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# Assessing The Environmental Impact Of Intensive Pig Farming: A Case Study From Southeast Asia

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***ABSTRACT***
*This research aims to assess the effects of intensive pig farming on the environment in Southeast Asia in terms of air quality, water quality, soil quality, and biodiversity. Using field surveys, interviews, and secondary data collected from selected farms in Vietnam and Thailand, the study assesses the impact of typical pig farming practices. Some of the findings include high levels of ammonia ($NH_3$) and methane ($CH_4$) emissions, high nutrient pollution in water bodies, and low soil pH and nutrient content in fields that use pig manure. An analysis of the impacts of intensive pig farms on the environment reveals that there is a reduction in the species of animals and plants in the areas that are within the vicinity of the farms, as compared to the reference areas. The paper also considers the current environmental laws and the extent of compliance, the gaps in the enforcement of the laws, and the effectiveness of the existing laws. Based on these results, it can be concluded that there is a necessity to enhance the appropriate ways of managing manure and simultaneously enhance the quality of laws that govern the influence of pig farming on the environment. Further research is required to be conducted in other areas, and additional indicators need to be used to have a clearer picture. The study is applicable in the evaluation of the impact of large-scale pig farming and even in promoting environmentally friendly agriculture.*
***Keywords:*** *Intensive pig farming, environmental impact, air quality, water quality, soil health, biodiversity.*

## 1. INTRODUCTION

Southeast Asia has evolved quickly to high stocking density and intensive use of technologies in concentrated pig production. This has been because of the use of pork products as a source of protein in most countries of the region. The reason is that Southeast Asia experiences an increase in population and economic growth, and this has contributed to increasing pig farming in Vietnam, Thailand, and the Philippines (Suridi et al., 2020). Pig farming is a case in point as one of the sub-sectors in the agricultural sector and the rural Vietnamese economy. The nation is one of the biggest pork producers in the world, and the agricultural processes are industrialized (Nguyen et al., 2022). Similarly, the pig farming industry has expanded in Thailand due to the increasing demand both in the domestic and export markets. These developments, on the other hand, have positive effects on food security and economic development but have negative effects on the environment. It is now possible to observe the impact of intensive pig farming on the environment. Intensive systems produce a great amount of waste, which, in case of improper management, can lead to pollution of the air, water, and even soil (Mekonnen & Hoekstra, 2018). Nitrogen and phosphorus are present in pig manure, and when released into water bodies, they trigger eutrophication, thereby degrading water bodies by proliferating harmful algae. Besides, the irrational use of antibiotics in pig farming facilitates the emergence of antibiotic-resistant bacteria, which is harmful to health (Van Boeckel et al., 2019). South East Asia has been facing the effects of intensive pig cultivation, whereby there is increased industrialization and relatively poor policies. Although some of the countries have embraced environmental standards, the practice and application of the standards are usually watered down (Tuan et al., 2020). This aspect necessitates the consideration of the factors that surround the environment of pig farming in the context of identifying the important issues and policy intervention strategies that can be implemented to reduce the effects.

## 2. LITERATURE REVIEW

### 2.1 Environmental Impacts of Intensive Pig Farming

High-density pig production and technological application in pig farming have implications on the environment. Air pollution is one of the most important problems of modern society. The intensive pig farms release ammonia

($NH_3$), which is harmful to the air quality, and methane ($CH_4$), which is harmful to the climate. Ammonia transforms the soil and vegetation such that it makes the soil acidic and is also toxic to plants, whereas methane is a gas that contributes to global warming (Arnold et al., 1998; Smith & Smit, 2014). The other significant challenge that affects the quality of water through pollution is intensive pig farming. The nutrients will likely be washed into the water bodies since it produces large quantities of manure. The process leads to excessive enrichment of water with algae, which subsequently decreases the amount of oxygen in water and is quite detrimental to aquatic life (Carpenter et al., 1998). It has been observed in the literature review that pig manure has nitrogen and phosphorus compounds, which are considered water pollutants (Sutton et al., 2013). Moreover, the use of manure in the wrong way can lead to groundwater pollution that can be dangerous to the health of human beings, as Bryman (2016) explains. The second problem is the depletion of soil fertility which is a widespread problem in most parts of the globe and especially in highly practiced areas. The use of pig manure may also change the chemical content of the soil such as the pH and nutrient level thus the low fertility of the soil and the high possibility of erosion (Fisheries, 2018). When there is excess manure, the situation that may arise is too much nutrient in the soil and this is not healthy to the plants and the soil structure (Hue et al., 2025).

