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Appropriate Technology Development for Energy Conservation in Animal Husbandry in the Context of Southeast Asian Countries

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Abstract

Climate change is a global issue causing adverse effects in different sectors all over the world. Nations in Southeast Asia are mostly developing nations and do not have adequate resources to tackle the catastrophic effects of climate change. An increase in greenhouse gas emissions led to a significant rise in temperature all over the world, which is more vivid in Southeast Asian nations as they are tropical countries. Many residents of rural areas in these nations rely on agriculture and animal husbandry as means of their income. Over the last decade, farmers and poultry owners have faced more challenges to mitigate the extreme temperatures in which livestock cannot survive. Additionally, depleting fossil fuel levels, rise in the price of commodities and frequent power outages only add to the problem. Thus, a new environmentally friendly sustainable strategy has been proposed which makes use of renewable energy. The study also focuses on energy conservation technologies and techniques that the farmers can implement. If farmers and poultry owners are able to control the ambient temperature of the livestock housing, they are more likely to stay in business because of more profits. This temperature control can be acquired from livestock wastes, which the farmers usually dispose, of by generation of heat and electricity. This not only promotes the use of green technology but also reduces pollution associated with these wastes creating a more hygienic environment, producing more power, and enhancing the economy while aligning with sustainable development goals.

Keywords: Animal Husbandry, Climate Change, Green Technology, Energy Conservation, Sustainability.

Introduction

Climate change is a global issue and Southeast Asian countries have been more susceptible to the catastrophic effects of climate change. Most Southeast Asian countries are developing countries and they lack the resources to counter the influences of climate change. Consequently, these regions have been prone to more intense and erratic downpours and drought. A massive portion of these developing nations still reside in rural areas and rely heavily on agriculture and animal husbandry as a means of their income. The rising temperature along with more frequent droughts and floods have compelled farmers to go out of business. According to Germanwatch, from 2000 to 2019 the countries who are most affected by climate change were monitored and it was observed that Southeast Asian countries like Myanmar, Philippines, Bangladesh, Pakistan and Nepal were in the top 10 having high global climate risk index scores and more loss in GDP (David Eckstein et al, 2021).

Animal husbandry plays a vital role in contributing to the GDP of Southeast Asian countries and creating employment in rural areas. This industry has taken a massive hit due to climate change as poultry owners and farmers are struggling to sustain their businesses. Globally there is an increased overall temperature in which livestock cannot survive. Global warming has led to frequent heat waves with summers becoming more prolonged and hotter. For instance, the ideal temperature for poultry farming is 65^{o}F-75^{o}F (Rakesh Kumar, 2016), it has been observed that the

Figure 1: Animal Husbandries in Southeast Asia (Source: Noor A Alam/TBS, Pratap Bista/Kathmandu post)

temperatures in Southeast Asian countries, which are mostly tropical, to exceed 100^{o}F during summers.

A fall in the animal husbandry industry will inevitably plummet the GDP and rural development of these regions. Moreover, more people will be unemployed, compelling small-scale farmers or poultry owners to live below the poverty line. Animal husbandry plays a crucial role in empowering women in rural areas. People of Southeast Asia could be deprived of their meat-based protein demand as they might encounter a scarcity of food. The nations that export animal-based products overseas are likely to have a more detrimental impact as it will decline their economy. Any other businesses directly or indirectly associated with animal husbandry might also be defunct. Furthermore, farmers will not have any biomass fertilizers for their cropland which has shown excellent yield. This study aims to focus on the mitigation measurements farmers can adopt to control the temperature by conserving energy and making use of renewable energy resources.

Effect of Temperature Rise on Animal Husbandry

The impact of rising temperatures on livestock farming and animal welfare can be significant and affect a variety of livestock farming practices. Rising temperatures are a result of climate change and global warming, and they can have an impact on animal husbandry both directly and indirectly. Here are some of the major effects:

- Heat stress: Higher temperatures can stress out animals, particularly those from species with poor thermoregulatory capacities like poultry and other types of livestock. Reduced feed intake, slower growth rates, poorer reproductive efficiency, and more susceptible to diseases are all effects of heat stress.
- Water availability: As temperatures rise, there may be more evaporation and less water available, decreasing animals' capacity to stay hydrated and raising their risk of dehydration.
- Changes in the quality and quantity of feed: Grazing pastures, forages, and feed crops can all be impacted by climate change.

Extreme weather conditions, including droughts or floods, can have an impact on crop productivity and cause cattle to run out of food.

