RABBIT PRODUCTION UNDER GLOBAL CRISIS OF CLIMATE CHANGE AND COVID-19 PANDEMIC

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ABSTRACT

Under a dramatic loss of human life worldwide and an unprecedented challenge to public health, food systems and jobs by the COVID-19 pandemic, the objective of this review paper is to introduce rabbit production as a good future perspective of food production with the widen urbanization areas, narrower agricultural lands and seriously epidemic diseases for animals and human beings. Rabbit production is easy to apply modernized and automatic systems with low water consumption, environmental pollution and producing areas. However it produces more meat products in a production unit compared to these of other animal species. Rabbit is an herbivore species, which produces lower greenhouse gases compared to ruminants. The COVID-19 pandemic caused health and human crisis threatening the food security and nutrition people around the world and its relation to rabbit outbreaks are also presented in this paper.

In recent years rabbit population continue to increase in the developing countries such as China, Indonesia, Vietnam, etc. for improving meat production by better use of green forages as compared to the developed ones. However in many farms in Italia, France, Germany, etc. the rabbit production is applied the modernized feeding systems and improved breeds with higher performance.With the increasing human population in the big cities, animal production systems in the urban areas to supply foods for them are necessary to change from the high to the low pollution, but higher yield and quality of products. Therefore a selection of animal species for raising to improve food production and human livelihood, and to adapt to negatively global changes is necessary.

Keywords*:* *animal protein, drought, greenhouse gases emissions, outbreak**,** rodent, solution.*

INTRODUCTION

It was reported that the COVID-19 pandemic has led to a dramatic loss of human life worldwide and presents an unprecedented challenge to public health, food systems and the world of work. The economic and social disruption caused by the pandemic is devastating: tens of millions of people are at risk of falling into extreme poverty, while the number of undernourished people, currently estimated at nearly 690 million, could increase by up to 132 million by the end of the year (WHO, 2020). While food crisis has caused recently severe problems in many countries of the world due to an increasing human population and worsening economic development, and global climate change has made these problems even more serious (Nguyen Van Thu, 2019). Alda et al. (2018) in their study concluded that in all regions of the world, increases in environmental temperature have been reported and predicted, indicating a trend towards a continuous increase for the next 50 years. The adaptation of animals and production systems to environmental variations and the possible lower input of resources may be fundamental for the sustainability of food production in agro ecosystems. To increase carbon footprint mitigation and animal adaptation to the adverse effects of climate change on animal production systems are very important, since a large part ofthe world's herd is in regions where animals are exposed to extensive systems and thus subjected to substantial fluctuations in environmental conditions. Climate change is a global phenomenon that results in global warming, droughts, flooding and depletion of natural resources (Naqvi and Sejian, 2011). In tropical developing countries which are highly vulnerable to climate change since their economy predominantly relies on agriculture that totally depends on natural factors. Under climate change in many regions along the coasts sea level rise, droughts, lack of fresh water for human and livestock consumption in dry season caused more serious problems of dead crops, low animal production and diseases (Nguyen Van Thu, 2018). Traditional farming systems practiced, which have low technological capacity, cannot help to adapt and mitigate drastic climate change (Tubiello, 2012), while the animal disease outbreaks have recently caused the heavy loss of the animal herds in the Word i.e. the African swine fever (ASF) and bird flu outbreaks reported in China, Vietnam, Korea, Nepal, Cambodia, etc. negatively global changes is very important for livestock production. The rabbit known as small herbivore animal placed after chicken for meat, which can be a great source of food production with advantages of very fast growing, better food converting rate, high productivity, small keeping space, less cost production and risks of disease outbreaks, and tasty and nutritious meat. Rabbit production is easy to apply modernized and automatic systems with low water consumption, environmental pollution and greenhouse gas emissions compared to other animal species (Nguyen Van Thu, 2010). Rabbit also has biological characterizations to tolerate high ambient temperature, diseases and variable markets. Therefore, the aim of this paper is to present problems of the World crises and rabbit production as a candidate practice to improve economic benefits, food supply and health care for human demands under COVID-19 pandemic.