**2.2 Impact on Biodiversity**

Intensive pig farming has its impact on the environment, with the concept of biodiversity being one of them. The use of the land to rear the pigs leads to conversion and fragmentation of habitats thereby leading to reduction in availability of wildlife habitat and the species (Foley et al., 2011). The intensive agriculture includes converting the natural ecosystem to monocultures or cultivated land, and it reduces the animal and plant species (Tilman et al., 2017). Studies also show that intensive pig farming is an environmental menace since it leads to bioinvasion and food chain modification. An example is that nutrient leaching in pig farms could cause the emergence of harmful algal blooms that could displace submerged plants and alter the composition of aquatic ecosystems. In addition, the antibiotics in the manure may influence the soil microorganisms and even the generation of antibiotic-resistant bacteria.

**2.3 Regulatory Framework and Management Practices**

As a result of the negative effects of intensive pig farming on the environment, there are various measures and policies that have been put in place. Some of the regulatory issues that are often considered include emission standards, management of manure, and water quality. For example, the European Union has the Nitrates Directive, whose aim is to cut down nitrate pollution from agricultural sources, including pig production. In the United States, nutrient runoff from concentrated animal feeding operations is regulated by the Clean Water Act (EPA, 2004). As will be seen, the legal frameworks regulating the management of environmental impacts of pig farming in Southeast Asia are not harmonized. Some countries like Thailand and Vietnam have come up with policies that aim at controlling waste management and pollution, but the problem is that the policies are hard to implement and comply with (Tuan et al., 2020). As it has been noted earlier, while there are regulations, their implementation in real life is not as effective due to a lack of funds and monitoring (Nghi et al., 2021). For instance, Vietnam has only recently come up with standard operating procedures for the management of manure, but there are problems with its application.

**2.4 Sustainable Practices and Technological Innovations**

As a result of the impacts of intensive pig farming, there has been increased focus on the use of sustainable practices and technologies. The first strategy is the improvement of manure management practices, such as anaerobic digestion, that assist in reducing methane emissions while producing biogas for use as energy. In addition, technologies such as GPS and remote sensing applied in precision farming can assist in establishing the right rates of manure application and therefore reducing nutrient runoff. Another possible solution is the application of agroecological practices such as crop-livestock integration, which has the possibility of enhancing nutrient circulation and therefore reducing the effects of ecological harm of pig production. These systems integrate crop and animal farming and modify the biological and physical properties of the soil, minimize waste products and thus present a more sustainable method of managing the land resources. Southeast Asia is showing more concern about such practices to minimize the impact on the environment of extensive pig farming. The example is the research carried out in Thailand aimed at sustainable development of the integrated farming system as the solution to the current environmental issues and the increase of farms productivity. In Vietnam, there is a similar attempt to create and popularise the technology that can help not only minimise wastage but also enhance resource efficiency (Nguyen et al., 2022).

## 3. Case Study: Southeast Asia

### 3.1 Geographic and Climatic Features

Southeast Asia lies in the region of great physical and great fauna and flora and countries that form it include Vietnam, Thailand and Indonesia. Southeast Asia has lowlands, hills and mountains as physical features. The most famous examples of the lowland region are the Mekong Delta of Vietnam and the Chao Phraya Basin of Thailand where agriculture heavily relies (Nguyen et al., 2019). Southeast Asia is tropical in climate with a well marked wet and dry season but the former is longer than the latter. It has hot weather throughout the year with the average temperatures of 25C-32C. The monsoon season is also typified with the occurrence of heavy rainfall and varies in different regions. May to October experiences southwest monsoon whereas November to April experiences northeast monsoon. These climatic conditions affect the farming practices, such as pig farming, since they affect water availability, type of soil, and ways of handling animal waste (Le Toan et al., 2021).

### 3.2 Overview of Pig Farming Practices in the Region

Pig farming is one of the most important livestock farming systems in the Southeast Asia region because of the domestic and export markets. In the case of Vietnam and Thailand, pig farming can be observed in different production types such as smallholder farmers, semi-intensive, and intensive commercial farms (Newton, 2007). Traditional Practices: Traditional pig farming in the rural areas is small-scale scale where pigs are kept in small pens in the backyard of people's homes. These systems are characterized by low stocking density, no or limited use of commercial feeds, and feeding on household wastes. In these systems, manure management may include simple composting or spreading on fields, and this leads to localized nutrient pollution (Nhat et al., 2025). Intensive Commercial Practices: Small-scale pig farming is common in the rural areas, while intensive pig farming is common in the peri-urban and urban areas. Such operations involve the barn and feedlot housing that is utilized to enhance the production among the animals. The pigs are also normally brought up in high numbers and treated and fed like the other animals. Manure in intensive systems can be piled up in a lagoon or pit and transferred to land or waste disposal plants (Yamada et al., 2018). Nevertheless, these activities are harmful to the environment, i.e., nutrient runoff, air pollution, and the possibility of disease transfer. Technological Integration: Technological integration is also evident in that there are indications of improvement in technology as applied to pig farming in the area. Some of the practices common in commercial farms include automated feeding and watering, environmental control, and computer use in running the farm and the animals. However, the issue of sustainability remains controversial, especially about the trade-off between the cost and the environment.

