Risk Analysis of Domestic Egg-Laying Chicken Farms Using Z-Score and VAR (Value at Risk) Methods

"A Case Study: Chicken Farms in Nagan Raya Regency"

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Abstract. The high risk of mortality is one of the main problems faced by domestic egg-laying chicken farmers. This study examines the risks facing domestic egg-laying chicken farmers and the economic loss impacts contributed by those risks. The analysis methods used in this study were z-score and VaR (Value at Risk). The results show four types of production risks facing a group of farmers in Nagan Raya Regency: stocking density, changes in weather, predatory pests, and diseases. The most significant sources of risk come from diseases and changes in weather. The risk of disease has a probability of 17.8%, while the change in the weather is 12.7%. Stocking density and predatory pests, on the other hand, are the least significant sources of risk with the probability of only 4% and 2.2%, respectively. The risk of disease brings the most significant economic loss impact amounting to Rp.362,617.00, - and farmers lost Rp.117,926.00,-due to the weather changes.

1 Introduction

The owners of domestic egg-laying chicken farm businesses in Nagan Raya Regency often face challenges in achieving the success of their business. The challenges could be in the form of different levels and types of risks. The most common type of problem is production risk. Production risk is the probability of the occurrence of events that may cost economic loss impact. Such a problem may be caused by the conditions of sheds, weather, predatory pests, or disease.

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2 Domestic Chickens

Domestic chickens, the local or native chickens from Indonesia, are originally from the Red Junglefowl that has been through the taming process. Domestic chickens successfully adapt to the local environment through evolution and domestication to be more resistant to the disease and weather than broiler chickens [1]. Domestic chickens can be found in almost all places in Indonesia.

In Indonesia, they are various breeds of domestic chickens, some of which are still not identified. The definition of domestic chicken may vary from one place to another. In general, however, domestic chicken has various feather colors (black, white, brown, yellow, or combinations). It also has a relatively small body size with long black, white or yellow legs. Pelung, Kedu, Merawang, and Sentul are probably some most widely recognized Indonesia's domestic breeds. As a result of the cultivation process and interbreeding naturally or wildly, as well as different environmental influences, various types of chickens with various physical appearances and varieties are formed [2].

Consuming domestic chicken meat and eggs is healthier because the cholesterol content is lower than broiler chicken, and the meat is also tastier and drier. Domestic chicken eggs are also much preferred because they are believed to increase stamina or vitality. The advantages of raising domestic chickens include ample and sustainable market opportunities; high and relatively stable selling price; the longer the maintenance, the more expensive the selling price; relatively resistance to disease and stress; and pride for raising local poultry [3].

3 Phases of Domestic Egg-Laying Chickens

The cultivation of egg-laying chickens is generally divided into three phases based on age, namely: [2].

1. The starter phase or the initial phase starts from the age of 0–8 weeks, where the shape, size, and uniformity are the goals.
2. The grower phase starts from the age of 8–20 weeks, and the chickens need to be kept under very carefully controlled feed management to prevent the chickens from having inappropriate body weight.
3. The layer phase begins after the chickens are 20 weeks old. In this phase, the growth of the chickens must be accelerated for sexual development and to achieve optimal body weight uniformity.

4 Production Factors

1. Day Old Chick (DOC)

a. Selection of Day Old Chick

Selection of the type of chicken breed is a significant factor in a laying hens farming industry. Day Old Chick (DOC) is a leading poultry commodity gained from crosses of high-productive chicken species with high economic value. One of the characteristics of this commodity is that it has very fast growth. Some of the characteristics of a good

quality DOC include being free from disease, weighing not less than 37 grams, DOC looks active, has bright hair, big and wet legs, looks fresh, has no physical defects, and has no pasty vent [4].

b. Delivery process of DOC
Although the quality of Day-Old Chickens produced (DOC) is excellent, they are still at risk if they are stressed and do not want to eat and drink, leading to death. In this case, the handling technique during the shipping process becomes a very critical point. The following are deaths caused by transportation factors.

a). Delivery Time of Doc
Delivery time is also a concern in the shipping process. The preparation generally begins in the afternoon until delivery at night. This is done to avoid unpredictable hot weather conditions during the day throughout the trip. The most common case related to DOC transportation is where the DOC condition is dehydrated (lack of fluids) when they arrive at the farm. This condition can occur because the DOC is too long in transit [5].