COVID-19 pandemic and food security

The COVID-19 pandemic is caused by infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus strain. On 11 February 2020, the World Health Organization (WHO) named the disease "COVID-19", which is short for coronavirus disease 2019. The virus that caused the outbreak is known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a newly discovered virus closely related to bat coronaviruses, pangolin coronaviruses, and SARS-CoV. The scientific consensus is that COVID-19 has a natural origin. The probable bat-to-human infection may have been among people processing bat carcasses and guano (Wikipedia, 2020). The COVID-19 pandemic is a health and human crisis threatening the food security and nutrition of millions of people around the world. Hundreds of millions of people were already suffering from hunger and malnutrition before the virus hit and, unless immediate action is taken, we could see a global food emergency. In the longer term, the combined effects of COVID-19 itself, as well as corresponding mitigation measures and the emerging global recession could, without large-scale coordinated action, disrupt the functioning of food systems. Such disruption can result in consequences for health and nutrition of a severity and scale unseen for a long time.

In the COVID-19 crisis food security, public health, and employment and labor issues, in particular workers' health and safety. Adhering to workplace safety and health practices and ensuring access to decent work and the protection of labor rights in all industries will be crucial in addressing the human dimension of the crisis. We are facing an impending global food emergency of unknown, but likely very large proportions. The outbreak of the COVID-19 pandemic and the control and mitigation measures enforced worldwide, combined with the massive economic impacts of these necessary measures, and are the proximate causes of this emergency. Conflict, natural disaster, and the arrival of pests and plagues on a transcontinental scale all preceded COVID-19 and serve as additional stresses in many contexts. But there are also deep structural problems in the way our food systems function. We are committed to pooling our expertise and experience to support countries in their crisis response measures and efforts to achieve the Sustainable Development Goals. We need to develop long-term sustainable strategies to address the challenges facing the health and agricfood sectors. Priority should be given to addressing underlying food security and malnutrition challenges, tackling rural poverty.

Climate change, livestock production and disease outbreaks

Green housegases and climate change

Enteric fermentation of livestock and animal wastes, and methane emissions occur during the production and transport of fossil fuels. As the concentration of GHGs increases, more heat is trapped in the atmosphere and less escapes back into space. This increase in trapped heat changes the climate and alters weather patterns, which may hasten species extinction, influence the length of seasons, cause coastal flooding, and lead to more frequent and severe storms, all of which will have negative effects on human activities, life and the environment, such as agricultural production, outbreaks, and disasters (Nguyen Van Thu, 2015) .

The relationship between GHG emissions and climate change and sea level rise has now been accepted and cannot be ignored in any discussion on future agricultural practices. Sea level increases will undoubtedly lead to considerable areas of fertile delta being removed, and weather patterns will certainly change, leading to more intense droughts and/or flooding rains at times. Crop and animal production systems have been adapted to drought, flooding, and saline water effects in a number of areas in Southeast Asia, such as Vietnam and Bangladesh. It has been suggested that we are now entering a stage where grain-based animal production will become increasingly expensive across the globe as there is increased competition for resources for food, feed, and fuel. Consequently, animal production industries based on herbivores will require extensive development to exploit a wide range of waste byproducts from agriculture or from land that is not dedicated to food or biofuel production (Leng, 2008).

Livestock production

Livestock production is very crucial to supply animal protein, which is essential for solving the malnutrition of human population in the World. However, its development depends on many factors such as climate, geography, soil fertility, technologies, production conditions, disease outbreaks, etc. The World livestock population is presented in Table 1.

Table 1. World livestock population (thousand head) and its annual change (%) from 2015-2018

Animal species	Year				Annual Change, %
	2015	***2016***	***2017***	***2018***	
Buffaloes	199,732	202,613	204,265	206,601	0.860
Cattle	1,449,085	1,468,399	1,473,287,	1,489,745	0.701
Pig	991,319	984,823	970,539	978,332	-0.328
Sheep	1,179,282	1,192,681	1,201,076	1,209,467	0.640
Goats	997,666	1,021,738	1,029,333	1,045,916	1.21
Rabbits	296,380	295,678	308,482	307,951	**0.976**
Chickens	21,678,753	22,826,754	23,212,565	23,707,134	2.34

Source: FAOSTAT (2020) adapted by Nguyen Van Thu (2020)

The development of World animal population from 2015 to 2018 showed that it was still continuous, while this was reduced for pig production. The higher population development was for chickens and goats. It is possible to explain that their production is more advantages of short times, less pollution and adapting to climate change. Intensive animal production systems produce high levels of nitrogen and phosphorus wastes, and concentrated discharges of toxic materials, and yet are often located in areas where effective waste management is more difficult. The regional distribution of intensive systems is usually determined not by environmental concerns but rather by ease of access to input and product markets, and relative costs of land and labor.