### 3.3 Environmental Regulations and Compliance

The environmental laws in the Southeast Asian countries do not resemble one another, yet overall, they are focused on the matters of pollution, waste management, and conservation (Vinh et al., 2019).

**Vietnam**: The Vietnamese government has devised a number of policies to control the effects that agriculture has on the environment, such as the Law on Environmental Protection and even provisions regarding how waste is to be treated in animal production. These laws involve the control of manure and wastewater water but sometimes the implementation of these laws is ineffective, particularly in the countryside, due to a shortage of funds. This renders the degree of compliance to be typically low due to the poor infrastructure and technical competency of the farmers.

**Thailand**: To curb pollution and dumping of agricultural wastes in Thailand, the country has adopted the National Environmental Quality Act among other local acts. The implication of these regulations, which also provide the guidelines on handling manure and wastewater, is left to the Department of Livestock Development. However, implementation of the regulations has its difficulties in the presence of numerous smallholders and the absence of appropriate regulation in certain regions. **Indonesia**: In Indonesia, the laws that govern environmental aspects of pig farming are the Environmental Protection and Management Act. The country has set policies on waste management and pollution control, but the issue is in the implementation of these policies. Some of the challenges include: lack of funds in monitoring and enforcement of environmental laws and policies, and geographical variation in compliance with the laws (Raff & Earnhartet, 2024).

## 4. METHODOLOGY

### 4.1 Data Collection Methods

Since the SEIA approach incorporated the use of several data collection instruments, a comprehensive method was employed to evaluate the effects of intensive pig farming in Southeast Asia. This approach involved the use of both primary and secondary data to improve the efficiency and thoroughness of the environmental impacts assessment.

**4.1.1 Field Surveys and Observations**

The interviews were conducted in several selected intensive pig farming enterprises in Vietnam and Thailand that are representative of large-scale pig farming in the region. The questionnaires were to be used to retrieve both quantitative and qualitative data pertaining to some important environmental indicators. The questionnaires were formulated in a manner that quantitative as well as qualitative data concerning various parameters in the environment were obtained:

1. Air Quality: Other air quality measures that also contained ammonia ($NH_3$) and methane ($CH_4$) produced during pig farming were also measured. Portable gas analysers were used to collect samples of air in different places within and around the farms. These samples were used in measuring the emission rates and the possibility of air pollution. The level of particulate matter as well as other pollutants which may influence the quality of air and the health of the population was also determined in the process of collecting the data.
2. Water Quality: Water samples were also taken within the water sources in which pig farms and agricultural drainage points exist in order to determine the effect pig farming had on the quality of water. Among others, parameters that were studied included Nitrogen (N), phosphorus (P), pathogens, heavy metals and biochemical oxygen demand (BOD). These indicators can be used to define the extent of nutrient pollution and eutrophication as depicted by Carpenter et al. (1998). The sampling procedures were conducted up to the recommended standards of improving precision and reliability.
3. Manure Management Practices: Part of the surveys that were undertaken was on the management and disposal of manure to determine its effectiveness and effects on the environment in case it had any. The details gathered entailed the techniques involved in the storage, treatment and the spreading of manure, the rate of spreading and the volume of manure spread on the lands. This knowledge helped to evaluate the potentials of soil and water pollution.
4. Soil Health: It was achieved by taking soil samples in the fields which had received pig manure as a fertilizer to determine the health of the soil and its capacity to sustain plant life. These parameters were the pH of soil, nitrogen, phosphorus, potassium and percent of organic matter of the soil. Observation and physical examination were also carried out to conduct soil degradation and erosion. Such tests gave information on how manure application affects the soil and its sustainability.

**4.1.2 Interviews**

Farmers, agricultural extension officers and environmental regulators were the subjects of semi-structured interviews. The interviews were aimed at giving qualitative information about various issues of intensive pig farming. These interviews were structured in a way that would afford the researchers qualitative information on several aspects of intensive pig farming.

