Risk level analysis of human-elephant in the Peusangan watershed of Aceh Province, Indonesia

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Abstract. The Peusangan watershed is home to hundreds of communities and approximately fifty individuals of the endemic wildlife Sumatran elephants (Elephas maximus sumatranus). Human-elephants conflict (HEC) is a competition in the intersection of needs that has a negative impact on the community welfare and elephants. Elephants are protected wildlife that must be preserved, while at the same time there are socio-economic interests of the community which must also be guaranteed to be protected from possible damage due to the movement of the elephants. This study aims to determine the risk level by using a descriptive quantitative approach to identify the level of risk in the village area which is directly adjacent to the home range and not directly adjacent to the home range in the Peusangan watershed area. The method used is observation. The research sample was taken by purposive random sampling. Data collecting in the form of questionnaires and interviews. Data on the risk level of human elephants conflict were analyzed using the risk level formula. The hypothesis test of this study was carried out by analyzing the Independent Sample Test. The results of the study indicate that there are differences in the level of risk in areas that are directly and not directly adjacent to the Home Range with \( t_{count} \) value of 3.384 > \( t_{table} \) which is 1.984467. The criteria for the level of risk in areas directly adjacent to the home range have a low risk level and outside the home range have a medium risk with a level of hazard (68%), vulnerability (60%) and capacity (26%). Differences in risk levels refer to the implementation of conflict mitigation strategies, knowledge, attitudes and actions of the community in responding to human elephants conflict.

1. Introduction
The Peusangan watershed has an important role in maintaining the sustainability of life for wildlife and supporting the sustainability of sources of environmental services [1]. The Peusangan watershed area is home to hundreds of thousands of people and home to 45-50 individuals of large mammal’s endemic in the Sumatra island, currently the elephant group in the Peusangan watershed which is divided into 3 groups of herds lives pressed and isolated in the human population [2]. The movement pattern of elephants is near their resources, especially water. The movement distance of Sumatran elephants tends to be close to rivers or water areas, on average between ± 286 m and 198 [3]. Several
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studies of elephants in Aceh also describe elephants approaching water sources, which is between 0 – 250 m and also close to natural forest such as the example of elephant research in Seulawah [4]. The conflict between elephants and humans in the Peusangan watershed has proven that elephants need adequate space. Sumatran elephants traverse primary and secondary forests in their daily movements as their habitat, this shows that Sumatran elephants do not wander too far from locations that provide their needs [5].

In recent years, the conflict between elephants and humans has increased rapidly[6]. The development of the pulp and paper and the palm oil industry is also a trigger for the loss of elephant habitat in the Peusangan watershed [6]. The development of palm oil plantations encourages conflicts between humans and elephants which are increasingly peaking. The shrinkage or loss of habitat has forced elephants to enter populated areas, thus triggering conflicts between humans and elephants and it leads to the environmental crimes which are generally carried out by poisoning, poaching, fragmentation and loss of elephant habitat [7]. The increase in human activities around elephant habitat also results in a decrease in the quality and quantity of elephant habitat. In addition, several villages in the Peusangan Watershed are very vulnerable to elephant conflicts. These include Karang Ampar village in Central Aceh, Pintu Rime Gayo subdistrict in Bener Meriah and Pante Peusangan village in Bireun. Communities in these three areas suffer the most from direct human interactions with elephants. The average number of elephant conflicts in this area ranges from 10 to 20 times per month.

Human-elephant conflicts occur randomly throughout the area with a rotational pattern of conflict. The entry of elephants into settlements is very disturbing to the community and feels aggrieved by the consequences, such as destroying agricultural or plantation land [8]. Evicting elephants from a location which in essence only moves conflict is not a sustainable solution. Therefore, it is necessary to conduct research in analyzing the level of risk and manage human elephant conflict mitigation around plantation areas and community settlements. Risk analysis is a study used in supporting decision making based on hazard analysis, vulnerability and the amount of capacity at risk [9]. This research was conducted to determine areas with high to low range of human-elephant conflict in Peusangan watershed to support ecological functions and biodiversity and increased the level of vulnerability at the community level. Therefore, information about the types of risk levels is needed to mitigate human and Sumatra Elephant (Elephas maximus sumatranus) conflicts.

