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# Does Socio-Economics Factor Influence Beef Cattle Farmers' Ability to Adapt to Climate Change?

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**ABSTRACT:** The livestock industry is still struggling with the effects of climate change. All commodities, including beef cattle, are subject to the negative effects of climate change. One such effect is heat stress, which can result in losses in the form of reduced reproduction and productivity as well as welfare losses. The negative effects of climate change must be reduced through prevention, which includes adaptation. Beef cattle farmers make several different modifications. Socioeconomic considerations are one of the many types of factors that can contribute to this modification. This research was conducted in Probolinggo, Sumenep, and Tuban districts because these three areas have the largest beef cattle population in East Java. We interviewed 206 farmers using a questionnaire. The acquired data were examined using quantitative descriptive analysis and STATA 17 software with a multivariate probit model. This study discovered that beef cattle farmers used four adaptation strategies to deal with climate change, such as changing forage types to provide more nutrition; having routine immunization; working with veterinarians to improve biosecurity, vaccination, and animal health; and promoting artificial insemination using high-quality semen. Furthermore, socioeconomic determinants that have a major impact include age, access to credit, farming experience, level of education, access to non-farming income, and access to climate change knowledge. However, gender, family size, and livestock size had no effect on adaptation.

**Keywords**: Adaptation; Beef cattle; Climate change; Socio-economic

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## INTRODUCTION

Climate change is one of the problems currently faced by the entire world, which has been occurring over the long term. In the 21st century, climate change plays a role in various scientific, political, and socio-economic issues, posing new threats and challenges to households, social groups, and regions worldwide (Mihiretu *et al*., 2019). One field closely linked to climate change is agriculture. Long-term climate change will affect agricultural productivity, posing a threat to food self-sufficiency or food security efforts (Yila & Resurreccion, 2013). The economies of many developing countries, such as Indonesia, Thailand, and Vietnam, which heavily rely on the agricultural sector, are highly sensitive to climate change (Feleke *et al*., 2016). In addition to developing nations, the most severe impacts of climate change will also be experienced by small-scale farmers in impoverished and less-developed countries (Hirpha *et al*., 2020).

Godde *et al*. (2021) explain that the livestock sector worldwide also considers climate change as a major issue. Climate change leads to temperature increases that significantly affect many critical factors for livestock production, such as water availability, animal productivity, reproduction, and health (Rojas-Downing *et al.*, 2017). The health factor is affected by climate change, which can create favorable conditions for the proliferation of pathogenic infections and insects (Kgosikoma *et al.*, 2018). However, livestock resilience to the impacts of climate change varies. Species, breeds, health status, body condition, previous exposure to stressors, performance level, mental state, age, and metabolic conditions are factors that influence the livestock's stress response to climate change (Sejian *et al.*, 2015). The adverse effects of climate change lead to a decline in productivity, which contributes to the poverty levels of the farmers (Nkuba *et al.*, 2019). The livestock sector in developing countries has the potential to contribute to food security. Food security in developing countries is at risk when efficient animal protein production is limited due to heat stress, which could be a significant contributing factor (Sejian *et al.*, 2013). Indonesia, as one of the developing countries, is considered to be the largest consumer of meat based on its population size (Khalil *et al.*, 2019). Greenwood (2021) explains that of the 17 million head of cattle in Indonesia, mostly managed by small-scale farms or family units, which only supply approximately 45% of the domestic beef consumption. In addition to supporting food security, the livestock sector can also reduce poverty and hunger by creating job opportunities and contributing to the country's Gross Domestic Product (GDP) (Chandio *et al.*, 2021). Small-scale livestock production provides income, food, fuel, building materials, electricity, and fertilizer for the general population in many developing countries (McKune *et al.*, 2015). The fuel and electricity obtained from livestock production, specifically biogas, are utilized for cooking and transportation activities, with the potential of being upgraded to biomethane, thereby becoming a renewable alternative energy source (Surendra *et al.*, 2014). In addition to being a renewable alternative energy source, biogas produced from the anaerobic digestion of animal waste is considered as one of the best solutions for waste management in the future (Khalil *et al.*, 2019).

Based on the explanations provided, it is essential to take action to reduce the intensity and magnitude of the ongoing and increasing impacts of climate change (Jha & Gupta, 2021). The appropriate and necessary response to control the magnitude of the adverse impacts caused by climate change is through adaptation (Gebrehiwot & Van Der Veen, 2013). Adaptation measures become crucial for climate-vulnerable communities, such as farmers, enabling them to cope effectively with weather conditions or extreme climate variations (Tesfaye & Seifu, 2016). Adaptation can help sustain the agricultural sector, protect

livelihoods, especially for the poor community, and enhance food security (Bryan *et al.*, 2013). Adaptation in each sector or field comes in various forms, depending on the impact or threats posed by climate change (Tripathi & Mishra, 2017). Based on the previous description, it is necessary to conduct research on the adaptation of beef cattle farmers in East Java to face climate change and analyze the socio-economic factors that influence the adaptation of beef cattle farmers to climate change. This study contributes to the literature by providing the first empirical evidence related to the factors affecting climate change adaptation among livestock farmers in Indonesia.