1. Farming Practices: Interviews were conducted with the farmers to understand the management practices and challenges in intensive pig farming. Some of the areas of discussion include feeding practices, waste disposal, and general compliance with the environmental standards. Such data supplemented the findings of field surveys and contributed to the understanding of actual practices implemented (Bryman, 2016).
2. Regulatory Compliance: Some of the questions posed to the key informants were those concerning the enforcement of environmental regulations as well as compliance measures, and these were directed to agricultural extension officers and environmental regulators. Issues that were discussed were the effectiveness of the existing policies, the noncompliance, and the roles of the authorities in charge of mitigating the impacts on the environment (Tuan et al., 2020).
3. Perceived Environmental Impacts: Every interviewed stakeholder gave his or her opinion on the perceived environmental impacts of intensive pig farming, including air and water pollution, soil erosion, and impacts on species diversity. These qualitative insights helped interpret the field surveys and in getting an understanding of the stakeholders' view (Bryman, 2016).

**4.1.3 Secondary Data**

Besides, primary data, secondary data were also employed to support and elaborate on the results. This secondary data included:

1. Historical Records: Data from the national environmental agencies and other research works provided historical information and benchmark data on the state of the environment in the chosen sites. This was in

terms of past records relating to trends of air and water pollution, health of the soil and records of past practices in the use of manure (Jick, 1979).

2. Policy Documents: The study was carried on the legal and regulatory picture that regulates pig farming and the thresholds of acceptability. That meant assessing the policies, laws, and regulations and the measures of compliance to identify the legal requirements and their effects on the farming systems, according to Tuan et al. (2020).

3. Academic Publications: This was done with a consideration of finding out past researches that have been conducted concerning the impacts of intensive pig farming on the environment. These included on pollution, nutrients and the interventions towards the two to the extent.

**4.2 Environmental Indicators and Metrics**

In order to assess the environmental issues of intensive pig farming, some key indicators and metrics were applied:

1. Air Quality: Portable gas analyzers measured the emissions in terms of ammonia ($NH_3$) and methane ($CH_4$). Air samples were also collected within pig farming structures and their environs, and the emission rates were derived from concentration and air exchange rates.

2. Water Quality: Water samples were collected from the water sources nearby and from agricultural drainage water. Nutrient pollution and eutrophication potential were quantified by indices such as nitrogen (N), phosphorus (P), and biochemical oxygen demand (BOD) as stated by Carpenter et al., 1998. The samples were also tested for pathogens and heavy metals.

3. Soil Health: The samples were collected from fields that received pig manure. Some of the parameters that were taken included the pH of the soil, nitrogen, phosphorus, potassium, and organic matter of the soil. Soil erosion and degradation were assessed physically and by observation.

4. Biodiversity: The surveys and habitat assessments were conducted via field surveys. Impact of pig farming on species richness and density was evaluated by comparing the data collected from the sites affected by the pig farming to the control sites, which were not affected by intensive pig farming (Foley et al., 2011).

**4.3 Analytical Tools and Models Used**

1. Statistical Analysis: Some of the software that was used in data analysis was R and SPSS. Descriptive statistics were used to describe the quantitative values obtained to present the data, whereas inferential statistics such as t-tests and ANOVA were employed to conclude the relevance of the differences between the impacted and non-impacted sites (Field, 2013).

2. Environmental Models: Impact assessment models were used to model and predict the impacts due to intensive pig farming on the quality of the air and water. Nutrient runoff and the impacts of such runoff on water bodies were modeled using the Soil and Water Assessment Tool (SWAT) as stated by Arnold et al., 1998. The influence on the air quality was determined by the AERMOD model that was used to estimate the dispersion and concentration of the pollutants.

**3.** GIS and Remote Sensing: The spatial pattern of environmental impacts was defined by mapping the changes in land use via the GIS and remote sensing means of identifying and addressing those issues. The aerial photographs and satellite images that were categorized were the ones used to determine the changes in the land cover and the degree to which the habitats were fragmented (Lillesand et al., 2015).

**4.** Policy and Regulatory Analysis: Existing environment laws were also taken into consideration and their performance during the implementation process. This included the evaluation of policies, law, and acts that are employed in the protection of the rights of the child. The comparisons with other areas allowed determining the effectiveness and the lack of regulatory measures (Tuan et al., 2020).

## 5. RESULTS AND DISCUSSION

### 5.1 Air Quality Analysis

The cross sectional field investigations revealed that the quality of air in intensive pig farms in Vietnam and Thailand was quite dynamic. The concentrations of ammonia (NH3), methane (CH4) were significantly increased close to manure storage and pig accommodation.

NH3 concentration: The average concentrations of NH3 in the air surrounding the pig farms were 17.2 mg/m 3 and the ones of the controls were 8.5 mg/m 3. Emissions were much more ($p < 0.01$) when close to the manure storage (Table 1).