In developing countries, industrial units are often concentrated in peri-urban environments because of infrastructure constraints. More than one-third of the World's methane emissions is said to be generated by rumen bacteria in farm animals such as cows, sheep and goats. As a GHG, methane is 20 times more powerful than carbon dioxide, which has led to researchers investigating ways to reduce this 900 billion ton annual release of methane (Innovative News 2010). Although much evidence has been amassed on the negative impacts of animal agricultural production on environmental integrity, community sustainability, public health, and animal welfare, the global impacts of this sector have remained largely underestimated and underappreciated. In a recent review of the relevant data, Steinfeld et al. (2006) calculated the animal agricultural sector's contributions to global GHG emissions and determined them to be so significant that measured in carbon dioxide equivalents they surpassed those of the transportation sector. However some non-ruminant species such as horse, rabbit, guinea pig, which are also fed by forages, they produce much less GHG emissions due to the fiber was mainly digested in the ceacum (Nguyen Van Thu, 2015).

Animal disease outbreaks

Climate change is increasing the incidence of viral disease among farm animals, expanding the spread of some microbes that are also a known risk to humans (Medicalxpress, 2009). Vector-borne diseases are especially susceptible to changing environmental conditions due to the impact of temperature, humidity, and demographics on the vectors. The impact of climate change on the emergence and re-emergence of animal diseases has been confirmed by a majority of the World Organization for Animal Health (OIE) Member Countries and Territories in a worldwide study conducted by the OIE among all of its national delegates (PigProgress, 2009). However, there is currently only limited evidence that climate change is directly responsible for an increase in the incidence of livestock animal diseases, with bluetongue disease in Europe being one of the exceptions. Climate change eliminates ecological barriers and constraints for pathogen transmission, and the timing of seasonal migration. Because information health systems are limited, changes in disease may have occurred but not yet been detected. As better information systems that are capable of measuring change in disease patterns, vector distribution, and environmental conditions are established, we may be surprised by the number of diseases that are already directly or indirectly affected by climate change. Among livestock diseases, experts agree that there is evidence that climate change explains the recent spread of bluetongue virus observed in Europe since 1998 (Purse et al., 2005).

African swine fever (ASF) is a highly contagious haemorrhagic viral disease of domestic and wild pigs with up to 100% case fatality rate, which has recently been responsible for serious economic and production losses in China, Vietnam, Mongolia, Laos, etc. (OIE, 2018 and FAO, 2019[b]). Bluetongue is a non-contagious, insect-transmitted, viral disease of sheep, which are generally the worst affected. It can cause spectacular disease outbreaks (DEFRA, 2019). After the serious bird flu outbreaks of A (H5N1) virus in 1997 in China, this avian and other influenza viruses have spread from Asia to Europe and Africa. In 2013, human infections with the influenza A (H7N9) virus were reported in China. Nepal reported three more highly pathogenic H5N1 outbreaks, while Iraq reported an event involving highly pathogenic H5N8, and Cambodia also reported with H7N4 in 2018 (CIDRAP, 2019). Foot and mouth disease (FMD) is a highly contagious disease of cloven-hoofed animals. During 2008–2015, a total of 140 FMD outbreaks were reported in eight provinces of Thailand. Most of the outbreaks occurred on cattle and buffalo farms, particularly backyard and smallholder farms. In contrast, only in intensive pig farms. It has been 19 months since the first African Swine Fever (ASF) outbreaks were reported in Vietnam and from January 1 to August 31, 2020, a total of 1,008 outbreaks were reported by the Ministry of Agriculture and Rural Development (USDA, 2020).

Although climate change is expected to worsen many kinds of disease, especially tropical illnesses carried by insects, coronaviruses like the current one are not on the list. Scientific evidence suggests that SARS-CoV-2, the germ that causes Covid-19, is closely related to a virus found in bats. Humans may have contracted it through an intermediate host, a scaly anteater called a pangolin that is traded at illegal wildlife markets. The virus doesn't appear to care what the average global temperature is; indeed, a National Academies of Sciences panel cautioned that changes in heat and humidity may not affect how Covid-19 spreads (Sarah Kaplanl, 2020).