## MATERIAL AND METHODS

*Research Location, Respondent, and Data Collection*

This research was conducted in three regions in East Java: Probolinggo, Sumenep, and Tuban from November 2022 to January 2023. We interviewed 206 beef cattle farmers who had been in the business for at least 1 year and resided in those three research locations by means of questionnaire. The questionnaire consisted of two main sections, such as the socio-economic characteristics of the farmers and questions related to farmers' adaptation to climate change. The socio-economic characteristics included name, age, gender, access to credit, farming experience, livestock ownership, education level, household size, access to non-farm income, and access to information about climate change. In addition, we collected the secondary data from reliable sources, such as documents, websites, and books from relevant institutions.

The dependent variables in this study include changing the type of forage with appropriate nutrition, routine vaccination of livestock, collaboration with veterinarians to optimize biosecurity, vaccination, and animal health, as well as artificial insemination with high-quality semen. The measurement of dependent variables concerning climate change is conducted using a binary variable, where 1 represents the use of specific adaptation strategies and 0 others. The explanation of the dependent variables regarding climate change is presented in Table 1.

**Table 1.** Assessment of dependent variables

| Variable | Description |
|---|---|
| Changing the type of forage with appropriate nutrition | Dummy – 1 If farmers change the type of forage with appropriate nutrition; 0 others. |
| Routine vaccination of livestock | Dummy – 1 If farmers conduct routine vaccination of livestock; 0 others |
| Collaborating with veterinarians to optimize biosecurity, vaccination, and animal health | Dummy – 1 If farmers collaborate with veterinarians to optimize biosecurity, vaccination, and animal health; 0 others |
| Artificial insemination with high-quality semen | Dummy – 1 If farmers use artificial insemination with high-quality semen; 0 others |

The independent variables include age (x1), gender (x2), access to credit (x3), farming experience (x4), education level (x5), household size (x6), access to income outside farming (x7), number of livestock ownership (x8), and access to information about climate change (x9). The assessment of independent variables regarding climate change is presented in Table 2.

**Table 2.** Independent variable assessment

| Variable | Variable Description | Hypothesized sign |
|---|---|---|
| Age | Age of beef cattle farmers in East Java (1-5) | + |
| Gender | Dummy, 1 if the gender of the farmer is male; 0 otherwise | + |
| Access to credit | Availability of access to credit or finance for beef cattle farmers (1-3) | + |
| Farming experience | Length of experience as a beef cattle farmer (1-4) | + |
| Level of education | Education level of beef cattle farmers (1-5) | + |
| Households size | Dummy, 1 if the number of family members is 1-5 people; 0 if the number of family members is more than 5 people | + |
| Access to non-livestock income | Dummy, 1 if a farmer has a non-livestock employment; 0 otherwise | + |
| Number of livestock ownership | Dummy, 1 if the number of beef cattle is 1-5; 0 if the number of beef cattle is more than 5 | + |
| Access to climate change information | Dummy, 1 when information regarding climate change is available; 0 otherwise | + |

***Data Analysis***

The data were analyzed using descriptive analysis and multivariate probit model using STATA 17 software. Quantitative descriptive analysis is employed to describe the frequency of socio-economic factors among beef cattle farmers in East Java, including age, gender, credit access, farming experience, education level, household size, access to income sources beyond farming, number of livestock ownership, access to climate change information, and to depict the adaptation strategies employed by beef cattle farmers in East Java in response to climate change.

The multicollinearity test was performed to demonstrate the interrelationships among the independent variables. The multivariate probit model is used to determine the adaptation strategy model. Analyzing using the same model can estimate the nature of relationships (interrelatedness, mutual influence, and the degree of association) among the studied variables (Piya *et al*., 2013). The equation of the multivariate probit model used in this study is as follows:

$$Yij = X'ij\beta j + eij$$

where :

Yij = The different adaptation strategy by the *i* beef cattle farmers (*i*=1,…,206)
X'ij = 1 x k vector of observed variables that affect the adaptation strategy
βj = k x 1 vector of unknown parameters (to be expected)
eij = Unobserved error term

## RESULTS AND DISCUSSION

### Socioeconomic characteristics of beef cattle farmers in East Java

Socio-economic characteristics of beef cattle farmers in East Java are presented in Table 3.