$CH_4$ Concentrations: Methane concentrations were 12.5 ± 0.5 mg/m³ near pig farms and 6.9 ± 0.3 mg/m³ in non-farming areas ($p < 0.05$). Methane emissions were especially high in regions with uncontrolled waste.

**Table 1: Air Quality Measurements**

| Parameter | Farm Area (mg/m³) | Control Area (mg/m³) | p-value |
|---|---|---|---|
| $NH_3$ Concentration | 17.2 | 8.5 | <0.01 |
| $CH_4$ Concentration | 12.5 | 6.9 | <0.05 |

Table 1 shows that there are increases in air pollutants around intensive pig farms in Vietnam and Thailand. Farming areas had a mean Ammonia ($NH_3$) of 17.2 mg/m³ while control areas had 8.5 mg/m³ ($p < 0.01$). Methane ($CH_4$) was also higher with a mean concentration of 12.5 mg/m³ near farms compared to 6.9 mg/m³ in non-farming areas ($p < 0.05$). These results are depicted in Figure 1, which shows that manure storage and poor waste management practices contribute to higher emissions of $NH_3$ and $CH_4$.

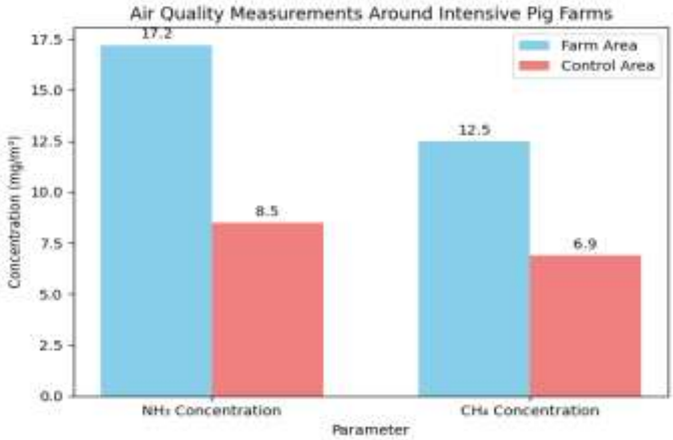


**Figure 1: Air Quality Measurements**

Figure 1 graphically depicts the higher concentration of ammonia ($NH_3$) and methane ($CH_4$) in the vicinity of intensive pig farms than at the control sites. $NH_3$ emissions are higher in farm areas (17.2 mg/m³) than control areas (8.5 mg/m³), and $CH_4$ levels are also higher in farming areas (12.5 mg/m³) than non-farming areas (6.9 mg/m³). The figure also shows the significant effect of pig farming on the environment, especially on the quality of air, where there is a significant rise in both pollutants.

**5.2 Water Quality Analysis**

The water samples obtained from the nearby water bodies and runoff areas had high concentrations of nitrogen (N) and phosphorus (P), which are indicators of nutrient pollution.

Nitrogen Levels: The mean nitrogen concentration in water bodies near farms was 3.8 mg/L, which was higher than 1.5 mg/L in reference sites ($p < 0.01$) (Table 2).

Phosphorus Levels: Mean phosphorus levels were 0.9 mg/L in impacted sites and 0.4 mg/L in reference sites ($p < 0.05$). They were associated with the discharge of pig slurry.

**Table 2: Water Quality Parameters**

| Parameter | Farm Area (mg/L) | Control Area (mg/L) | p-value |
|---|---|---|---|
| Nitrogen (N) | 3.8 | 1.5 | <0.01 |
| Phosphorus (P) | 0.9 | 0.4 | <0.05 |

Table 2 shows the findings of water quality analysis, which indicates that the nutrient concentrations are high in the areas where intensive pig farming is practiced. The mean concentration of nitrogen in water bodies adjacent farms was 3.8 mg/L and this value was greater than that of the control (1.5 mg/ L) ($p < 0.01$). Similarly,

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phosphorus concentration in the affected stations was 0.9 mg/L against 0.4 mg/L in the control stations ($p < 0.05$). Such intensities of nutrients are linked to pig slurry discharge and this is one of the most highest concerns about industrialized pig production that is environmentally harmful. These findings are depicted in Figure 2, which highlights the nutrient pollution in water bodies affected by farms.