- Increased temperatures can influence the distribution and prevalence of some diseases, parasites, and pests, which can have an impact on animal health and necessitate modifications to disease prevention measures.
- Animals may alter their behavior in reaction to hotter weather by looking for shade or avoiding particular locations. This may have an impact on social interactions, productivity levels, and feeding patterns.
- Distribution changes in animals: Some livestock species may be more sensitive to temperature changes than others, which could cause geographic distribution changes as they attempt to relocate to climates that are more suited to them.
- Infrastructure and management issues: To lessen the effects of increased temperatures, animal husbandry procedures, such as housing and ventilation systems, may need to be enhanced or modified. Farmers may incur higher costs as a result, and maybe substantial investments.
- Reduced productivity: Overall, heat stress, variations in the feed supply, and illness difficulties can cause livestock to be less productive, which can have an impact on the quantity and quality of meat, milk, eggs, and other animal products.

Energy Utilization in Animal Husbandry

Thermal Energy Usage

Thermal energy usage in animal husbandry in South Asia plays a crucial role in ensuring the productivity and maintenance of Livestock in the region. Thermal energy in animal husbandry is mainly used for feed, housing, and manure management.

Thermal Energy Usage for Animal Feeding

Water Heating In colder regions of South Asia, particularly during the winter season, the provision of heated drinking water to animals becomes a critical aspect of animal husbandry. This practice is essential to ensure the well-being and proper digestion of livestock. By offering heated water, the body temperature of animals is effectively regulated mitigating the adverse effects of cold weather. Warm-blooded animals are sensitive to temperature changes and often are homoeothermic. Exposure to cold water can increase stress in animals. Intake of warm water aids in the digestive health of livestock by ensuring optimal blood circulation and nutrient assimilation from the feed. Dairy animals like cows and buffalo mostly benefit from drinking warm water as it increases milk production. In colder climates, animals may exhibit reduced water intake due to their instinct to conserve body heat. This behavior poses a risk of dehydration, which can give rise to various health issues. By encouraging animals to drink more through the offering of warm water, farmers effectively mitigate the risk of dehydration.

Drying and processing of animal feed, grains, and other agricultural products use thermal energy. Animal feed comprises ingredients like grain, corn, wheat, and rice that contain a high level of moisture content. To prevent fungal growth, spoilage, and the loss of nutritional value it is essential to reduce moisture content to a suitable level. Also, feed like hay and silage availability is limited in some regions during certain seasons. Drying these feeds using thermal energy prevents them from catching mold and feeds can be stored for a long period. Along with this heat treatment is used to break down anti-nutritional factors, such as toxins or enzyme inhibitors, in certain feed ingredients, making them safer and more suitable for consumption by livestock. The benefits of thermal drying and processing in animal husbandry are to enhance the nutritional value of feeds, prevent disease and make them more digestible for the animals leading to better growth and transformation. Additionally, this process reduces transportation costs by reducing feed weight and volume and also ensures year-round availability of feed.

Thermal Energy Usage for Housing

- Space Heating: In colder regions during winter providing a heating system is essential to keep animals warm and comfortable. Especially for young or vulnerable animals, as it helps in maintaining their body temperature and preventing stress-related issues.
- Incubation: Poultry farming is a significant aspect of animal husbandry, and maintaining proper temperature and humidity levels in incubators is crucial for the successful hatching of eggs.
- Insulation: Thermal insulation is crucial in animal housing to reduce heat loss during cold weather and heat gain during hot weather. Insulated walls, roofs, and floors help create a more stable and controlled environment, minimizing temperature fluctuations and reducing energy consumption for heating or cooling.

Thermal Energy Usage for Manure Management

Thermal energy usage in manure management is a crucial aspect of sustainable agriculture, especially in large-scale animal husbandry operations. The process involves harnessing heat to treat, process, or utilize manure effectively.

Thermal Drying: In some cases, thermal energy is applied to dry manure, reducing its moisture content and preventing nutrient loss during storage. Drying manure to a certain moisture level makes it easier to handle, transport, and store, as well as reducing the potential for odor and flies. Additionally, the dried cow and bull dung can be used as valuable biofuel, promoting sustainable energy solutions.

Heat Treatment for Pathogen Reduction: Heat treatment can be used to pasteurize or sanitize manure, effectively killing harmful pathogens that may be present in the raw material. This is important when manure is intended for use as a fertilizer.

Other than these main three reasons thermal energy is also used in processing cow, buffalo, and goat milk by pasteurizing and sterilizing milk, extending its shelf life, and ensuring its safety for consumption.

Additionally, Thermal energy is used in wool processing units for washing, and drying sheep's wool.