**1. Age**

Based on Table 3, it can be observed that out of the 206 respondents, 41% are aged between 41 to 50 years, while beef cattle farmers aged between 21 to 30 years constitute only 1% of the total respondents. The findings above indicate that beef cattle farming in East Java is predominantly carried out by farmers above the age of 40. The fact that beef cattle farming in East Java is run by farmers aged 40 and above is attributed to the difficulty in finding successors or replacements to manage the farms, as well as many farmers

discontinuing their farming businesses (Joosse & Grubbström, 2017). Another reason for the high number of beef cattle farmers in East Java aged above 40 years could be attributed to the broader understanding of older farmers compared to younger ones regarding livestock management, such as their comprehension of beef cattle diseases due to the experience held by the respondents (Mapiye *et al.*, 2018). The deeper knowledge and understanding possessed by older farmers can serve as a guide for choosing appropriate adaptations to mitigate the adverse impacts of climate change. Older beef cattle farmers may face challenges in adopting technology for farming practices leading to the use of traditional adaptation methods in running their beef cattle businesses (Dang *et al.*, 2019).

**Table 3.** Socioeconomic characteristics of beef cattle farmers in East Java

| Characteristics | Total | Percentage (%) |
|---|---|---|
| Age (years) | | |
| 21-30 | 3 | 1 |
| 31-40 | 22 | 11 |
| 41-50 | 85 | 41 |
| 51-60 | 63 | 31 |
| >60 | 33 | 16 |
| Gender | | |
| Male | 200 | 97 |
| Female | 6 | 3 |
| Access to Credit | | |
| Own Capital | 123 | 60 |
| Credit | 36 | 17 |
| Own Capital and Credit | 47 | 23 |
| Farming Experience (years) | | |
| 1-10 | 74 | 36 |
| 11-20 | 100 | 49 |
| 21-30 | 22 | 11 |
| >30 | 10 | 5 |
| Level of Education | | |
| No Education | 22 | 11 |
| Primary Education | 105 | 51 |
| Junior Education | 39 | 19 |
| Primary Education | 39 | 19 |
| Diploma/Bachelor Degree | 1 | 0 |
| Household Size (person) | | |
| 1-5 | 189 | 92 |
| > 5 | 17 | 8 |
| Access to Non-livestock Income | | |
| Yes | 139 | 67 |
| No | 67 | 33 |
| Access to Climate Change Information | | |
| Yes | 135 | 66 |
| No | 71 | 34 |
| Number of Livestock Ownership (Heads) | | |
| 1-5 | 181 | 88 |
| > 5 | 25 | 12 |

## 2. Gender

The number of respondents in the study is dominated by males compared to females (Table 3), indicating that beef cattle farming in East Java is predominantly carried out by males. The results of this research can be attributed to the ease that males have in accessing support for their cattle farming businesses, such as technological information (Zamasiya *et al.*, 2017). Ease of access to technological information can assist farmers in utilizing

technology for beef cattle farming as an adaptation to mitigate the adverse impacts of climate change. The reason for the low representation of women in beef cattle farming is attributed to the perception that women are only seen as supporting their husbands in farming and are primarily responsible for household management and tasks (Contzen & Forney, 2017). Another reason why female participation in beef cattle farming is rare is that female farmers prefer conventional agricultural practices that are safer and more comfortable (Dang *et al.*, 2019). The statement from Dang *et al*. indicates that female farmers opt for adaptation strategies with lower risks, consequently resulting in limited or underdeveloped adaptation choices used by female farmers.

**3. Access to Credit**

Table 3 shows that 17% of the respondents use credit, while 23% of the respondents combine their own capital with credit. This can be interpreted that the availability of credit access for beef cattle farmers in East Java is still low. The findings of this research align with the statement by Islam *et al.* (2014), which mentions that limited access to credit is one of the economic constraints and barriers to adaptation activities in the fisheries sector. The requirement for collateral or guarantees to obtain credit is a reason for the low utilization of credit (E. Saqib *et al.*, 2018). Farmers without collateral to obtain credit choose to utilize alternative financial sources to support their farming businesses. The limited availability of credit access reduces significant opportunities for households to invest and address issues within the beef cattle farming sector, such as cash availability and implementing climate change adaptations (Opiyo *et al.*, 2016). This leads beef cattle farmers in East Java to resort to adaptations that do not require additional costs, thereby narrowing down the range of available adaptation options.

**4. Farming Experience**

Table 3 shows that out of the 206 respondents, 48% have been engaged in beef cattle farming for a period ranging from 11 to 20 years. This indicates that farmers in East Java have a considerable amount of experience. Warner *et al*. (2015) state that the experience and knowledge possessed by farmers are directly proportional to the time spent in operating a beef cattle farming business. The experience possessed can train individuals to understand the environment and take climate events into account, thereby allowing farmers to plan adaptations to climate change more effectively (Yegbemey *et al*., 2013). The statements above indicate that farmers with extensive experience have a deep understanding of matters related to beef cattle farming, including climate change occurring in the surrounding environment, enabling them to implement appropriate adaptations.