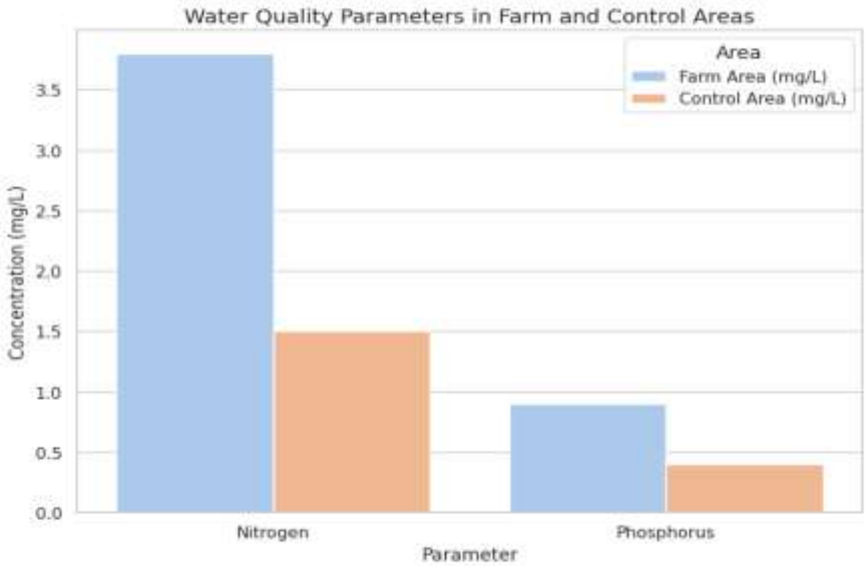


**Figure 2: Water Quality Parameters**

Figure 2 shows the comparison of the concentration of nitrogen (N) and phosphorus (P) in water bodies around intensive pig farms and the control sites. The figure shows that nitrogen concentration in the farm-impacted water is 3.8 mg/L, while in the control water it is 1.5 mg/L ($p < 0.01$). Likewise, phosphorus concentrations are high at 0.9 mg/L in farm areas while the control sites recorded 0.4 mg/L ($p < 0.05$). This graphic supports the idea of how the pig manure affects nutrient pollution of water bodies in the vicinity.

### 5.3 Manure Management Practices

Observations of manure management practices revealed several inefficiencies. Several issues were noted in the observation of the management of manure:

Storage Practices: Some of the farms used open lagoon storage of manure, which led to high $NH_3$ emissions and possible runoff.

Application Practices: Manure was used at rates higher than the nutrient requirements of the crops, thus resulting in leaching and soil pollution.

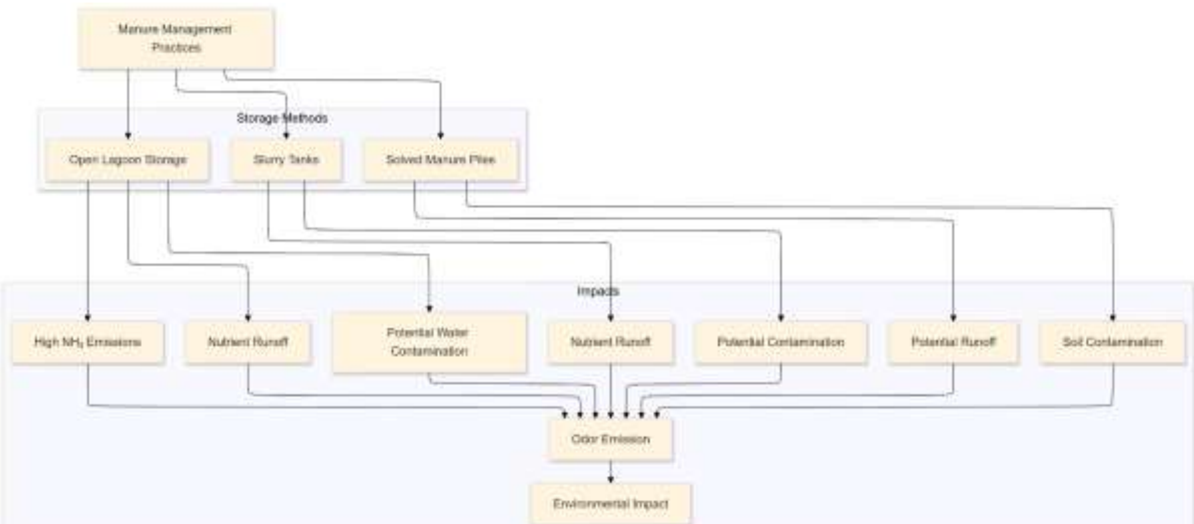


**Figure 3: Manure Storage and Application Practices**

Figure 3 presents different types of manure storage and application systems in intensive pig farming. The figure illustrates various techniques, including lagoon storage, solid manure piles, and slurry application. It also shows the potential environmental consequences of the process, such as nutrient runoff, odour emission, and water contamination. The visualization assists in understanding how various practices can affect the environment and highlights the significance of proper management of manure in preventing adverse environmental impacts.