Major diseases linked to eating animals

In the midst of the growing global coronavirus disease (COVID-19) pandemic, it's time we all made the connection between eating animals and major disease outbreaks around the world. Factory-farm sheds crowded with thousands of chickens, pigs, or cows; bloody abattoirs; and "bush meat" markets selling the flesh of wild animals are all breeding grounds for pathogens. The problem is global, and it isn't going away, 60% of known infectious diseases in humans are transmitted from other animals (PeTA, 2020).

Here are just selections of the human disease outbreaks that are linked to eating animals. The new coronavirus pandemic is thought to have originated at a "wet market" in the Chinese city of Wuhan in late 2019 (COVID-19). Like other types of coronavirus, it began in other animals before being transmitted to humans. The latest research links it to bats and pangolins, both of which were sold for their flesh at the Wuhan market. Severe acute respiratory syndrome (SARS) is a disease caused by a coronavirus that originated in wild animals – bats and civet cats – and was transmitted to humans. PeTA (2020) reported that the SARS pandemic started in China and resulted in an outbreak of deadly pneumonia that killed 774 people. It's thought that the virus may also have begun in a wet market. The H5N1 strain of bird flu originated in farmed geese before infecting chickens raised for meat and eggs. Some strains of bird flu can be transmitted from birds to humans, and the most deadly of these are H5N1 and H7N9, which have killed hundreds of people in China and around the globe. The virus can be passed on to humans who touch the feathers, flesh, or faeces of infected birds. Swine Flu caused by the H1N1 virus caused a pandemic when it was transmitted from pigs to humans, killing up to 575,400 people worldwide. Middle East respiratory syndrome (MERS) is another disease caused by a coronavirus. The respiratory illness was first reported in Saudi Arabia and has now spread worldwide, killing 858 people to date. The World Health Organization advises that camels have played a role in spreading the virus to humans and has issued guidance on avoiding the consumption of camel milk and meat.

Food security and safety

Alfredo (2015) suggested that organic livestock farming may be a useful strategy to overcome the challenges of the agricultural sector such as sustainability, food security, and food safety while matching with consumers´ tendencies on good animal welfare, better health, environmental benefit, etc. To produce organic livestock or products such as meat, eggs or milk, animals must eat only organic feeds. Ideally, the feed will be grown on-farm; it is required that livestock graze organic pasture. Livestock producers prevent illness in their animals by providing good nutrition, sanitation, and a low stress environment. While livestock also provide manure, a very important source of fertility in traditional farming systems and an excellent means of recycling nutrients within a crop rotation. Response to the challenges posed by global warming and the declining availability of most non-renewable resources will require a paradigm shift in the practice of agriculture and in the role of livestock within the farming systems (Nguyen Van Thu, 2015).

Farming systems should aim to maximize plant biomass production from locally available diversified resources, processing the biomass on the farm to provide food, feed, and energy, and recycling all waste materials. This supports for the forage-eating animal production, particularly for rabbits, due to the limitations of feed resources (land) in the rural poor areas. The following sections outline an approach whereby the production of food/feed can be combined with the generation of electricity, thus ensuring a supply of both food and energy for families in rural areas. This is achieved through the fractionation of biomass into edible components (for food/feed) and inedible cell wall material. The cell contents and related structures are sources of digestible carbohydrates, oil, and protein that can be used as human food and/or animal feed. Organic rabbit farming is easy to practice due to the herbage is the least expensive. However a better understanding of herbage intake is needed to appropriately adjust the size of the forage area and the amount of feed supplementation with cereal/legume mixtures or commercial pelleted feeds.

Rabbit population and biological characteristics

The world rabbit population is presented in Table 2.

Table 2. Rabbit population (thousand head) development of different parts of the World (2015-2018)

Item	Year				Annual change, %	% World (2018)
	2015	***2016***	***2017***	***2018***		
World	296,380	295,678	308,482	307,951	0.976	100
Africa	18,162	17,745	18,816	18,031	-0.180	5.86
Americas	5,695	5,770	5,776	5,797	0.448	1.88
Asia	249,289	248,554	260,884	261,230	1.20	84.8
Europe	23,234	23,609	23,006	22,893	-0.367	7.43

Source: FAOSTAT (2020) adapted by Nguyen Van Thu (2020)

In the World, rabbit population is still developing annually (0.98%), while in Asian countries; this is enhancing to adapt to the high and fast meat demand of increasing human population by many innovations of production systems with the highest percentage (84.8%). However, In

Europe and Africa it is slightly reduced (-0.367 and -0.18%, respectively).