**5. Level of Education**

Based on Table 3, it can be observed that out of 206 respondents, elementary school education is the highest level of education pursued by respondents, accounting for 51%. Furthermore, 39 farmers or 19% of respondents completed their education up to junior high school and high school levels. This data indicates that the education level of respondents in East Java is still low.

This aligns with the explanation provided by Islam *et al.* (2014), who stated that low education can be a social barrier to adaptation activities. One of the underlying reasons for the low education level of respondents is the limited access to further education (Khanal *et al.*, 2018). The low education level of respondents in East Java can result in decreased performance due to a lack of knowledge and skills in understanding issues related to beef cattle farming, such as climate change that poses risks to resources (Wetende *et al.*, 2018). The low education level also leads to adaptation activities conducted by beef cattle farmers being aligned with the knowledge and skills they possess in addressing the adverse impacts of climate change.

**6. Household Size**

Table 3 indicates that 92% respondents have a family size of 1 to 5 members. This indicates that the household size of beef cattle farmers in East Java is relatively small. The results of this research suggest a lower likelihood for farmers to experience poverty with a small family size (Thi Lan Huong *et al.*, 2017). The household size owned by beef cattle farmers in East Java also influences adaptation activities. Bhattacharjee & Behera (2018) state that larger household sizes tend to adapt less due to the heavier economic burdens within the household. Different findings were discovered by Ullah *et al.* (2015), who explained that smaller household sizes possess available resources that can be diverted towards developing the cattle farming business. The low resource requirements can be utilized to implement adaptation strategies for beef cattle farming in East Java in the face of extreme climate changes.

**7. Access to Non-Livestock Income**

Based on Table 3, only 33% out of 206 respondents do not have access to income sources beyond farming. This indicates that beef cattle farmers who were sampled in the study in East Java also receive income from sources outside of farming. Farmers diversify their income sources to adverse risks and smoothen their income (Nugroho, *et al*., 2023). The availability of access to income sources beyond farming can be related to adaptation strategies for mitigating the adverse impacts of climate change. The open access to income sources beyond farming for beef cattle farmers creates opportunities in the form of financial resources to implement climate change adaptation strategies (Adeagbo *et al.*, 2021). The statement explains that farmers do not face financial constraints when they have additional income sources apart from farming while implementing adaptation strategies. Thinda *et al.*, (2020) elucidate that the utilization of climate change adaptation strategies experiences an enhancement as household income increases. The interview outcomes indicate that several respondents engage in other occupations such as farming, construction work, fishing, casual labor, or freelancing.

**8. Access to Climate Change Information**

According to Table 3, it can be observed that 66% of the respondents have access to information regarding climate change, indicating that access to information about climate change is widely available among beef cattle farmers in East Java. The sources of climate change information owned by 66% of the respondents support their willingness to make changes in their farming practices, such as adaptive behaviors (Zamasiya *et al.*, 2017). Livestock farmers who possess information about climate change can plan appropriate adaptation activities to mitigate the adverse impacts of climate change. The interview results indicate that information regarding climate change is acquired from sources, such as radio, newspapers, television, or even from personal experiences. Another research finding reveals that 34.5% of the respondents have lack of access to information about climate change. The limitation or absence of reliable information concerning climate change leads to a lack of understanding among beef cattle farmers regarding climate change (Habtemariam *et al.*, 2016). This hampers farmers' ability to prepare adaptation strategies to address the negative impacts of climate change.

**9. Number of Livestock Ownership**

Table 3 indicates that 88% of the respondents own less than five cattle showing that the number of beef cattle ownership by farmers in East Java is relatively small which is also found by Nugroho *et al.*, (2022) in many areas on Java. The limited number of beef cattle ownership can be one of the reasons for the low awareness of climate change adaptation (Rakgase & Norris, 2015). The reason for the low number of beef cattle owned by farmers in East Java may be due to the reduction in the number of beef cattle as one of the adaptation measures to climate change (Idrissou et al., 2020). Another factor that

can affect livestock ownership is the spread of Foot and Mouth Disease (FMD) that occurred in East Java during the research.

**Characteristics of Beef Cattle Farmers' Adaptation Strategy in East Java**

The first adaptation strategy, which involves routine livestock vaccination, is utilized by 59% of the respondents. Vaccination is one of the management practices employed to address disease-related issues (Namonje-Kapembwa *et al.*, 2022). Respondents who adopt this strategy state that this adaptation approach is employed through increasing the frequency of vaccination in beef cattle. The findings show that farmers employing this strategy conduct vaccinations routine at least 1-2 times a year.