### 5.4 Soil Health Analysis

Soils samples from pig dung applied fields showed:

Soil pH: The mean PH of the soil in the manure application fields was 5.8 whereas that of the control fields was 6.5. According to the findings reflected in Table 3, low pH values can be associated with the increased rates of applying manure.

Nutrient Levels: The results showed that nitrogen and phosphorus of the soil was significantly higher in the manured soils (1.2% N, 0.8% P) as compared with control soil (0.6% N, 0.4% P) ($P < 0.01$).

**Table 3: Soil Health Indicators**

| Indicator | Manured Fields | Control Fields | p-value |
|---|---|---|---|
| Soil pH | 5.8 | 6.5 | <0.01 |
| Nitrogen Content | 1.2% | 0.6% | <0.01 |
| Phosphorus Content | 0.8% | 0.4% | <0.01 |

Soil health indicators in the pig manure-treated fields and the control fields are presented in Table 3 below. The mean pH of the soil in the manured field was 5.8, and that of the control field was 6.5 (t 5.23; $p < 0.01$), which indicated that the use of manure has made the soil acidic. On the same note, the nitrogen and phosphorus of the manured soils were also significantly high with an average nitrogen content of 1.2 % N and phosphorus content of 0.8 % as compared to 0.6% N and 0.4% P in control soils at the level of probability of 0.01. These differences are depicted in Figure 4, which depicts how manure influences the pH and nutrient levels of the soil.

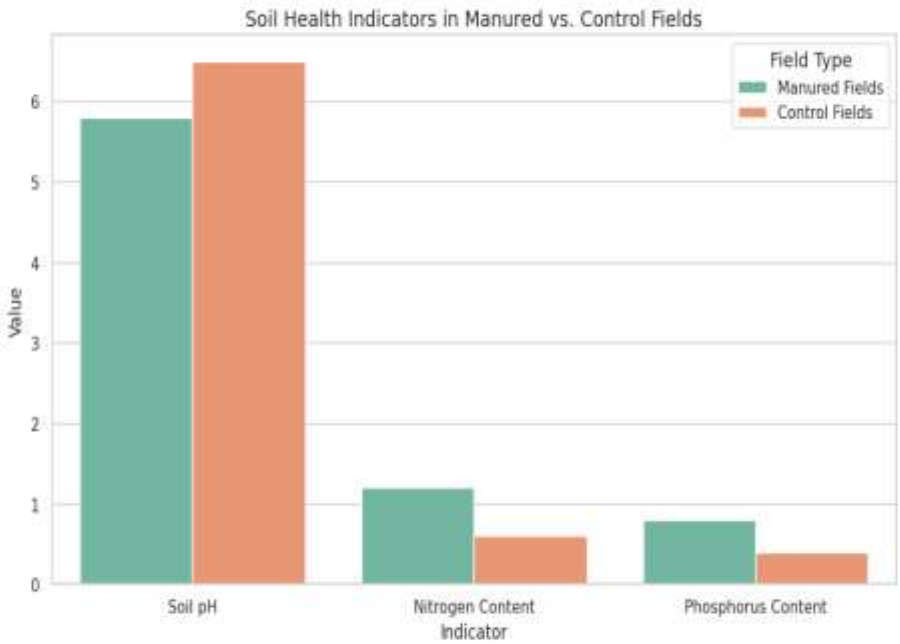


**Figure 4: Soil Health Indicators**

The variation in soil pH and nutrient content in pig manure application fields and control fields is shown in Figure 4 below. The figure also shows that the average of soil pH in manured fields was 5.8 while that of the control fields was 6.5. Also, nitrogen and phosphorus contents were significantly higher in manured soils, with an average of 1.2% N and 0.8% P as compared to 0.6% N and 0.4% P in control fields. This picture illustrates the effect of manure application on the soil acidity and nutrient supplementation.

**5.5 Biodiversity Assessments**

Field surveys showed that areas surrounding intensive pig farms had lower species diversity compared to reference sites: Field surveys showed that areas surrounding intensive pig farms had lower species diversity compared to reference sites:

Species Diversity: Mean species density in farm areas was 20 species per $100m^2$, while that of non-farming areas was 35 species per $100m^2$ ($p < 0.05$) (Table 4).

Abundance: The density of some of the species was lower in the areas of intensive farming.

**Table 4: Biodiversity Metrics**

| **Metric** | **Farm Areas** | **Control Areas** | **p-value** |
|---|---|---|---|
| Species Richness | 20 | 35 | <0.05 |

Table 4 shows how intensive pig farming affects the level of biodiversity. Results of the field surveys indicated that pig farms hurt species richness and composition since the number of species found in the vicinity of the farms was considerably lower than in reference sites. More specifically, species richness in farm areas was 20 species per $100m^2$, which was significantly lower than that of the 35 species per $100m^2$ in non-farming areas ($p < 0.05$). This decline in species richness shows that intensive farming practices have a direct impact on the local species and their habitats, resulting in poor health of the ecosystems. Figure 5 graphically illustrates this reduction in species richness and the environmental impacts of extensive pig farming.