2. Feed
Feed or ration is a collection of food ingredients suitable for eating chickens and arranged according to specific rules. The feed has the value of nutritional needs for chickens and the value of the nutritional content of the food ingredients used. Feed for egg-laying chickens in Indonesia is mostly divided into two types according to the period of maintenance: feed for the early period of laying and feed for the late period of laying. These two types of feeds have different nutritional content. Therefore, it is necessary to pay attention to the age of the chicken. Chicks less than four-week old are given early feed, whereas they are given late feed when the chickens are four weeks old [4].

Feeds have three physical forms: complete flour, granules (pellets), and (crumble). Complete form feed can be used for all ages, from day-old laying chicks to laying hens. Pellets or granular feed are only used for laying hens, namely pellets with a diameter of 3.2 mm. Meanwhile, crumble is widely used for laying hens during the starter period [3].

Domestic chickens aged 1–2 months need rations ranging from 25–45 g/day/head, age 2–3,5 months the ration needs 45–60 g/day/head, age 3.5–5.5 months 60–80 g/head/day [6]. The amount of feed consumption depends on the size of the animal's body, genetic characteristics, temperature, environment, size of the sheds, feeding place per head, condition of drinking water, quality and quantity of feed, and disease [7].

3. Drugs and Vaccines
Drugs and vaccines in this study refer to the drugs used to treat disease in livestock. Vaccines are used for the prevention of diseases originating from viruses, as well as antibiotics and vitamins, and can support the growth of chickens so that they can grow optimally.

Vaccines, vitamins, and antibiotics should be given regularly. This is very important to prevent disease outbreaks in chickens, especially against ND disease, which is very dangerous for livestock, and Infectious bursal disease (IBD), known as Gumboro. Administering the vaccine can be done through eye drops, nasal drops, injection, or spray method (fine spraying) [8].

4. Shed

Just like humans, chickens also need a proper place to live that can guarantee their health. Cleanliness of the shed and the ideal shed environment is an absolute requirement so that chickens can avoid various diseases. Some models of chicken sheds have different variations depending on the purpose of raising chickens, for example, egg-laying chickens, broilers, or chickens for decoration. [9]. The following are the requirements that must be considered when building a chicken shed.

1. Shed Location
   The following are essential items that must be considered when building a chicken shed,

   1. The shed must be built in an ideal location that will not disturb the environment, especially if it is built for larger chickens.
   2. The position of the cage should be higher than its surroundings so that water does not stagnate when it rains.
   3. The minimum distance is at least 10 m from the residential area.
   4. The shed must be designed for easy cleaning.
   5. The shed design must have good ventilation so that air exchange in the shed can work properly.
   6. The shed design must let sunlight into the chicken shed, especially in the morning.

2. Shed Density
   The ideal density standard for grower egg-laying chicken is 15 kg/m^2, equivalent to 6–8 broilers and 12–14 grower layer hens [6]. The size of the shed depends on several factors, such as the type of the shed, size of the chicken, temperature, environment, and ventilation conditions. The floor area recommended by the European Commission for medium-sized domestic chickens is 45 cm^2/head. The shed density of 8 birds /4050 cm^2 equivalent to 506 cm^2/head in young Wareng-Tangerang chickens provides a comfortable enough space for optimal production life [10].
3. Shed Construction
   The shed can be made of economically strong material, but it must have easy access for maintenance such as cleaning and disinfection. In addition, the material and construction of the cage must provide chickens protection from accidents and physical damage. The sheds should also have sewerage.

The shed's position should be built facing east so that it can get enough direct sunlight in the morning. The chickens are protected from the harmful heat of the sun during the day. The location must be separated from the residential area and is at least 500 m from the outer fence. The distance between chicken breeding farms and other farms (cows/buffaloes, goats/sheep, and horses) is at least 500 m and at least 1000 m away from animal waste shelters. The shed must not be located in the exact location as the hatchery or at least 500 m away.