The most commonly used vaccines for beef cattle are for FMD and anthrax. The use of routine vaccination strategies can be supported by policies implemented by local departments or governments (Phuong *et al.*, 2018). This statement is consistent with the current situation of beef cattle farming in East Java, which is facing issues related to the spread of FMD. As a result, both central and regional governments through the Livestock Department have mandated vaccination.

The second adaptation strategy, which involves collaborating with veterinarians to optimize biosecurity, vaccination, and animal health, is adopted by 55% of the respondents. The second strategy is used to enhance security and prevention for beef cattle against environmental changes brought about by climate change. Animal health is threatened by the increase in disease pathogens, prolonged pathogen life cycles, as well as reduced immunity in livestock due to climate change (Charlier *et al.*, 2022). The presence of a veterinarian can provide options related to biosecurity to farmers according to the specific needs or priorities of their farms (Moya *et al.*, 2020). Respondents implement the second adaptation strategy by performing sanitation practices in matters related to beef cattle, such as the barn, feeding and drinking areas; administering various types of vaccines, such as anthrax, FMD, and providing medications and vitamins, such as deworming agents or vitamins A, B-complex, B-12, E, and D. The previous study conducted by Nguyen *et al.* (2016) found differing results, where the same strategy was adopted by 88% of dairy cattle farmers and 42% of dairy sheep farmers in the Oristano province of Sardinia, Italy. The variations in these findings can be influenced by geographical factors between Indonesia and Italy, affecting factors, such as temperature, wind speed, number of rainy days, and so on.

The third adaptation strategy, which involves artificial insemination with high-quality semen, is implemented by 50% of the respondents in their beef cattle farms. The use of this third strategy aims to enhance the reproductive capacity of beef cattle, ensuring the availability of regeneration to maintain the beef cattle population. The same strategy is employed to improve the genetic traits of beef cattle, ultimately yielding more climate-resilient cattle that can efficiently cope with climate change, thereby ensuring sustained productivity (Muchuru & Nhamo, 2017). Respondents mention that crossbreeding between local cattle, such as Madura cattle and crossbreeds of Ongole with Limousin or Simmental cattle, has been widely used through artificial insemination to address climate change and enhance productivity. These findings support Nugroho *et al.*, (2021) who found that farmer in East Java crossed Ongole breeds with European breeds such as Limousin and Simmental yielding Limousin-Ongole (LO) and Simmental-Ongole crosses (SO) to obtain hybrid vigour for beef production. Another study by Wetende *et al.*, (2018) found similar strategies being employed by 27% of dairy cattle farmers, involving crossbreeding dairy cattle that tolerate to rising temperatures. The variation in research outcomes can be attributed to geographical and demographic differences between Kenya and Indonesia. The last

adaptation strategy, which involves switching to higher-nutrition forage in response to climate change by beef cattle farmers in East Java, is utilized by 18% of the respondents. This strategy aims to minimize the negative impacts of heat stress caused by climate change (Sejian *et al.*, 2015).

Respondents employing this strategy switch to higher-nutrition forages such as elephant grass, Guinea grass, leguminous plants like moringa and leucaena, or agricultural byproducts such as rice straw, rice bran, and corn residues. The low adoption of this strategy is attributed to respondents perceiving that the forage provided as feed already meets the needs of the beef cattle.

The percentage of strategy usage is much lower compared to the findings of Nguyen *et al.* (2016), where 66% of dairy cattle farmers and 42% of dairy sheep farmers in Sardinia, Italy, utilized the same strategy. The disparity in research outcomes can be attributed to the distinct geographical conditions of Indonesia and Italy, with Indonesia having two seasons while Italy experiences four seasons. This could result in the availability of different types of forage as feed.

**Tabel 4.** Adaptation strategies of beef cattle farmers in East Java

| Adaptation Strategies | Total | Percentage (%) |
|---|---|---|
| Substituting forages with high nutritional value. | | |
| Yes | 38 | 18 |
| No | 168 | 82 |
| Routine vaccination of livestock. | | |
| Yes | 122 | 59 |
| No | 84 | 41 |
| Collaborating with veterinarians to optimize biosecurity, vaccination, and animal health. | | |
| Yes | 113 | 55 |
| No | 93 | 45 |
| Artificial insemination with high-quality semen. | | |
| Yes | 102 | 50 |
| No | 104 | 50 |

**Multicollinearity Test**

The results of the multicollinearity test among the independent variables are presented in Table 5.

Based on the test results, it can be observed that the nine independent variables have VIF values ranging from 1.02 to 1.65, with an average value of 1.24. Another test for multicollinearity, the tolerance values for all nine independent variables, is above 0.1, ranging between 0.6 and 0.9. This indicates that there is no multicollinearity among the 9 independent variables.