Temperature Control:

An animal's body temperature is predominantly influenced by temperature, humidity, and the level of direct sunlight. However, several other factors also play crucial roles, including precipitation, wind conditions, the degree of night cooling, and exposure to fescue endophyte a type of symbiotic fungus. All these elements collectively contribute to the regulation of an animal's body temperature and overall well-being. Normal temperatures for mammals range from 97° F to 104° F. Most birds have a normal temperature between 106° F and 109° F (Larson, 2009). The climate varies significantly across the region of Southeast Asia. Southeast Asia is mostly within the tropical climatic zone with temperatures above 77°F throughout the year (Yuen, B., & Kong, L., 2009).

The region is strongly influenced by the Asian monsoons, which bring a significant amount of rainfall to parts of Southeast Asia. Also, in winter some of the region's temperature ranges from 45°F to 77°F. Energy utilization for controlling temperature in animal husbandry is a crucial aspect of modern farming practices, ensuring a comfortable and conducive environment for the well-being and productivity of livestock. Proper temperature management is essential for various livestock species, as extreme heat or cold can lead to stress, reduced growth, and decreased productivity. To achieve this, farmers employ various energy utilization methods. In colder regions or during cold weather, space heating is used to provide warmth inside animal shelters, barns, or housing structures, often using radiant heaters, hot water pipes, or forced-air heaters.

In contrast, in regions with hot and humid climates, cooling systems like fans, exhaust fans, and misters are employed to dissipate heat and maintain a comfortable temperature inside animal housing. Insulation is another key component, helping to reduce heat loss during cold weather and heat gain during hot weather by using insulated walls, roofs, and floors to create a more stable and controlled environment. Proper ventilation is essential to remove excess heat, moisture, and noxious gases. Additionally, thermal

energy plays a crucial role in incubators for hatching eggs and brooding systems for providing warmth to newly hatched chicks. Advanced animal husbandry facilities may incorporate sophisticated control systems using thermal sensors to monitor indoor temperatures and automatically adjust heating or cooling systems accordingly. By striking a balance between providing a comfortable environment for animals and optimizing energy usage, farmers ensure the overall health, productivity, and sustainability of their operations.

Existing Technologies to Control Temperature

Livestock is extremely sensitive to temperature and requires suitable conditions to survive. The temperature in Southeast Asian countries often exceeds during the summer and drops during the winter when compared to the temperature suitable for livestock. Farmers in rural areas have limited access to resources and lack funds. Thus, they resorted to simple technologies to control the temperature of their livestock housing. The mitigation measures implemented vary from one country to another depending on their climatic and economic conditions. Some of the most used technologies to control temperature are:

- Exhaust fans: Farmers and poultry owners have seen to install exhaust fans to reduce the body temperature of the animals they are farming. This also helps in controlling the ambient temperature of the livestock housing.
- Ventilation: Farms and poultry sheds are strategically designed with proper ventilations consisting of windows, ridge vents, etc. to ensure proper air circulation within the livestock house and to maintain and constant and cool temperature.
- Shade netting: Shade netting is used as a barrier of the livestock house that enables both air circulation and prevents direct exposure to sunlight.
- Wetting systems: Sprinklers are used as a measure to cool the body temperature of livestock by means of evaporative cooling.

- Burners: A wide range of applications of burners can be seen in controlling temperature in animal husbandry. Burners are heating devices that farmers use for drying feed, heating hay to store it for a prolonged period, drying manure, etc.
- Incubators: During spells of extreme cold, poultries are unable to hatch eggs as they are unable to provide sufficient heat. Thus, eggs are kept in incubators which provide sufficient heat for the eggs to hatch at a suitable time.

Farmers need to be prepared for encountering temperature changes in both summer and winter adapting to both heating and cooling technologies. Frequent power outages can be observed in some of the rural regions of Southeast Asian countries, making some of these adapted technologies inefficient. Additionally, depending on climatic conditions like humidity, temperature, and wind speeds implementation of technologies may vary. It is observed that farmers refrain from using advanced technologies due to their deteriorating economic condition. Technologies that make use of renewable energy and are also affordable should be designed and encouraged to be applied as a measure to control the temperature because of the plummeting amount of fossil fuels and insufficient power supply.

Appropriate Technology Application in Producing Thermal Energy from Renewable Sources

By incorporating energy conversation techniques farmers can enhance their self-sufficiency by reducing dependence on external resources. Renewable energy not only enables cost saving but also reduces the impacts of global warming. Various renewable energy options like solar, water, biomass, and geothermal can produce electricity for heating, lighting, and fuel for use on the farm. Renewable energy sources are growing rapidly and are very beneficial for small-scale animal husbandry businesses. They meet the growing demand for energy worldwide by enlarging the global energy supply, energy prepared from it can be used as an alternative to expensive fossil fuels. The expansion of renewable energy provides a new

opportunity for the agricultural commodity market to flourish sustainably. It reduces greenhouse gas emissions and ensures long-term sustainability.