4. Shed equipment
   Egg-laying chicken farms should have some shed equipment depending on the capacity/number of chickens. The equipment must be easy to use and easy to clean, and not easy to rust. The equipment needed are brooder, feeder for various ages, waterer for various types of age, lighting equipment, cleaning tools, egg trays and nests that function for laying eggs are usually made on the side of the shed in the litter/postal cage, the exhaust fan is a tool to remove CO2 gas and ammonia gas from inside the cage out of the shed.
5. Shed Lighting
   Lighting is crucial to help the chicken egg production process. The functions of lighting are:

   1. Stimulates appetite
   2. Stimulates the FSH hormone for the formation of egg yolks
   3. Stimulates the hormone LH for the release of egg yolk cells.
   4. The duration of lighting should not be reduced.

For egg production, the maximum duration for lighting is 16 h (12 h of sunlight + 4 h of light at night), or the addition of light is 4 h/day.

5 Research Method

The method used to examine the probability of risk occurrence is the standard value method or z-score. This method can be used if there is historical data and is in continuous (decimal) form. In this study, what will be calculated is the probability of risk in production activities (Fig. 1).

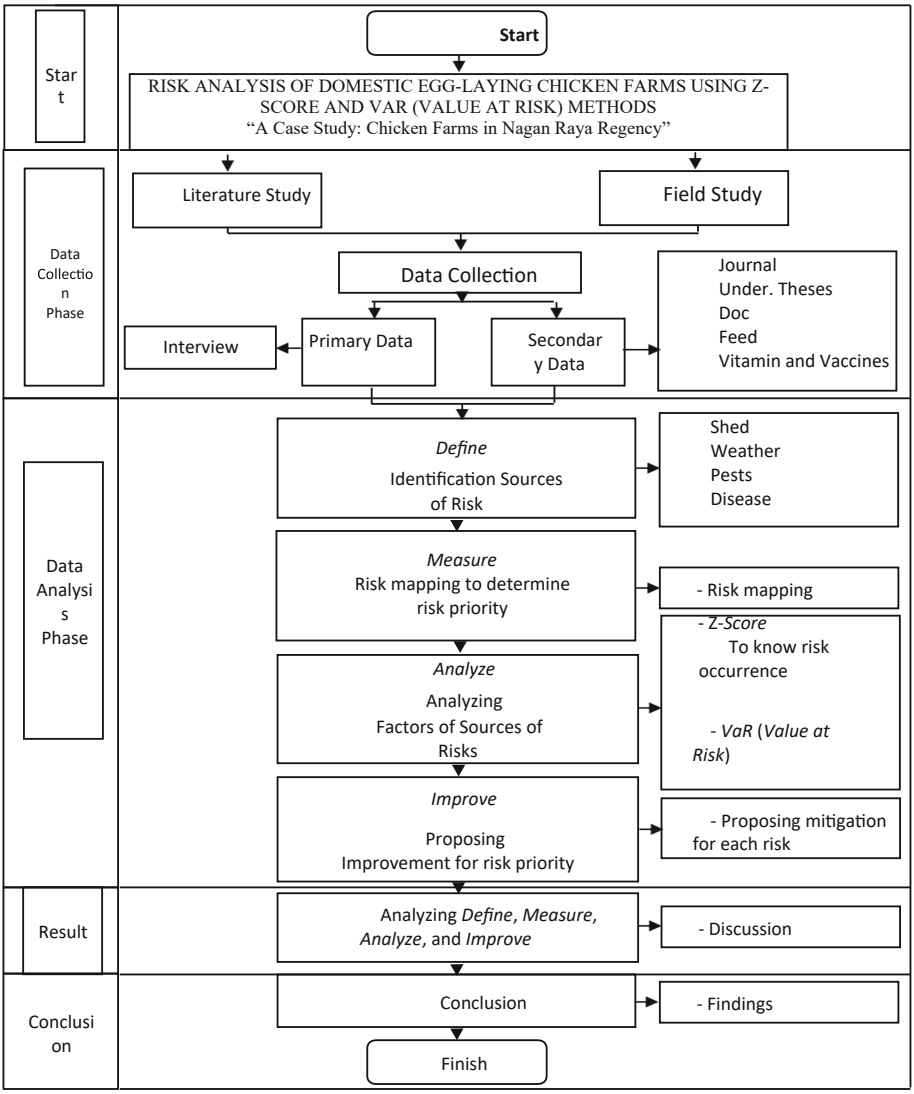

Fig. 1. The flowchart of the research

6 Discussion

6.1 Domestic Egg-Laying Chicken Mortality Rate

The data of mortality rate of domestic egg-laying chickens obtained from the group farmers in Nagan Raya Regency can be seen in Table 1.

Table 1. Data of chicken mortality in Domestic Egg-Laying Chicken Farms in Nagan Raya

No	Month	Initial number	Disease	Weather change	Predatory pest	Shed	Total mortality	Mortality percentage
1	January	4,000	10	5	0	0	15	0.38
2	February	3,985	0	0	0	0	0	0
3	March	3,985	0	5	0	0	5	0.13
4	April	3,980	20	10	5	0	35	0.88
5	May	3,945	0	0	10	5	15	0.38
6	June	3,930	0	10	3	0	13	0.33
7	July	3,917	0	0	0	0	0	0
8	August	3,917	28	0	0	5	33	0.83
9	September	3,884	0	25	5	0	30	0.75
10	October	3,854	0	15	0	0	15	0.38
11	November	3,839	37	20	0	8	65	1.63
12	December	3,774	15	20	0	0	35	0.88
13	January	3,739	40	7	5	0	52	1.30
14	February	3,687	15	13	0	16	44	1.10
15	March	3,643	50	0	0	0	50	1.21
16	April	3,593	40	20	5	5	70	1.75
17	May	3,523	0	5	0	10	15	0.38
18	June	3,508	20	0	0	0	20	0.50
Total		**3,488**	**275**	**155**	**33**	**49**	**512**	**12.80**

Source: Group of Domestic of Egg-Laying Chicken Farmers in Nagan Raya

6.2 Probability Analysis of Production Risk