Rabbit population development of representative countries is showed in Table 3.

Table 3. Rabbit population (thousand head) development in representative countries from 2015 to 2018

Country	Year				Annual change, %
	2015	*2016*	*2017*	*2018*	
China	216,034	215,372	227,843	227,731	5.41
Vietnam	855	821	965	1,044	22.1
Italy	5,734	6,132	6,269	6,282	9.56
Greece	906	900	869	843	-6.95
France	871	768	732	714	-18.0
Egypt	6,445	6,165	7,105	6,505	0.93
Nigeria	4,599	4,641	4,633	4,678	1.72
Algeria	220	183	175	166	-24.5

Source: FAOSTAT (2020) adapted by Nguyen Van Thu (2020)

Table 3 indicates that rabbit production systems may be good selection chances for meat production under the negative effects of climate change and fast urbanization such as serious disease outbreaks of pigs and poultry, narrower agricultural land, higher ambient temperature, environmental pollution, etc., particularly in Vietnam, Egypt and Nigeria. The main producing countries in the EU are Italy, France and Germany, while Venezuela and Egypt are the main producing countries in Latin America and Africa. However, in some countries of Europe such as Greece and France rabbit populations are reduced recently.

The rabbit known as small herbivore animal placed after chicken for meat, which can be a great source of food production with advantages of very fast growing, better food converting rate, high productivity, small keeping space, less cost production, and tasty and nutritious meat. Rabbit production is easy to apply modernized and automatic systems with low water consumption, environmental pollution and producing areas, but higher products in a production unit compared to other animal species. Rabbits are known to be 2.5-4.0 times more efficient in extracting proteins from forages than sheep, and beef cattle due to higher reproductivity.

Rabbit production for adapting to climate change and disease outbreaks

Grass and other plants as rabbit feeds

Rabbit consuming staple feeds, which are mainly forages such as grasses (Fig. 1), legumes and other tree leaves. Carbon sequestration is the capture and storage of CO_2 that would otherwise reach the atmosphere. There are a variety of carbon sequestration options being investigated by Department of Energy (DOE) and National Energy Technology Laboratory (NETL) of USA including terrestrial CO_2 sequestration. Terrestrial sequestration is the enhancement of CO_2 uptake by soils and plants, both on land and in freshwater. Early terrestrial efforts include tree-plantings, no-till farming, wetlandsrestoration and land management on grasslands and grazing lands, and forest preservation. More advanced research includes the development of fast-growing trees and grasses and forest preservation. Weare able to plant more than just trees to make the air cleaner. One hectare (2.47 Acres) of tropical grass can capture as much as 60,000 kgs (133,000 lbs) of CO_2 per year. So planting grass can be very beneficial in making the world a better place (Fig. 1). Not only capturing CO_2, covering the tropical world with grass, provides a place for animals to eat, increase biodiversity, decreases temperature, controls erosions, protects and improves the quality of the soil (FAO, 2010).

Fig 1. Planting Setaria grass for rabbit feeds and carbon sequestration

(Source: Nguyen Van Thu, 2019)

It is not a question of which activity should have priority, as the source of the biomass should facilitate the production of both food and energy. It is certainly not acceptable, nor is it necessary, to convert potential food sources into fuel, as are the current strategies underlying the production of ethanol (from starch and sugar) and biodiesel (from edible plant oils). Energy from biomass must be derived only from the fibrous residues following extraction of the food/feed component. Many crops lend themselves to fractionation of the food and energy components. In Vietnam, several water plants could be used as human food and animal feeds, e.g., water spinach stems and leaves (Fig. 2 and 3); the water spinach stems are used to make pickles for human consumption, while the leaves with their high protein content are good supplement feeds for rabbits (Nguyen Van Thu and Nguyen Thi Kim Dong, 2011) and other animal species.