Anaerobic Digester

An anaerobic digester is a specialized system used in animal husbandry to treat organic wastes such as feedstock and convert them into biogas and a nutrient-rich organic fertilizer (Stewart, D. M.,2022). This anaerobic digestion process takes place in the absence of oxygen, carried out by microorganisms that break down organic matter. Feedstock consists of animal manures that are urine and feces excreted by animals, food waste, dry litter materials of poultry farming, etc. The main products of anaerobic digestion in animal husbandry are Biogas and Digestate which is a nutrient-rich organic fertilizer.

Mechanism of an anaerobic digester

One of the mechanisms that can be utilized in producing renewable energy is the implementation of an anaerobic digester which breaks down anaerobic manure organic matter in anaerobic conditions and takes place in an enclosed structure. An anaerobic digester consists of a number of stages in which organic matter is decomposed into methane (CH_4) and carbon dioxide (CO_2). The stages involve:

- Collection: The collection of organic feedstocks, which comprises any biodegradable plant and animal matter, takes place and is stored in an enclosed anaerobic digester system. An airtight sealed environment is created to collect the products produced. This is achieved in various ways like: by making a concealed concrete tank, designing a lagoon, or a membrane covering the digester.
- Mixing and loading of feedstock: This is an essential step that ensures microbial activities among incoming new feedstock by means of mixing where the feedstock is loaded at a specific rate. A thorough mixing prevents the formation of solid floatable scum or sinking sediment while ensuring consistent decomposition throughout the digester (Jegede. et al, 2019). Some digesters have

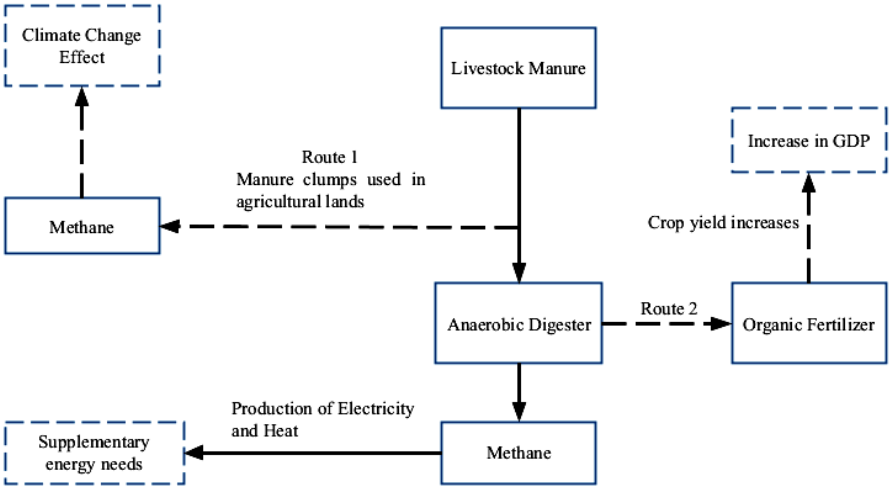
auto-circulatory mechanical mixers that stir the bacteria and the feedstock periodically.

- Anaerobic Digestion: In this process, the organic matter collected is broken down by bacteria in the absence of oxygen which takes place in multiple steps A group of microorganisms called Methanogens are used which is responsible for the breakdown of organic matter into simpler components.
- Production of Biogas: Biogas such as methane (CH_4) and carbon dioxide (CO_2) are produced as a result of anaerobic decomposition. The ratio of the two gases may vary depending on the composition of the digested material.
- Collection and Storage of Biogas: This stage is vital as proper collection and storage of biogas in a concealed environment determines how effectively this mechanism will operate. Biogas and be collected and stored in the following ways:
    1. Tank or storage facility: It is an infrastructure where biogas is stored from the time it is collected to the time the biogas is required to be used. These storage facilities can additionally contain pressure gauges or gasometer which monitors the increase or decrease of pressure of biogas within the storage unit.
    2. Flexible membrane: Flexible membranes are installed over lagoons, ponds, or digesters and prevent the gases from escaping by providing an airtight flexible cover that expands and stores gases.
    3. Collection pipes: These pipes are placed just over the digester and link the digester and gas collecting system by accumulating the gases produced in anaerobic digestion and storing them in a safe unit. Both the storage tank and flexible membranes comprise of collection pipes.