**Table 5.** Multicollinearity test results

| Variable | VIF | Tolerance |
|---|---|---|
| Access to Non-Livestock Income | 1,65 | 0,607646 |
| Farming Experience | 1,48 | 0,674543 |
| Access to Credit | 1,31 | 0,762220 |
| Age | 1,30 | 0,772135 |
| Level of Education | 1,21 | 0,827273 |
| Household Size | 1,12 | 0,892832 |
| Number of Livestock Ownership | 1,06 | 0,941991 |
| Gender | 1,03 | 0,969823 |
| Access to Climate Change Information | 1,02 | 0,976538 |
| The Average VIF | 1,24 | |

Source: Primary data processed, 2023.

**Socioeconomic Factors Affecting Beef Cattle Farmers' Adaptation in East Java**

The multivariate probit model analysis using simulated maximum likelihood (SML) is presented in Table 6. The prob > chi2 values found for the 4 dependent variables, namely switching to higher-nutrition forage; routine livestock vaccination; collaborating with veterinarians to optimize biosecurity, vaccination, and animal health; and artificial insemination with quality semen, are all 0.0000. This finding indicates that H0 is rejected at the 1% level. It suggests that the socioeconomic factors of the farmers significantly influence climate change adaptation strategies, which will be explained as follows:

**1. Age**

Table 6 shows that age has a negative and significant impact at the 1% level on artificial insemination with quality semen. This finding suggests that as farmers get older, their likelihood of deciding to use artificial insemination with quality semen as an adaptation strategy diminishes. Similar results are shown by Amamou *et al.* (2018), who mentioned that dairy farmers in Tunisia with an average age of 47-49 years chose not to adopt new cattle breeds or implement genetic improvements. Ojo *et al.* (2021) explained that older farmers have a lower interest in adopting climate change adaptation strategies to avoid potential risks. One possible risk of using artificial insemination with quality semen is the possibility of failure in animal impregnation.

**2. Gender**

Table 6 shows the results of the gender factor analysis on the four adaptation strategies of beef cattle farmers in East Java towards climate change. The findings indicates that gender does not have a significant influence on the four adaptation strategies. This suggests that gender does not determine the decision to use the adaptation strategies employed by beef cattle farmers in East Java.

**3. Access to credit**

Access to credit has a positive and significant impact at the 1% level on the adaptation strategy of switching to higher-nutrition forage (Table 6). This indicates that the availability or possibility of farmers obtaining credit increases the likelihood of farmers to use the strategy of switching to higher-nutrition forage. A different finding is shown by Okello *et al.* (2021), who found that feed development is not significantly influenced by access to credit.

These differing results could be attributed to the level of education among the respondents in their study, which averaged only 3 years, while respondents in this study had an average education level of primary school or 6 years. Abbas *et al.* (2022) stated that the unavailability of better forage varieties acts as a barrier to the adoption of this strategy. Limited forage types constitute one of the adverse impacts stemming from climate change (Zampaligré *et al.*, 2014). The availability of credit access assists farmers in obtaining the desired forage without being hindered by purchasing or transportation costs. Table 6 also shows that access to credit also has a positive and significant impact at the 5% level on the adaptation strategy of collaborating with veterinarians to optimize biosecurity, vaccination, and animal health. The decision to use this strategy can increase as the opportunities to obtain credit increase. Mankad (2016) stated that financial capability is one of the challenges faced by farmers in implementing biosecurity with veterinarians. This can be attributed to the fact that effective biosecurity management requires numerous elements, each with a relatively small influence and dependent function on the specific farm context (Cardwell *et al.*, 2016). The abundance of components in implementing this strategy can be addressed by the availability of credit access.

**4. Farming experience**

The experience factor of livestock farming has a negative and significant

impact at the 5% level on routine livestock vaccination strategies (Table 6). This indicates that the longer livestock farming experience a farmer has, the less confident they might be in adopting routine livestock vaccination adaptation strategies. Phuong *et al.* (2018) mentioned that only 6 respondents employed the livestock vaccination adaptation strategy based on their perceived experience when adopting this strategy. Unpleasant experiences during routine vaccination activities, such as the perceived lack of benefits from the administered vaccines, can be a reason for the decline in interest in using this adaptation (Mumba *et al.*, 2018). Another reason for the decrease in vaccine usage is that the vaccines received by farmers have reduced quality and effectiveness due to the lack of supporting equipment, such as portable refrigerators (Ayal *et al.*, 2018). This becomes a factor that can deminish farmers' interest in adopting routine livestock vaccination adaptation strategies.