The results of identifying the sources of production risks in the domestic egg-laying chicken farming industry in Nagan Raya Regency provide information that there are four types of production risk sources. The following is a probability analysis of each source of risk to examine their probability of occurrence.

This probability analysis was carried out to determine which sources of risk are most and least likely to occur so that the priority of handling can then be determined. The data used to carry out this probability were obtained from interviews with the farm owners and production reports from January 2020 to June 2021. Meanwhile, the determination of conditions, limits, and quantities used to calculate probability analysis based on farmer calculations referring to the reality that occurred in previous periods. The calculation of this analysis was performed using the z-score method.

6.3 Probability Risk Analysis of Changes in Weather

The probability of the risk from weather changes in the domestic egg-laying chicken farms is shown as follows.

The z-score method calculation showed that the z value for the source of production risk in the form of weather changes is −1.14. The negative (−) z value indicates that the value is on the left of the average value of the normal distribution curve. When mapped on the z distribution table, the z value for the source of the risk of weather changes will show a value of −1.14 with a probability of weather change of 12.7%.

6.4 Probability Risk Analysis of Predatory Pests

The following is the probability of the source of predatory pest risk in the domestic egg-laying chicken farms.

The z value for this source of risk obtained from calculations using the z-score method was −2. The z value, which was also negative (−), indicates that the value is on the left side of the average value of the normal distribution curve. The z value for the source of predatory pest risk, when mapped on the z distribution table, will show a value of −2 with a probability of predatory pest risk of 2.2%.

6.5 Probability Risk Analysis of Shed Density

The following is the probability of Shed Density Risk in the domestic egg-laying chicken farms.

The z value for shed density risk obtained from calculations using the z-score method is −1.75. A negative (−) z value indicates that the value is on the left side of the average value of the normal distribution curve. The z value for the source of shed density risk, when mapped on the z distribution table, will show a value of −1.75 with a spatial density probability of 4%.