Prior to using the collected biogas, it needs to be compressed and purified to ensure the biogas produced meets the required standards.

- Biogas Utilization: The collected, compressed, and purified biogas can be used for powering a number of electrical appliances, and heating systems or even be sold as a biofuel to power cars.

Figure 3: Flow Diagram of Manure Management in Animal Husbandry



Solar

Solar renewable energy is a type of energy that comes directly from sunlight. It uses the power of sunlight and converts it to electricity or heat through various technologies. Solar energy is clean, available, and widely used. Integrating solar energy in animal husbandry offers various benefits contributing to sustainable farming. Solar renewable can be used in operating water pumps, fans, lights, and heaters.

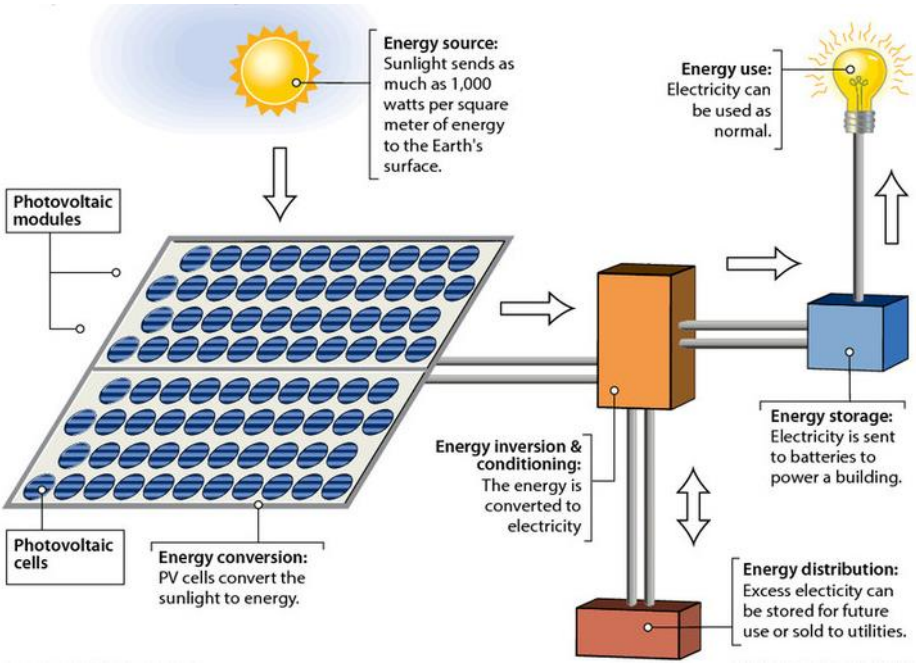
Mechanism of Solar Power Energy

Solar technologies convert sunlight into electricity by using two technologies. One is Photovoltaic panels (PV) other is Concentrating Solar-

thermal power. Concentrating solar thermal power (CSP) technology is basically used for large-scale farms or power plants. The Photovoltaic panel technology is suitable for small-scale farms. When sunlight falls on a solar panel, the photovoltaic (PV) cells within the panel absorb the energy from the sunlight. This absorption generates electrical charges within the PV cells, which then move in response to an internal electrical field present in the cell. As a result, an electric current is created, allowing electricity to be generated. The Stages involve:

- Photovoltaic Panel: When Sunlight strikes the Photovoltaic Panel the semiconductor material (Silicone) present in the panel absorbs the photons and this creates electron-hole pairs where electrons are released leaving behind positively charged holes. Due to the electric field, these separated charges move in opposite directions with electrons moving toward the top surface and holes moving toward the bottom, this movement generates an electric current in the form of direct current (DC).
- Inverters: Inverters are used to convert the direct current electricity (DC) generated by the Photovoltaic panel into alternating current (AC) electricity(Figure 4).

Figure 4: Mechanism of Photovoltaic Solar System



- Storage: Batteries allow for the storage of solar photovoltaic energy, so it can be used during power outages or when weather elements keep sunlight from reaching PV panels. Batteries are playing an increasingly important role in utilities.

Energy Efficient Burners

Energy-efficient burners or stoves aim to provide more efficient cooking and heat transfer while using minimal fuel, reducing greenhouse gas emissions, and preventing life hazards by producing less smoke. There is an energy-efficient burner called 'Bondhu Chula' (Figure 5) in Bangladesh which is a fuel-efficient, sustainable, and climate-friendly stove (Bangladesh Bondhu Foundation).

Figure 5: Concept of Bondhu Chula (Source: Climate Impact Partners).