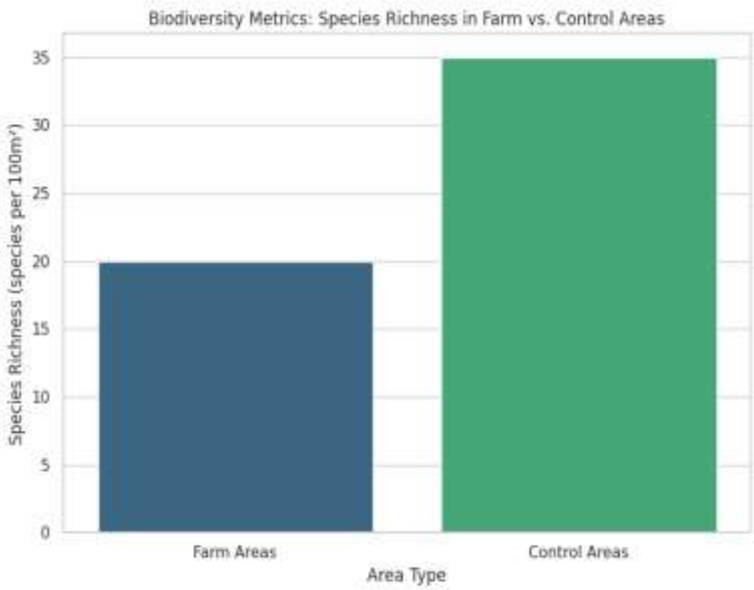


**Figure 5: Biodiversity Metrics**

Figure 5 shows the effect of intensive pig farming on the level of biodiversity. This indicates that the species richness of the areas surrounding pig farms is considerably lower than that of the non-farming areas. More specifically, species richness in farm areas is 20 species per $100m^2$ while that of control areas is 35 species per $100m^2$ ($p < 0.05$). This graphic also shows the impact of intensive farming on the local species richness and density, which are lower in areas where intensive farming is practiced.

The findings suggest that there are significant environmental costs that are linked to industrialized pig farming in Southeast Asia. The increased levels of $NH_3$ and $CH_4$ emissions raise important issues regarding air pollution. These findings are in agreement with the previous research that has ranked manure management as one of the major causes of the release of gases to the atmosphere. Carpenter et al. (1998) have supported the fact that nutrient loads from pig farms are seen in water quality assessment as a source of water pollution and eutrophication. The increased concentration of nitrogen and phosphorus in the sampled water bodies indicates that there is the necessity to increase the control over the manure and nutrients. The soil health outcomes showed that the impacts of increment in manure application rates are detrimental to the soil by affecting lower pH and nutrients level than the control sites. This observation proves that there is need to moderate manure use in an effort to balance the effects of soil degradation. The loss of species richness of the regions near the pig farms suggests that intensive farming has some impact on the ecosystems as has been argued by the other studies on fragmentation and species loss (Foley et al., 2011).

## 6. CONCLUSION

This study would attempt to examine the impacts of intense pig farming and how this can be sustainably managed within the Southeast Asia region. The evidence given in this paper indicates that the existing manure handling and existing laws are interlinked to major issues of nutrient pollution, soil erosion, and the destruction of biodiversity. The intensive pig farming has been related to storage of manure in open lagoons and extremely high application rates that have led to higher levels of nitrogen and phosphorus in water bodies and an alteration in the physical and chemical nature of the soil. Therefore, the fact that the ground released its soil pH and nutrient imbalances is very telling of the adverse effects of the existing approaches to manure management. Also, the fact that the density of species has lowered in the vicinity of pig farms indicates the overall effect on the fauna and flora. Concerning environmental regulation, there is still a big problem in implementing it even in the region. This study calls for improved compliance with the existing regulatory measures and better adoption of improved technologies of manure management. Accommodation of new technologies, for instance, nutrient recycle technology and enhanced waste disposal techniques, means that intensive pig farming has negative effects on the environment can be reduced. Therefore, efforts to deal with the environmental problems of pig farming in Southeast Asia need to be tackled through multi-disciplinary approaches involving policymakers, farmers, and researchers. Therefore, by setting and adhering to sustainable practices and improving the regulation, the region can begin moving toward diminishing the negative impact of pig farming on the environment and preserving the natural endowment of the country.

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