2. Materials and methods
2.1. Scope and location
Determination of the location of the sample was determined by purposive sampling based on a map of the distribution of elephants in the Peusangan watershed and the village area directly adjacent to the elephant corridor. The number of villages is divided into 2 groups, 5 villages are taken as samples as areas that are in the home range trajectory while 5 village groups are villages outside the home range area which are included in 3 districts (Bireun, Bener Meriah, & Central Aceh) within the Peusangan watershed area., as shown in table 1.

| No | Category      | Village   | District   |
|----|---------------|-----------|------------|
| 1  | Home Range    | Bergang   | Central Aceh |
| 2  | Home Range    | Karang Ampar |            |
| 3  | Home Range    | Negeri Antara | Bener Meriah |
| 4  | Home Range    | Alur Gading |            |
| 5  | Home Range    | Musara Pakat |            |
| 6  | Non Home Range| Alur Cincin |            |
| 7  | Non Home Range| Rimba Raya |            |
2.2 Research instrument
The research instrument used is a questionnaire to determine the level of conflict risk of the Human and Sumatran Elephant (*Elephas maximus sumatranus*). In addition, observations and interviews (in-depth interviews) were conducted. Observations were made in the form of types of plants on community plantations, the presence of lick minerals, the anatomy of elephant-human conflicts that occurred in the area, mitigation efforts that were applied, and the damage caused by elephants.

2.3 Research method
This research is descriptive quantitative using a likert scale. The research was conducted by direct observation at the study site and direct interaction with the people who were in the location by providing a questionnaire to be filled out by the community. The type/model of the research used is observational research through purposive sampling, namely by exploring predetermined locations that have been affected by the conflict between Sumatran elephants and humans.

2.4 Data collection method
Risk level data collection was carried out through interviews using questionnaires sourced from communities around areas prone to human-elephant conflict. The interview guide includes age, education level, income level, type of work, factors that trigger elephant-human conflicts and mitigation efforts implemented by the community. Respondents were determined by purposive sampling from groups and community members who were disturbed by the presence of elephants. To find out the community's perception of elephant conservation and management of the corridor area, it was done through filling out questionnaires and structured interviews with a list of questions that had been prepared in advance. Secondary data were obtained from government agencies, journal publications, the internet, or from previous research.
2.5 Data analysis method

The data analysis of the risk level of human’s elephants conflict was obtained by using questionnaire sheets which were analysed in a tabular manner for quantitative data regarding the level of risk between the components of the hazard, vulnerability and the capacity in managing threats [10], using the following formula:

\[ R = \frac{H \times V}{C} \]  

(1)

Description:

\( R \) = Risk  
\( H \) = Hazard  
\( V \) = Vulnerability  
\( C \) = Capacity

Then the calculation results are interpreted into a risk level table in Tables 2.

| Interval (%) | Risk Level Criteria |
|--------------|---------------------|
| 65%-100%     | High                |
| 34%-64%      | Medium              |
| 1%-33%       | Low                 |

Table 3. Tests normality of risk level data.

| Risk Level       | Kolmogorov-Smirnov Stat | Shapiro-Wilk Stat | Sign. | Kolmogorov-Smirnov Sign. Value | Shapiro-Wilk Sign. Value |
|------------------|-------------------------|-------------------|-------|-------------------------------|-------------------------|
| Home range       | .100                    | .200*             | .949  | 50                            | .052                    |
| Non Home range   | .287                    | .120              | .811  | 50                            | .051                    |

For normality testing on Risk Level data, it can be seen based on the output table above. sig value. Kolmogorov Smirnov of home range and non-home range are 0.200 and 0.120, due to the value of sig > 0.05 then H0 is accepted, meaning that the data is normally distributed. The decision-making criteria based on the comparison of the t-count and t-table values are:

a) If the value of \( t_{\text{count}} > t_{\text{table}} \) then H0 is rejected or Ha is accepted. This means that there is a difference in the average risk of elephant-human conflict between home range and non-home range areas.