The main purpose of using energy-efficient burners or stoves is to reduce energy loss in the form of thermal energy, instead of recycling and reusing the thermal energy that is conventionally wasted. These burners can be utilized in animal husbandry for cooking animal feedstock, water, and housing heating purposes. To achieve such high efficiency proper design of

the stoves is indispensable. To ensure optimal usage of heat that is supplied, stoves are insulated to avoid any heat loss and retain as much heat as possible. Additionally, one of the key components of combustion, which is oxygen, needs to be supplied in ample amounts. Ducts are fabricated in the stoves that allow air circulation and oxygen supply within the stove to ensure complete combustion. This is followed by more thorough heat transfer within the stove by means of convection and radiation, thus, promoting better usage of thermal energy. More safety features are inaugurated in these burners, such as heat shields and handles, and proper combustion chamber design, to prevent any kind of serious injuries. Users also have the freedom to regulate the heat at their desired intensity. Energy-efficient burners also make use of biomass, which is produced in animal farming, as fuel by ensuring more complete and efficient combustion. The implementation of such burners would not only result in reduced fuel consumption and cost but also mitigate the environmental impacts conventional burners or stoves have.

Temperature Control

Controlling temperature in animal husbandry is crucial for the well-being and productivity of livestock as they are vulnerable to changing temperatures. Various methods can be applied to manage temperature effectively in animal husbandry. Some methods are:

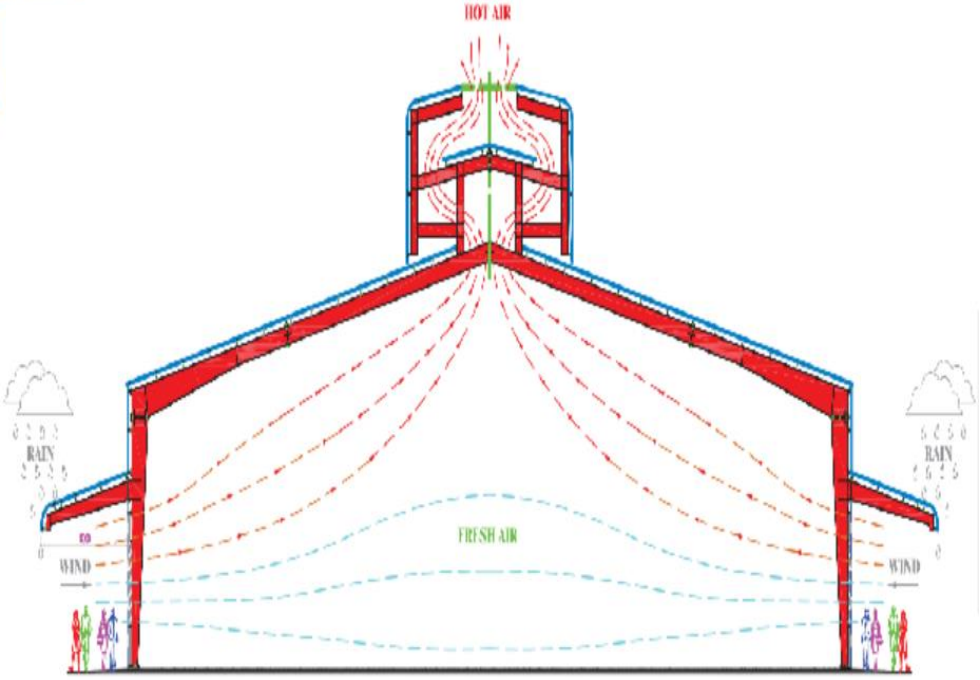
Water sprinklers: Ensuring a constant supply of fresh and cool water is essential for animals to regulate their body temperature. Misting systems or sprinklers can also be used to cool the air and create a more comfortable environment.

Ventilation: Ridge vents are a popular and effective natural ventilation solution for small structures such as barns and livestock housing. Positioned along the peak of the roof, these long, narrow openings covered with ridge caps enable passive airflow. As warm air rises from the animals and indoor environment, the ridge vent allows it to escape, creating a vacuum effect that draws in fresh, cooler air from outside.

Figure 6: Water sprinklers used for controlling poultry temperature (Source: Poultry Hub Australia)

- This continuous air exchange helps regulate temperature, reduce humidity, remove odors and dust, and improve air quality for the animals. The design of the ridge vent and its ridge cap provides weather protection, preventing rain or debris from entering the building while still allowing for effective ventilation. Ridge vents offer a cost-effective and energy-efficient way to maintain a comfortable and healthy environment in small-scale animal farming operations.