Table 6 also shows that livestock farming experience also has a significant negative coefficient towards the adaptation strategy of collaborating with veterinarians to optimize biosecurity, vaccination, and animal health ($p \leq 0.05$). This illustrates that engaging in cooperation with veterinarians has a lesser chance of being adopted by farmers as their experience grows. Nguyen *et al.* (2016) mentioned that the limited utilization of this strategy is due to farmers continuing the same adaptation practices from generation to generation based on experience passed down from elders. Previous farmers, if they did not use the adaptation strategy of collaborating with veterinarians to optimize biosecurity, vaccination, and animal health in facing climate change, then this strategy is likely not to be carried out by the next generation of farmers. Farmers who have less experience regarding past disease outbreaks may reduce their interest in using biosecurity (Toma *et al.*, 2013). Livestock experience significantly and positively influences this strategy at the 1% level (Table 6). The use of artificial insemination with high-quality semen as one of the adaptation strategies to climate change can increase with growing experience. This is likely due to the successful artificial insemination performed on animals, which can provide advantages to the farm (Yaseen *et al.*, 2018). Different results were obtained, indicating that experience does not significantly influence artificial insemination practices (Okello *et al.*, 2021). This difference could be attributed to the research by Okello *et al*., (2021) which found an influence from another factor: the education level of dairy farmers in relation to artificial insemination. This illustrates that farmers have an awareness of using artificial insemination to enhance milk productivity.

**5. Level of education**

Table 6 shows that the level of education significantly and positively influences the adaptation strategy of switching to higher-nutritional forage types ($p \leq 0.10$). This indicates that the higher the level of education pursued by farmers, the higher the likelihood of using this strategy. Similar findings were discovered by Menghistu *et al.* (2021) who stated the level of education significantly influenced ($p \leq 0.05$) the improvement of livestock feed. Both of these findings reaffirm that the education level of farmers is important to consider. Education serves as a means to instill awareness about the risks posed by climate change and to plan appropriate adaptation actions (Amir *et al.*, 2020). The majority of beef cattle farmers in East Java have only received education up to elementary school level, which is one of the reasons for the low adoption of this strategy (18%).

**6. Household size**

Table 6 shows that household size does not have a significant impact on the four adaptation strategies. This suggests that the number of family members does not determine the utilization of adaptation strategies used by beef cattle farmers in East Java.

**7. Access to non-livestock income**

Table 6 shows that income outside livestock farming influences positively and significantly on the strategy of changing to forage with higher nutrition ($p \leq 0.10$). This suggests an increase in the utilization of higher-quality forage replacement as an adaptation strategy for beef cattle farmers in East Java, supported by the availability of income from sources outside livestock farming. The replacement of forage with higher nutrition requires higher costs due to the need for additional labor (Thornton & Herrero, 2014). This explanation is related to feed, which is the most significant cost component in livestock management, accounting for around 70% (Sejian *et al.*, 2015). This proves that feed and costs are closely related, enabling the implementation of this adaptation strategy with the support of income from sources other than beef cattle.

**Table 6.** Multivariate probit analysis of the influence of socio-economic factors on beef cattle farmers' adaptation strategies in facing climate change in East Java

| Variable | Substituting forages with high nutritional value | | Routine vaccination of livestock | | Collaborating with veterinarians to optimize biosecurity, vaccination, and animal health. | | Artificial insemination with high-quality semen. | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | P > \|z\| | Coefficient | P > \|z\| | Coefficient | P > \|z\| | Coefficient | P > \|z\| |
| Age | -0,088 | 0,544 | 0,058 | 0,622 | 0,172 | 0,138 | -0,340 | 0,007*** |
| Gender | 0,145 | 0,833 | -0,290 | 0,645 | -1,209 | 0,129 | -0,959 | 0,203 |
| Access to Credit | 0,383 | 0,005*** | 0,098 | 0,453 | 0,297 | 0,022** | 0,219 | 0,102 |
| Farming Experience | 0,217 | 0,218 | -0,316 | 0,026** | -0,371 | 0,019** | 0,414 | 0,006*** |
| Level of Education | 0,242 | 0,082* | -0,068 | 0,533 | 0,033 | 0,771 | 0,168 | 0,119 |
| Household Size | 0,172 | 0,683 | 0,166 | 0,636 | 0,064 | 0,863 | -0,457 | 0,220 |
| Access to non-livestock income | 0,557 | 0,087* | -0,755 | 0,005*** | 0,878 | 0,001*** | 0,962 | 0,000*** |
| Number of Livestock Ownership | -0,491 | 0,104 | 0,223 | 0,429 | -0,151 | 0,616 | -0,508 | 0,101 |
| Access to Climate Change Information | -0,031 | 0,895 | 0,828 | 0,000*** | 0,077 | 0,710 | -1,218 | 0,000*** |
| Constant | -2,595 | 0,020 | 0,577 | 0,548 | 0,255 | 0,824 | 1,571 | 0,143 |
| *Log Likelihood* | | | | | | | | -380,82433 |
| *Number of obs* | | | | 206 | | | | |
| *Wald chi$^2$ (36)* | | | | 143,69 | | | | |
| *Prob > chi$^2$* | | | | 0,0000 | | | | |
| *Likelihood ratio test* | | | | 69,0561 | | | | |

