatment. The exhaust, waste water and residue generated from the operation should be treated in time according to relevant national regulations.

3.4.5 Integrated Combination of Mechanized Disinfection with Farming Technologies and Disinfectant Selections

Attention should be paid to the integrated combination of mechanized disinfection with farming technologies and disinfectant selections in the process of prevention and control of zoonosis. For example, for pigs of age 15 days in 40~60 days of low immunity period, that is a period of high incidence of porcine infectious diseases. It is necessary to strengthen the mechanized spray disinfection in livestock farms, which can effectively prevent and control epidemic diseases from happening. In addition, foot-and-mouth disease virus, which causes the type A infectious disease for pigs, is a kind of no capsular virus. The virus can survive for a long time under low temperature conditions with resistance to heat and drying, but it is sensitive to acid and alkali. It can be quickly inactivated when pH is lower than 6 and pH is higher than 9, and can be instantly inactivated when

pH is lower than 3. In view of these characteristics of the virus, 3% polyhydrin ether complex iodine can be selected as disinfectant with strong acid effects, and the disinfecting on foot-and-mouth disease virus is effectual when diluted by 1:500. Therefore, combining the farming technologies, selecting the correct disinfectant, and strictly following the prevention and control procedures, can better exert the effectiveness of mechanization.

3.4.6 Main Factors Restricting Mechanized Prevention and Control

At present, in the management of livestock and poultry farming in Asia-Pacific region, the application level of mechanized prevention and control is generally not high. The major constraints are demonstrated as follows.

(1) The overall capacity on epidemic diseases prevention and control is insufficient. Severe acute respiratory syndrome (SARS) in 2003, influenza A (H1N1) in 2009 and covid-19 virus outbreak since 2019 have all caused great losses to human beings. Asia-Pacific countries are inadequate of management and technical response measures in the overall prevention and control of major epidemics. Capacity building, capital and equipment investment in the epidemic prevention and control system need to be increased. The safety, reliability, and innovative progress and application of prevention and control technologies need to be further improved.

(2) The disease prevention and control in small-scale and small householder farms is very weak. Smallholder farms are dominant in many countries in Asia-Pacific region, and the mechanization level of livestock farming is very low, which mainly rely on manual operation, so it is difficult to achieve mechanized operation in prevention and control of diseases. Moreover, the practitioners directly engaged in livestock farming, epidemic prevention, feed production, equipment manufacturing, and farming services demonstrate inadequate adherence to the epidemic prevention and control rules on "Prevention Is Priority". In addition, it was found that practitioners are lack of consciousness on the importance of the overall prevention and control effort. Instead, they affect to rely on medication treatment and vaccines. This becomes difficult to bring prevention and control measures in place, and it is difficult to adopt mechanized prevention and control measures in a wider range. The occurrence of epidemic diseases in small-scale farming and small household farming will increase the overall risk of farming

(3) The research and application systems on mechanized disease prevention and control are yet complete. Research on disease pathology and livestock physiology is the fundamentals for the development of disease prevention and control. Mechanized disease prevention and control requires an effective combination of prevention and control space, time, and medicines to effectively kill pathogens and biological vectors, block transmission routes, and isolate vulnerable infected humans and animals. In Asia-Pacific countries, the research and application systems for epidemic prevention machineries are inadequate, the integration on disease prevention and mechanization technologies is slow, and the overall level of effectiveness of machinery operation is not high. For example, the use of spray and disinfection in the epidemic prevention are mixed with the use of spray for plant protection, resulting in failure of epidemic prevention or harm to humans and animals.

(4) The role of specialized service organizations in livestock farming is yet fully played. Professional service is an important part of service industry in livestock farming. In the production process of livestock farming, specialization stands outstanding for livestock waste treatment and disease prevention and control. Due to different efficiencies in different farms and the cognitive levels of practitioners, large and medium-scale breeding farms usually choose professional social services, such as the harmless treatment of livestock and poultry carcasses, and fire-fighting services for disease vectors. However, small-scale farms and smallholder farmers mainly carry out the work of the kind on their own, and the effectiveness is far poorer than that of specialized operations.

3.4.7 Opportunities and Challenges Faced by Mechanized Prevention and Control

With rapid development of agricultural machinery industry and information technology, particularly, the widely-adopted application of automatic control technologies and sensor technologies applied in traditional machinery, the deep integration of big data and Internet of Things technology with mechanization enables mechanized solution to play a greater role in disease prevention and control system with stronger target-orientated function. At the same time, more attention should be paid to the integration of mechanization with farming technologies and drug control technologies. African pig fever and Coronavirus disease and COVID-19 are threatening the safety of farming and human livelihood. According to a report by the World Organization for Animal Health (OIE), between June 26 and July 9, 2020, the number of pigs killed by African pig fever in Asia was 16,894, accounting for 96.2% of the global total in the corresponding period of previous year. In response to the COVID-19 pandemic, the Asia-Pacific region has learned the lessons and accumulated extensive effective prevention and control experiences. As early as 1951, the *Livestock Infectious Disease Control Act* was promulgated in Japan making clear regulations for the outbreak, transmission and control measures on zoonotic diseases. In 1953, the implementation rules of the law were promulgated by the Ministry of Agriculture, Forestry and Fisheries, Japan, which clearly defined the application of the disinfecting equipment such as sprayers [5] [6]. The National Zoonotic Committee was established in Indonesia in 2011 aiming at enhancing the ability of disease prevention and control through international cooperation, data sharing and laboratory diagnosis. At the same time, Indonesia also faces many challenges, such as government management is more decentralized, budget is insufficient, geographical dispersion and local veterinary professionals are insufficient which also faces many challenges, such as government management authority is not centralized, budget is insufficient, scattered geographical conditions and local veterinary professionals are inadequate. The Chinese government has requested that biosafety should be incorporated into the national security system, and at the same time, the national biosafety risk prevention and control system construction should be systematically planned, and the national biosafety governance capacity should be improved in a comprehensive way. The biosafety law should be taken effect as soon as possible to accelerate the construction of the national biosafety legal system and institutional guarantee system. The consciousness among livestock farming operators on "Overall Prevention and Control" and "Prevention Is Priority" has been further strengthened and unified, and consensus has been achieved on improving the integration of both software and hardware facilities related to biosafety. It is significant to summarize and highlight the successful experiences and proven technologies on mechanized prevention and control in order to meet the requirements of biological safety risk prevention and control process.