Fig 2. Harvesting water spinach along the canals for rabbit feeds

Fig 3. Water spinach leaves as a good protein supplement for rabbits

(Source: Nguyen Van Thu, 2011)

Water hyacinth (Fig. 4) grows well in canals, ponds and rivers, and in many cases causes environmental problems. This plant has traditionally been underutilized for animal production, but has been studied as a feed for ruminants and rabbits in recent years.

Fig 4. Water hyacinth as rabbit feed source in the Mekong delta of Vietnam

(Source: Dept. of Science and Technology of Ben Tre, Vietnam)

Table 4. Feed and nutrient intakes (g·animal^{-1}·day^{-1}), and growth performance of rabbits fed different levels of water hyacinth (WH) in a feeding trial

(Source: Nguyen Van Thu and Nguyen Thi Kim Dong, 2009)

Item	**Treatment**						**± SE/*P***
	WH0	***WH20***	***WH40***	***WH60***	***WH80***	***WH100***	
DM intake of WH							0.41/0.001
CP	8.18^{a}	8.42^{ab}	8.51^{b}	8.53^{b}	8.50^{b}	6.81^{c}	0.001/0.001
NDF	32.5^{a}	32.0^{a}	31.4^{ab}	30.8^{ab}	29.8^{b}	22.4^{c}	0.572/0.001
ME, MJ/rabbit/day	0.57^{ab}	0.58^{a}	0.59^{a}	0.61^{a}	0.60^{a}	0.50^{b}	0.024/0.007
DWG, g	18.9^{a}	19.3^{a}	19.6^{a}	19.0^{a}	16.2^{c}	14.0^{c}	0.955/0.001
Feed conversion ratio	3.75^{ab}	3.68^{a}	3.63^{a}	3.76^{ab}	4.37^{b}	4.25^{ab}	0.196/0.009
Econo. return, VND	24,521	24,620	26,279	24,409	16,819	13,265	

Note: WH: water hyacinth; WH0: basal diet; WH20, WH40, WH60, WH80 and WH100: WH replaces Para grass at levels of 20, 40, 60, 80, and 100%, respectively, of the amount of Para grass consumed in WH0. Means with different letters within the same row are significantly different at the 5% level.

The results in Table 4demonstrated that water hyacinth could be used as a main feed for the rabbit; however, the optimum level in feed was found to be 40%, with 60% Para grass (*Brachiaria mutica*).

Methane production in rabbit

It is reported that rabbit is an herbivore species with low greenhouse gas production as compared to ruminants (Nguyen Van Thu, 2011). In rabbits, the main fermentation site is the caecum, where microorganisms convert nutrients from the small intestine into volatile fatty acids (VFA), gases (CH_4, CO_2, H_2), and ammonia and compounds incorporated into microbial cells. Hydrogen is formed during fermentation, but a high partial pressure of H_2 in some anaerobic ecosystems reduces the fermentation efficiency. An investigation in *in vivo* and *in vitro* experiments on the effect of different sources of fiber and starch on caecal fermentation pattern and methane production in rabbits was done. Then Belenguer et al. (2011) indicated that unlike fermentation in other species, methanogenesis may not be the major H_2 sink in rabbit caecal environment. However, methane formation could become remarkable *in vitro* with a pH closer to neutrality, which seems to be favorable, supporting the assertion that methanogenic Archaea exist in caecal contents. Methane production cannot be associated with diet characteristics *in vivo* because of the high individual variability, although the source of starch modulated volatile fatty acid profile and thus affected caecal methanogenesis *in vitro*.

When compared methane production on sheep and rabbit, Lan Mi et al. (2018) concluded that methane production between the sheep and the rabbits can be explained by the different physiological environments of their respective digestive organs and the micro biota residing therein. Lower abundance of hydrogen-producing microbes (bacteria, fungi, and protozoa) and methanogens, and increased homoacetogenesis as an alternative hydrogen utilization pathway in the rabbit cecum might result in lower CH_4 yield from the rabbits. The cecum of rabbits is potentially a rich resource to fibrolytic bacteria and hence novel cellulolytic enzymes. Ragna et al. (2011) stated that methane production was similar for two species (0.13 ± 0.007 L/LW/d and 0.28 ± 0.11 L/LW/d) and represented 0.69 ± 0.32 and 1.03 ± 0.29% of gross energy intake in rabbits and guinea pigs, respectively. In relation to body mass (BM) guinea pigs produced significantly more methane than rabbit, while in Zebu crossbred cattle this was from 0.698 to 0.777 L/LW/d reported by Nguyen Van Thu et al. (2018).