Note: *, **, ***, indicate significance at the 10%, 5%, and 1% levels, respectively
Source: Primary Data Processed (2023)

Table 6 also shows that non-livestock income significantly and negatively affects the strategy of routine vaccination of livestock ($p \leq 0.01$). This finding explains that even though farmers in East Java have income from non-livesctock farming, the opportunity to adopt routine vaccination of livestock as an adaptation strategy to climate change decreases. This could be due to the relatively high cost of vaccines and their limited availability in the region (Mumba *et al*., 2018). Wreford & Topp (2020) also explained that routine vaccination can lead to continuous operational costs, including labor and maintenance expenses. Farmers in East Java who use this strategy need to make long-term financial preparations, requiring careful consideration. The interview results indicate that other occupations of farmers in East Java are still climate-related, such as fishermen.

The adaptation strategy of collaborating with veterinarians to optimize biosecurity, vaccination, and animal health is positively influenced and significant at a confidence level of 99% (Table 6). This result indicates that farmers who have occupations other than being livestock farmers have a greater opportunity to make decisions to use the adaptation strategy of collaborating with veterinarians to optimize biosecurity, vaccination, and animal health. Berhe *et al*. (2017) explained that the availability of non-livestock income sources can enhance armers' ability to access animal health services from veterinarians. Biosecurity activities that can be performed include recording information about diseases, disinfecting vehicles and barns, preparing special barn clothing, and using additional supplements (Can & Altuğ, 2014). These measures can help tighten livestock security in terms of both infrastructure and the health of beef cattle, thus mitigating the adverse impacts of climate change.

Table 6 also shows that non-livestock income positively and significantly influences the use of artificial insemination with high-quality semen ($p \leq 0.01$). This finding illustrates that the availability of non-livestock income increases the tendency to use artificial insemination with high-quality semen as an adaptation strategy. Farmers using artificial insemination need to allocate additional costs compared to farmers who own breeding bulls (Mwanga *et al.*, 2019). Non-livestock income sources can be a way to address financial issues, allowing for the adoption of these adaptation strategies in farming (Feyissa *et al.*, 2023).

**8. Access to climate change information**

Table 6 shows that access to information about climate change has a positive and significant influence on the level of confidence at 99% towards routine vaccination of livestock, indicating that every increase in access to information about climate change obtained by farmers will enhance the decision to use this strategy. Climate information regarding the current and future seasons helps communities make appropriate adaptation decisions in response to climate change and variability (Sejian *et al.*, 2015). Another reason that supports farmers is their awareness that beef cattle are responsive to disease strains, which can have economic and welfare implications for the farmers (Cooper *et al*., 2015). Climate change information enables farmers to plan the vaccination schedule or the type of vaccination to be given to beef cattle.

Table 6 also shows that access to information about climate change has a negative and significant influence on artificial insemination with high-quality semen ($p \leq 0.01$). This finding indicates that the availability of information about climate change reduces the decision to use artificial insemination with high-quality semen as an adaptation to climate change in East Java. This could be due to weather information not supporting the improvement of the predictive value of the semen fertility used (Kamphuis *et al.*, 2020).

Climate change information provided by the meteorology office is only used as a decision enabler, while their knowledge

remains the main determinant of operational and tactical decisions (Mapfumo *et al.*, 2016).

**9. Number of livestock ownership**

Table 6 shows that the number of livestock ownership does not have a significant impact on the four adaptation strategies. This suggests that the quantity of beef cattle owned by farmers in East Java does not determine the utilization of adaptation strategies in facing climate change.

**10. Access to climate change information**

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## CONCLUSION

The research found that there are four types of adaptation strategies used by beef cattle farmers in East Java to cope with climate change. These four adaptations are as follows: first, changing the type of forage, such as switching from natural grass or leaves to higher-nutrition forage options like elephant grass, napier grass, legumes, or agricultural waste. Second, increasing the frequency of routine vaccination for beef cattle, with a minimum of 1-2 times a year. Third, collaborating with veterinarians to optimize biosecurity, which includes ensuring sanitation in the barns, feeding and drinking areas, administering vaccines for diseases like foot-and-mouth disease (FMD) and anthrax, and providing animal health care through medications or vitamins. Fourth, using artificial insemination with high-quality semen, involving crossbreeding local cattle with Simmental or Limousin. The socio-economic factors of beef cattle farmers in East Java, such as age, access to credit, farming experience, education level, income outside of farming, and information about climate change, positively or negatively influence the decision-making process regarding the adoption of these four adaptation strategies in facing extreme climate change. One of the limitations of this study is its focus on determining livestock farmers' adaptation. However, the effects of climate change adaptation on livestock farmers' outcomes, such as productivity, are not available in this study. Therefore, future research can

examine the effects of livestock farmers' adaptation on outcomes such as productivity and income.

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