b) If the value of \( t_{\text{count}} < t_{\text{table}} \), then H0 is accepted or Ha is rejected. This means that there is no difference in the average risk of elephant-human conflict between home range and non-home range areas.
3. Results and discussion
3.1. Risk level of human elephants conflict (HEC)

The results of data analysis related to the level of risk of human and elephants conflict in the Peusangan watershed area were obtained from a combination of Hazard, vulnerability and Capacity factors. The significance of the difference in the risk level of human elephant conflict (HEC) in this study was tested for hypotheses using the Independent Sample T-Test. This test is performed to compare two unpaired samples. It has been found that there is a significant difference in the level of risk of HEC directly adjacent to the home range and outside the home range. The level of confidence used in this study is 95% with an error value of 5%.

| HEC Risk Level | df    | $t_{count}$ | $t_{table}$ |
|----------------|-------|-------------|-------------|
| 98             | -3.384| 1.984467    |             |

Based on the output above, it proved that the significant value $t_{count}$ is 3.384 (negative value is ignored) > $t_{table}$ which is 1.984467. Then the result is reject H0. This means that there is a difference in the level of risk between the home range and non home range areas.

![Figure 2](image_url)

**Figure 2.** The risk level of human elephant conflict (HEC).

Based on Figure 2, it clearly defined that the factor of (Hazard) has a not very significant difference between the two areas (home range and non-home range). The Hazard component defines as the potential to experience conflict between elephants and humans which can result in loss of life, injury, or material loss/damage. Based on the hazard factor, the area that is not directly adjacent to the home range has a hazard indication of 68%, while the lowest hazard indication is in the home range area with a percentage of 62% in category level medium.

The vulnerability in the home range area with a percentage of 52% that is relatively the same as the non-home range area with a percentage of 60%. In addition, in terms of the capacity factor, the home range area has a percentage of 45% with a high level category, while the capacity factor in the non-home range has a percentage of 26% with a lower category. The high level of risk of hazard factors outside the home range because the villages in the elephant track area are land that was traditionally often traversed by elephants but is now occupied by the community and used as agricultural land. This factor has triggering the entry of elephants into community agricultural land and causes losses in the form of damage to crops owned by the community.
The fact is that the distribution of wild elephants is no longer concentrated in protected areas which are their natural habitat, but most of their time is spent in areas outside protected forests which spatially occupy community-managed areas for cultivation [4]. This fact has created a disharmonious interaction between the existence of wildlife, especially the Sumatran Elephant (Elephas maximus sumatranus) with the communities who inhabit and operate in the area. Changes in occupancy space for the Sumatran elephant's habitat in the Peusangan watershed area can be traced based on an understanding of the characteristics and habitat preferences of the Sumatran Elephant (Elephas maximus sumatranus) [11].

Therefore, the level of risk experienced by the community affects the reaction of the community in dealing with conflicts with elephants in terms of capacity in mitigating elephant conflicts. Communities in villages that are in the elephant track area have adequate capacity and have the ability in terms of herding which is carried out by the existence of conflict mitigation teams, there are the Flaura and Fauna Defender team (TPFF) who are members of several villages who occupied with smart patrol ability in human-elephant conflict handling. In fact, elephants basically move away from human-dominated areas and prefer to forest areas available in mountainous areas [4]. Therefore, village areas close to the home range are not too disturbed by the presence of elephants and do not significantly trigger risk and increase vulnerability. This risk refers more to the movement of elephants that have overlapped with production and residential areas so that several villages outside the home range experience a relatively high level of risk [11]. Since elephants are believed to move between patches of its suitability.