Adapting to climate change and disease outbreaks

Climate change, which is essentially caused by the living activities of human being producing greenhouse gases in the world due to the increasing the high population. The threat of climate change, which is now talking by everyone.However, it is rarely mentioned together with population growth, despite the fact that they interrelated. Though they would lead to powerful reductions in greenhouse gas emissions. The consequences of the world being over populated has numerous effects which include: lack of food and water, environmental effects, depletion of natural resources, effects on the economy, and disease outbreaks, in which food demand satisfied is the key issue. The increasing requirement of animal protein as results, which need to be solved by livestock production systems in developing and developedcountries. Rabbit husbandry can be practiced in their conditions and situations, where the rabbit could adapt to and mitigate the greenhousegas emissions.

The most countries likely to be affected by climate change are in tropical developingcountries such as Guinea Bissau, Sierra Leone, South Sudan, Nigeria, Bangladesh, Vietnam, Cambodia, Philippines, Haiti, etc. They have the lower incomes compared to the others. Thus the negative effects of climate change are even more serious than we think, particularly in livestock production for animal protein supply. Ume et al. (2018) stated that in Africa, small holder rabbit farmers have devised varied adaptation coping strategies in cushioning the effects of climate change in their rabbit farms. Although, the coping strategies are location and farmers specifics, and included; provision of sunshade, use of fan, position of hutches, use of plastic bottle of frozen water, use of tolerant rabbit breeds, improved nutritional management and destocking (Okorie, 2011). However, it becomes necessary to identify the adaptation strategies used by the farmers and factors influencing their choice of adaptation strategies in the study area, since there is paucity of such knowledge. Despite rabbit project successes need to be widely replicated across in Africa continent so that smallholders can benefit, mostly by enhancing food security and income generation (Oseni and Lukefahr, 2014). In Egypt, Kamel and Lukefahr (1990) reported that village rabbit projects that directly involved young people reportedly decreased the rate of youth migration to urban areas. Small-scale rabbit projects have also targeted the more vulnerable households (e.g. recovery programs from natural disasters like the devastating earthquake in Haiti in 2010, as reported by Kaplan-Pasternak and Lukefahr, 2011). In addition, Lukefahr (1999) reported that small-scale rabbit production provides opportunities as humanitarian projects that assist people who live in poor rural communities.

In Vietnam with the heavy loss by the bird flu outbreaks (H5N1) in 2006, during this time the development of rabbit production quickly increased for meat supplying the domestic markets, then a rabbit population increase supported for the successfully national projects (Nguyen Van Thu, 2019), despite H5N1 virus still spread causing the bird flu disease in many provinces of Vietnam. Recently because of the ASF outbreaks with serious losses of meat production and economy in almost provinces of the country, rabbit production has been encouraged for better development by the Ministry of Agriculture and Rural Development to supply more meat for compensation. Two serious diseases caused by viruses rarely seen in rabbits, are myxomatosis and viral hemorrhagic disease. Because they are viral diseases, there are no effective treatments once the rabbit is infected. Two other infectious diseases of rabbits are encephalitozoonosis (a neurologic disease caused by the parasite *Encephalitozoan cuniculi*) and respiratory infection caused by the bacteria *Pasteurella multocida*. These are common in indoor pet rabbits. Although Mykytyn et al. (2020) demonstrated that rabbits are susceptible to SARS-CoV-2, however, further investigations on the presence of SARS-CoV-2 in farmed rabbits must be considered.

CONCLUSIONS

It is concluded that:

The rabbit could successfully adapt to the climate change, due to its ability of efficient forage utilization compared to ruminants, high meat performance and reproductivity, good resistance to existing serious outbreaks, low water use and pollution, wide range of adapting to ambient temperature, and mitigating greenhouse gas emissions.

Rabbit production systems are better adaptation to low or high technologies and different geography areas under climate change conditions and besides the hemorrhagic disease with available effective vaccine, very few rabbit outbreaks have been reported.

More studies on improving rabbit breed performance, nutrition, feeds and supplements, reproduction, micro-climate of housing and disease outbreaks should be implemented to improve its performance and adaptation to the harsh conditions of climate change and the COVID-19 pandemic.

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