Figure 7: Ridge vent air circulation (Source: PEB Steel)



- Fans: Fans or exhaust fans are mechanical ventilation systems. The electricity produced from biogas and solar can be used to run these mechanical ventilation systems during load shedding or current shortage.
- Thermal Insulation: Properly insulating animal housing structures can minimize heat loss during cold weather and heat gain during hot weather, maintaining a more stable and comfortable indoor temperature. Fiberglass, hay, fire retardant cellulose from recycled papers, foam boards, etc can be used as thermal insulation.
- Colour Coating to Reduce Temperature: Red rust-proof paint coating can reduce the temperature of animal husbandry sheds because of its emissivity and radiation characteristics.

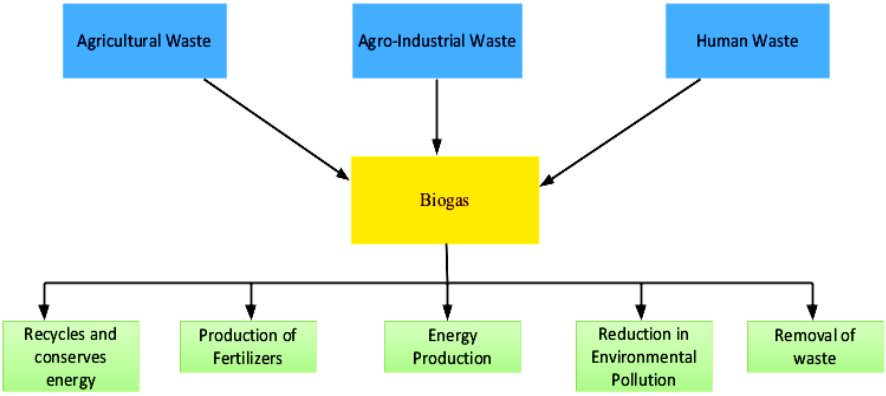
By employing these temperature control strategies, farmers can create a conducive and comfortable environment for their livestock.

Significance

The detrimental effects of global warming becoming more intense, and farmers and poultry owners must resort to new mitigation measures to sustain their business. The mitigation measures proposed in this study are not only environmentally friendly but also use renewable energy resources making it sustainable. Adapting to such mitigation measures will result in a significant reduction in greenhouse gas emissions, fuel costs, and impact on the environment.

Due to the high population density in Southeast Asian countries, there is a high demand for electricity. Over time it has been observed that more power outages have been taking place in these nations while the rural areas

Figure 8 : Benefits of Using Biogas



face the worst consequences. A self-sustaining anaerobic digester is more advantageous in the long run, especially for Animal Husbandry owners or farmers of rural areas as they are not only removing waste but also producing electricity and heat which can support their small-scale farms.

Solar energy also acts as a renewable source of energy by converting sunlight into electricity. Along with it, solar energy can be stored in batteries and used during power outages or to run appliances. Temperature control in animal husbandry involves both cooling and heating. Energy-efficient burners can be used for different heating purposes associated with livestock maintenance.

Even though the initial installation cost of the proposed measures might be expensive, the farmers can make more profits over a longer period of time. Implementation of these methods would make use of green energy while preventing the use of fossil fuels. This will result in less carbon emission. Additionally, the products acquired from the anaerobic digester can be used as fertilizers in agricultural lands. Farmers will also need to pay less for electricity as they will be generating their own electricity. It is to be noted that all the products acquired from an anaerobic digester come from livestock wastes, which farmers conventionally used to dispose of without any treatment. Thus, such practices promote energy conservation and implementation. Consequently, the overall cost of a farm significantly decreases resulting in larger profits adapting to these mitigation measures will also enhance the efficiency of existing mitigation measures that farmers practice.

Economic Analysis

Most Southeast Asian country climates are tropical and the regions are densely populated. As a result, developing countries are switching rapidly towards industrialization. Conventionally the economy was mostly based on agriculture but over time the dynamic has been observed to be shifting towards industrialization while agricultural activities are declining. After the COVID-19 pandemic, the economic forecasts indicated net negative economic growth. Restrictions on transportation affected the import and export businesses. Garments and other industries couldn't benefit much as these businesses highly rely upon imports and exports. As a result, there was a hike in fuel prices, food prices, and other daily necessities. The pandemic affected food security and was found to be interconnected with those of other natural disasters. For instance, countries previously

Figure 8: Trend in food price index (Base year = 2015) in Southeast Asia during 2020 (Source: FAO, 2020)