Standardized scale livestock farming is the main direction of modern farming development. However, in a certain period, large-scale livestock farming and large number of small household farms will continue to coexist. On the one hand, standardization construction on large-scale farms should be accelerated; on the other hand, the mode- "company +small farmer" and "community farming" should be up-scaled and extended, which shall help and lead the smallholder farmers to integrate their farms into modernized farming and thus improve the overall scale of livestock farming industry. According to different scale farms, related rules for allocation of mechanized prevention equipment should be formulated and social organizations should be encouraged to carry out professional disinfection and control services in order to provide effective epidemic prevention solutions for scale farms and individual smallholder farms.

4. Measures and Suggestions for the Development of Farming Mechanization

Countries in Asia-Pacific region should draw lessons from each other's development experience according to their national conditions, formulate development plans and practical action plans, and constantly improve the level of scale, mechanization and intelligence of livestock farming on an on-going basis. Proposed measures for the development of livestock farming mechanization in Asia-Pacific region are suggested as follows.

4.1 Scientific and technological innovation and new technology promotion should be strengthened: to increase collectively integration and innovation of livestock farming equipment technologies with livestock health, disease prevention and control, as well as environmental control technologies; to strengthen the fundamental research on new materials and information technologies; to accelerate the application of automation, information and intelligent equipment technologies in statistical monitoring, genetic improvement and production performance testing; to build a safe and stable Internet of Things for the livestock farming industry; and to carry out agricultural machinery test, demonstration and promotion, and improve the supply of green, safe and efficient livestock machineries.

4.2 Appropriate scale livestock farming, and standardized farm construction should be encouraged: to achieve sound development of livestock farming and planting industry in a harmonized way, encourage the proper disposal of farming wastes locally or in nearby areas and promote the re-use of organic fertilizer. It is significant to promote the standardized livestock farming farms, innovation of facility farming mode, scientific planning and appropriate scale mechanization design. It is also important to strengthen the guidance on collectively integrated technologies of large-scale farming facilities and equipment, and promote the whole-process mechanization to be applied in the livestock farming industry.

4.3 Science-based mechanized prevention and control measures on epidemic diseases and mechanization application should be persisted: to incorporate the provisions on prevention and control of epidemic diseases into administrative laws and regulations; to formulate technical specifications for mechanized disinfecting and strengthen the technical guidance for the equipment operation; support should be provided to large scale farms (zones) for equipping with facilities with

automatic environmental monitoring and control, utilization of livestock and poultry manure, and harmless treatment of dead livestock and poultry carcasses to reduce the risks of disease occurrence in the larger farming environment resulted from preventive failure by individual famers households.

4.4 Greater significance should be attached to the role of market-oriented, socialized and professional service organizations: to promote the farming mode of "company + small farmer (family farm)" with objective to guide and support small-scale farmers to develop standardized and large-scale farming operations; to give full play to the role of market-driven activities encouraging social service organizations to provide specialized services including efficient silage (grass) harvesting and processing, utilization of manure and sewage resources, storage and transportation of livestock products, safety and decontamination, and epidemic prevention.

4.5 Government support and financial insurance support should be up-scaled: governments should establish an incentive mechanism for the construction of large-scale farms increase the supports for farms and farmer households for purchase of livestock machineries and equipment; to encourage financial institutions to carry out mortgage loans for livestock machinery and equipment. Temporary loan discount should be offered to improve the coverage of policy-driven insurances for the livestock industry.

4.6 Training and educational programmes for practitioners should be carried out to engage in extensive international exchanges and cooperation: to expand training for practitioners through intensified learning sessions on livestock facilities and equipment knowledge; foster technical personnel on livestock machinery operation and maintenance; and improve the overall competency of the practitioners in the livestock industry sector. Agricultural mechanization sector/department of countries should strengthen the cooperation with other sectors/departments such as animal health, epidemic control and environmental protection. Experiences exchange, data sharing, cooperation with international organizations such as World Health Organization (WHO), World Organization for Animal Health (OIE) and Food and Agriculture Organization of the United Nations (FAO) should be enhanced.

5. Summary

Scale production and mechanization of livestock farming industry in Asia-Pacific region have great development potential with both opportunities and challenges. Countries should make full use of mechanization to prevent and control zoonotic diseases from taking place in the scale livestock farming. At the same time, attention needs to be attached to help and lead smallholder farmers, through the intervention of social service providers, to improve livestock farming management for effective supply of livestock products, environmental protection and disease prevention to ensure the health of human and help achieve sustainable development in livestock farming industry in the Asia-Pacific region.

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