6.6 Probability Risk Analysis of Disease

The z value for risk of disease obtained from the calculations using the z-score method is −0.92. A negative (−) z value also indicates that the value is on the left side of the average value of the normal distribution curve. When mapped on the z distribution table, the z value for the disease risk shows a value of −0.92 with a disease risk probability of 17.8%.

From the probability analysis results of the sources of production risk in domestic egg-laying chicken farms in Nagan Raya, the probability of each source of production risk can be seen in Fig. 2.

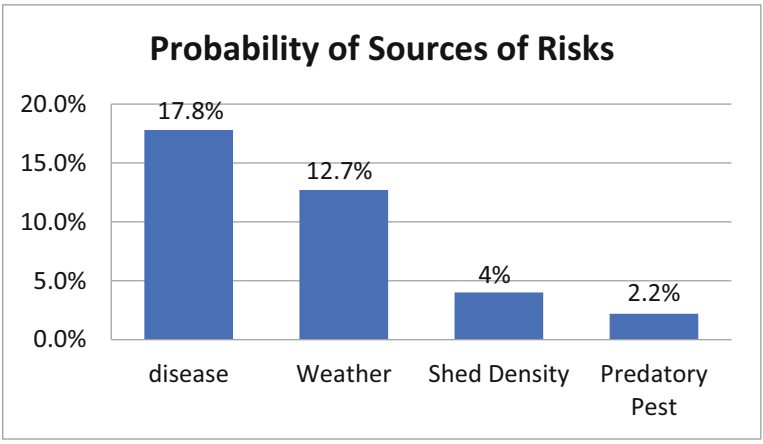

Fig. 2. Pareto diagram of probability Source of Risk

6.7 Production Risk Mapping

The probability and impacts of each source of production risk on domestic egg-laying chicken farm groups in Nagan Raya have been analyzed and calculated. Before formulating a risk management strategy, it is vital to carry out risk measurements to produce a risk status and risk map. Risk status is a measure that shows the level of risks from several sources of production risk that have been previously identified. The value of the risk status is obtained from the result of the multiplication of the risk probability and the risk impact of each risk source. The risk status of each source of production risk can be seen in Table 2.

Table 2. Status of the Risk Source in Egg-Laying Chicken Production

Source of production risk	Probability (%)	Impact (Rp)	Risk status
Disease	17.8	2,037,179	362,617
Weather	12.7	928,555	117,926
Shed Density	4	999,553	39,982
Predatory Pest	2.2	303,029	6,666

6.8 Analyzing the Sources of Risks in Domestic Egg-Laying Chicken Farms

Based on the data simulation analysis results of risk sources in domestic egg-laying chicken farms, the next step is to analyze the sources of domestic egg-laying chicken farms in Nagan Raya. The following is an analysis and mitigation of risk sources in domestic egg-laying chicken farms:

1. Changes in Weather

Extreme weather conditions significantly affect the mortality of domestic egg-laying chickens. In general, the change in weather from rain to heat is the primary source of risk impacting the chickens. Such a condition often affects the condition of the chicken's body. The immune system in the chicken body will significantly decrease in case of extreme weather changes. The following is a precaution that can be taken when extreme weather occurs (Table 3):

Table 3. Mitigating sources of weather change risk

No	Activity/Action	Objectives
1	Vitamin Supplementation (Especially Vitamin C)	To increase the body's immune, so that the chicken is more resistant to extreme weather changes
2	Paying attention to the opening and closing on the curtain	To maintain the temperature in the shed
3	Improving biosecurity	To prevent disease transmission. For example, controlling entry, spraying sheds with disinfectants (sterile infectious agents), maintaining the shed's cleanliness, feeder, and the surrounding environment

2. Disease

Gumboro or Infectious bursal disease (IBD), omphalitis (inflammation of the ovaries), Newcastle disease, and chronic respiratory disease are the common diseases attacking domestic egg-laying chickens. Viruses and bacteria cause this disease. Table 4 is the prevention that can be done against the disease:

Table 4. Management of sources of disease risk

No	Activity/Action	Objectives
1	ND Hitcner B1/ND Lasota vaccination on 4 day old chickens	To increase chicken's antibody. The antibody of chickens aged 4 decreased, making them prone to disease, especially ND
2	Vaccination of Gumbroro A on chickens aged 4–8 weeks	To increase immunity to Gumboro disease, because Gumboro disease generally attacks in the first and second weeks
3	Vaccinate ND Lasota/ND Clone 45 on chickens aged 4 weeks and so on every 3 months	To maintain antibody titers preventing other diseases

If chickens have been vaccinated three times but still die, they must be diagnosed by a veterinarian. If the chickens are tested positive for avian influenza (AI), then the AI vaccine should be given in the next vaccination.

3. Predatory Pests

Pests are predatory organisms. The most common predatory pests for chicken farms are civets and snakes. Many predators are active at night, making them difficult to detect. Table 5 shows the prevention that can be done against predatory pests:

Table 5. Mitigation of Predator Pest Risk Sources

No	Activity/Action	Objectives
1	Maintaining shed cleanliness	To keep pests out of the shed
2	Performing checks during the night	To prevent the attack of the pests during the night
3	Installing security such as wire on the floor and the wall	To prevent the pest from entering the shed

4. Analyzing the sources of the risk of shed density

Under normal conditions, the ideal number of chickens in the cage is 8–10 birds/m^2. The impact of the density of a shed is an increase in the temperature that may lead chickens to experience a critical condition, such as unstable (snoring), which occurs due to heat evaporation. The chickens need to stabilize the heat in their body. If the heat stress continues and the density of the shed is not controlled, it may make chickens weak or die because their heart fails to function. Usually, the chicken will die when the body temperature reaches 38–42°. However, the shed density in the chicken farms in Nagan Raya did not significantly affect the chickens because the size of the shed and the number of chickens in each shed were ideal.

The measures that farmers can put in place when observing the signs of heat stress in their chickens or when knowing that the temperature in the shed is hot can be seen in Table 6.

Table 6. Mitigation of shed density risk

No	Activity/Action	Objectives
1	Opening the curtain during the day	To ensure optimal air circulation in the shed

(*continued*)

Table 6. (*continued*)

No	Activity/Action	Objectives
2	Installing cooling aids, such as fans, blowers, etc	To facilitate air circulation in the shed
3	Performing the grading of the chickens based on their size	To prevent competition between big and small
4	Replacing drinking water with cold water	To help stabilize the body heat
5	Do not feed during the day	To prevent the increase of body heat
6	Multivitamin supplementation	To increase the immune system of chicken To increase the immune system of chickens

7 Conclusion

Based on findings of this research regarding the analysis of production risk analysis on domestic egg-laying chicken farms, the conclusion that can be made is as follows:

1. The results of the analysis using the z-score method showed that there are 4 sources of production risk, namely disease risk, which possess the highest probability of 17.8%, changes in weather with a probability of 12.7%, followed by shed density with the probability of 4% and predatory pest with the probability of only 2.2%. Risks of disease and weather changes brought the most significant impact, while the shed density and predatory pests had minor impacts.
2. The VaR (value at risk) method showed that disease and weather changes were the most significant source of risks. The calculation showed that the impact losses of disease risk were Rp. 362,617,00, and weather changes were Rp. 117.926.00, -
3. Mitigation strategies are carried out based on the sources of risk that have the most significant impact on the group of domestic egg-laying chicken farmers in Nagan Raya Regency.

   Strategies for mitigating sources of disease risk:

   a. Doing ND Hitcner B1/ND Lasota vaccination on four day old chickens
   b. Perform Gumboro A vaccination on chickens aged 4–8 weeks.
   c. Vaccination against ND Lasota/ND Clone 45 on chickens aged four weeks and so on for tree months.

   Strategies for mitigating sources of risk of changes in weather:

   a. Opening the shed curtain in hot weather
   b. Closing the shed curtain in cold or rainy weather

c. Installing cooling aids
d. Giving colder drinking water, especially in high-temperature conditions
e. Giving multivitamins
f. Improving biosecurity.

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