3.2 Human elephant conflict area in Peusangan watershed
The intersection occurs because many forests are converted into plantation areas with plants that elephant’s preference. However, the villages in the home range area do not have significant indications of disturbance that affect the magnitude of the impact of conflict risk on the entry of elephants because there is still an adequate forest area to support the supply of food for elephants without having to disturb and enter settlements. Meanwhile, the areas that are often crossed by elephants outside the home range area are plantation areas that have elephant feed and residential areas that trigger disruption of local community livelihoods and damage to community cultivated plants.

According to the explanation of Figure 3, the condition of the area that is not directly adjacent to the Home Range has an indication of a more medium range of elephant conflict, while the area within the Home Range has low risk criteria. In addition, conflicts over spatial use in the Peusangan watershed area are getting higher due to the physiographical conditions of the area, which are massively hilly, with little sloping land, especially in Bener Meriah Regency [2]. The occupancy of the
space with a gentle slope also results in high animal and human conflicts, especially in the Krueng Peusangan valley area. This was a mismatch condition of cultivated commodities developed by the community with wildlife mitigation effort. Regarding spatial patterns, Aceh's Environmental and Forestry Agency conveyed there was tendency in error approach, in terms of handling forest disturbances/forest damage, identical focus is more on units that handle the forestry sector. However, there should also be contributions outside the forestry sector to be able to jointly ensure all parties involved in their respective sub-sectors to comply with spatial management. It has identified that there are overlapping areas within the elephant corridor area. The fact is that 85% of elephant’s corridor are outside conservation areas which ideally should be in conservation areas[12]. In this case, the commodity development sector should analyze the appropriate targets for planting and how to ensure that the parties comply with the spatial structure and pattern in accordance with the direction of spatial control as appropriate.

3.3 Human elephant conflict vulnerability factors
Types of plants planted by the communities in the Peusangan watershed 76% -78% planted the annual crops as the main commodities such as rice, rubber, areca nut, and bananas, and several types of seasonal plants such as candlenut, chili, and coffee as secondary commodities to increase income or for consumption. Low level of education is also closely related to community perceptions of forest resources [13]. Low education causes limited livelihood options other than as farmers or farm laborers to meet their daily needs, so that people are forced to take advantage of the resources around them.

From Figure 4.5 above, it can be seen that on average the crop commodities that are most often damaged by Sumatran elephants are bananas, palms oil, durians, areca nut, and others. Bananas are the most widely planted crops by the community and the elephants prefer the most. Elephants usually damage these plants by laying down the plant first and then taking the midrib and shoots of the plant because it is rich in minerals needed by elephants [14]. Meanwhile, for Poaceae species such as rice and sugar cane, elephants eat these plants by breaking them down and then eating them. Unlike the case with durian stems, the elephant lays down or shakes the stem until the fruit and leaves fall and then the elephant eats the durian leaves and fruit. Elephants also sometimes peel the bark of plants from the Malvaceae tribe to fulfill salt and minerals for elephants [3].

Meanwhile, for several types of plants such as citronella, pepper, nutmeg, and chili according to the respondent's information, elephants are not interested in these types of plants and usually elephants
only cross or step on these types of plants, this happens because elephants do not like substances contained in several types of these plants, Capsicum Oleoresin contained in pepper, and chili is effectively used as an elephant repellant because elephants do not like the strong smell [15].

**Table 5.** Seasonal commodities.

| Commodities | Spesies          | Family   |
|-------------|------------------|----------|
| Rice        | *Oryza sativa*   | Poaceae  |
| Chilli      | *Capsicum frutescens* | Solanaceae |
| Nut         | *Arachis hipogea* | Fabaceae |
| Candelnut   | *Aleurites moluccana* | Euphorbiaceae |
| Lemon grass | *Cymbopogon citrates* | Poaceae |
| Pepper      | *Piper ningrum*  | Piperaceae |
| Banana      | *Musa sp*        | Musaceae |
| Sugarcane   | *Saccharum Officinarum* | Poaceae |