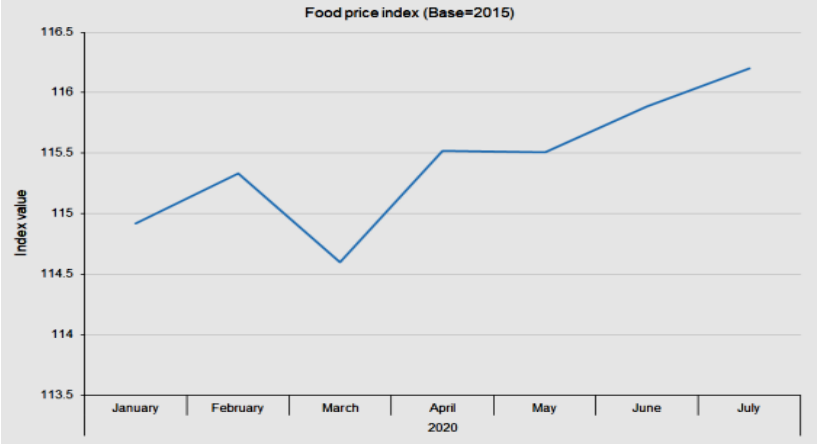
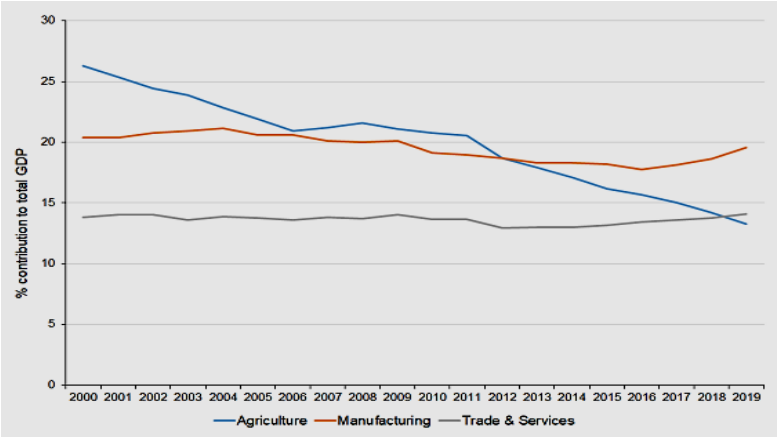


Figure 9: Shifts in Percentage Contribution of total GDP (Source: ASEAN)



affected by droughts and floods in 2018 and 2019 faced even more intensified consequences of the pandemic on their societies. Several renewable energy, green technology, and sustainable development goal projects were delayed because of the pandemic (ASEAN State of Climate

Change Report, 2021). Appropriate technology for energy conservation in animal husbandry will reduce the price hike of foods and will ensure food security. Additionally, farmers will have to invest less in electricity, fuel, and fertilizer. With the production of additional energy, the economy is more likely to boost while maintaining sustainable development.

Conclusion

Developing nations like those in Southeast Asia often struggle to counter the effects caused and catalyzed by climate change. While every aspect of these developing nations is crucial, animal husbandry plays an important role in contributing to such a country's GDP by creating employment in rural areas, promoting the development of regions, and meeting the meat-based protein demand of a country. Global warming had some adverse effects on the animal husbandry industry as farmers and poultry owners are unable to control the temperature, leading to a loss in livestock and compelling them to go out of business. With their conventional practices to mitigate extreme temperatures proven to be inadequate and insufficient, new strategies that use renewable green energy must be formulated and adapted. Farmers often throw away livestock waste, unaware of how much energy they can generate. An anaerobic digester makes use of these livestock wastes and produces biogas which can be used for electrical and heating purposes. This method not only promotes energy conservation but also can be used as a fuel in vehicles, thus, preventing depletion of fossil fuels. In a similar manner, solar panels are also proposed which generate electricity from sunlight. This can help in meeting the power demand of a country and making the most use of land owned by farms. On the other hand, energy-efficient burners are designed in such a way as to ensure uniform heat transfer and more efficient heating.

Adapting to these mitigation measures would significantly diminish the adverse effects of climate change by making use of green, innovative technologies that conserve and reuse energy. Additionally, the efficiency of existing mitigation practices would also be enhanced by implementing the proposed mitigation measures. It would enable farmers and poultry owners to have a firmer grip on controlling the ambient temperature of the

livestock housing which would result in bigger profits. The energy surplus and the growth in GDP, in the long run, outweigh the initial installation and maintenance cost of these technologies. Optimal sustainability can be achieved through global action which requires collaboration among nations and a worldwide unity to counter this global issue. Implementation of a number of such sustainable mitigation measurements together is more likely to produce better results. The mitigation measures proposed in this study contribute to achieving SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, innovation, and infrastructure), SDG 11 (Sustainable cities and communities) by making use of green technology to produce energy while having less environmental impact and boosting the economy.

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