**Table 6.** Annual commodities.

| Commodities | Spesies            | Family   |
|-------------|--------------------|----------|
| Coffee      | *Coffea Arabica*   | Rubiaceae |
| Betel nut   | *Areca cathecu*    | Arecaceae |
| Durian      | *Durio zibethinus* | Malvaceae |
| Chocolate   | *Theobroma cocoa*  | Meliaceae |
| Palm Oil    | *Elais guenensis*  | Arecaceae |
| Jernang     | *Daemonorops draco* | Arecaceae |
| Nutmeg      | *Myristica fragrans* | Myristicaceae |

The main elephant movement path is under the Peusangan river valley. Residential areas and community gardens are on the hill. From August to December, elephants often enter the village consuming bananas, sugarcane, pineapples, areca nut, destroying cacao stalks, eating palm leaves. Meanwhile, for the types of secondary crops grown by the community, such as corn, soybeans, cassava, cucumbers, green beans in general, people no longer plant these crops because crops such as corn are often damaged by Sumatran elephants and the selling price is relatively low.

![Figure 5. Elephant arrival frequency.](image-url)
The level of preference for elephant food is a determining factor in the high or low damage caused by conflicts between humans and Sumatran elephants. Sumatran elephants usually choose the type of plant they will consume. Almost all of the village areas in the Home Range area and outside the Home range have main commodities that were damaged by the Sumatran elephant when the Sumatran elephant entered the community's plantation area.

In these two areas, as much as 90% of the frequency of entry of elephants starting every >3 months, 6 months - 1 year occurs in the home range area because basically elephants are staying on their trajectory. In this case the roaming pattern which is currently starting to shift, the frequency of the entry of elephants in villages outside the elephant home range area also has almost the same frequency as much as 78% caused by several factors and changes in wildlife behavior, especially the roaming of Sumatran elephants. Historically, it can be found in a protected area dominated by protected forest areas and other typologies of protected areas in the Peusangan landscape. It has been identified that the appearance of elephant presence was dominantly correlated to the high intensity of forest cover and vegetation productivity, it has to be more frequent found in forested areas of relatively high productivity and in mountain valleys [11]. According to the results obtained, many physiographical and ecological facts related to elephants have changed, therefore the behavior of roaming spaces and feeding areas and other activities has changed.

In addition, the Sumatran elephant conflict often occurs at night, this has a direct impact on the community in terms of security, as well as losses due to damage to cultivated plants, infrastructure and water sources, as well as disturbances to the death of livestock and human casualties. In addition, the death and injury of elephants due to the intersection of needs with humans is a bad impact on the survival of elephants as protected wildlife. The increase in population, the transfer of land and area functions have directly been the trigger for elephant-human conflicts. This encourages the need for the use of the area, especially for settlements, when the population increases it will result in an increase in the need for land, infrastructure, agricultural cultivation, and the community's economy [16].

Changes in behavior and spatial patterns create differences in the context of the level of risk that occurs in areas (villages) that are on the elephant corridor route and villages that are outside the elephant corridor route. These factors contribute to the occurrence of various levels of risk in the home range which is a proxy indication of spatial management skills and conflict management. Importantly, ensuring the sustainability and spatial management of the area as a resource to support the lives of local communities and protected wildlife that inhabit the downstream area of the Peusangan watershed is the key to manage human and elephant in harmony.

4. Conclusions
Based on the study in can be conclude that there is a difference in the risk level of human-elephant conflict between areas that are directly adjacent to the home range and those that are not directly adjacent to the home range in the Peusangan watershed. The criteria for conflict risk in the home range are lower than in villages that are outside the home range. The criteria for the level of risk in areas directly adjacent to the home range have a low risk level with a level of hazard (62%), vulnerability (52%) and capacity (45%) and outside the home range has a medium risk with a level of hazard (68%), vulnerability (60%) and capacity (26%). The greater capacity factor of the community in the home range area so that they have adaptive capabilities that can reduce risk aspects. The triggering factors for a significant level of vulnerability in both regions are the availability of food commodities, house structures that are vulnerable to damage by elephants, and the distance of settlements that cross the elephant track.
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