Causal loop of system thinking in mitigating human tiger conflict based livelihood around Leuser

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Abstract. Human tiger conflict (HTC) has become serious problem in Indonesia in term of conservation effort of Sumatran tiger (Panthera tigris sumatrae) since population of this species has declined in recent years. The threat of tiger death increases following the number of conflict accidents with humans. The solution requires a comprehensive approach, because it involves the interests of parties. This research was conducted around Gunung Leuser National Park by purposive sampling in Bahorok (Langkat Regency) and Tapaktuan (South Aceh Regency). This study used the system thinking approach in looking at the variables that affected the complexity of HTC. Analysis of needs resulted variables as controlled input of model that describing by causal loop. This study will see the interrelationship of conflict-causing factors with the livelihoods of forest communities. Five aspects of livelihood that became the focus of research consisted environmental, economic, social, human and physical resources. The causal loop of each variable reflected in a diagram.

1. Introduction
Gunung Leuser National Park (GLNP) is one of the oldest conservation areas in the first five national parks in Indonesia. The existence of GLNP is in the core of a fairly wide landscape known as the Leuser Ecosystem Area (KEL). The GLNP area is habitat for one of four charismatic key species, which is the Sumatran tiger (Panthera tigris sumatrae) [1]. But unfortunately, GLNP is currently under serious threat due to the conversion of forests to other uses which have damaged the balance of ecosystems and wildlife habitats. [2] stated that the sources of damage at KEL included the construction of road infrastructure, plantations, encroachment, and illegal logging.

Disturbance of GLNP potentially reduce carrying capacity of wildlife habitat and lead to conflicts between human and wildlife (HTC) including human and tiger conflicts. Theoretically, conflict is caused by several factors that become conflict circles [3], such as: 1). Human relations problems, 2). Data problems, 3). Differences in interests, 4). Structural problems and 5). Difference in value. Some studies on human-wildlife conflict in general have been carried out, including: causal factors and predictions of conflict [4-6], characteristics and conflict management [7,8], the impact of conflict [9]. Economic aspects, compensation and willingness to pay [10] as well as aspects of social behavior and community perceptions of wildlife conflicts [11] show that social and economic dimensions of human and wildlife conflicts need attention in a comprehensive approach with the related parties. The research on mitigation
techniques [12,13] in each region illustrates the importance of adjusting mitigation techniques with local characteristics and landscape conditions. This research is expected to describe human and tiger conflicts through a system of thinking. This approach is taken to describe the relationship among factors of HTC through causal loops.

2. Methods

2.1. Study site
The research carried out around the Gunung Leuser National Park (GLNP) by taking case studies in two locations. Determination of location was done using selected sampling method (purposive sampling) that have been occurred human and tiger conflicts. Those are Panton Lues Village, Tapak Tuan District, South Aceh Regency, Nangroe Aceh Darussalam Province. It’s a buffer zone in form of other use areas and bordering with protected forests. Secondly, Timbang Lawan Village, Bahorok District, Langkat Regency, North Sumatra Province. It’s located in the forest edge of GLNP

2.2. Procedure on data collection
Data consist of primary and secondary data. Primary data was collected by interview techniques, field observations and focus group discussions (FGD). Responden consist of communities around the forest, local government, national parks, plantations and non-governmental organizations. Secondary data was collected mainly from any reports.

2.3. Data analysis
All data is analyzed qualitatively by using system thinking. Sistemgram in the system of thinking describes the connection of the factors involved. The thinking system operates as a continuous feedback chain. That is, the system does not stop functioning at the last node. The elements presented in the systemigram are synthesized from the definition of literature, which is mainly derived from [14,15]. Submission of feedback loops is done by following steps: 1) preparation of goals to be achieved; 2) black box making with analysis of variable needs. 3) making a causal loop diagram by giving a "positive" sign for elements that can provide additional or increased targets or "negative" signs for elements that can reduce or decrease the target. To get an overview of the sub-models that will be produced, we need to determine the variables that will compile the sub-model. Analysis of the needs of the measured variables is arranged based on knowledge or theory that is the basis of research thinking. In this study the variables that have been compiled will be confronted with key stakeholders. The aim is so that we can get a picture of how important or prioritized the parties are according to the parties who are directly involved in the conflict with the tiger. Controlled input in the next causal loop is taken from 1/3 of the variables that have the highest rating.

3. Results and discussion

3.1. Identification of objectives
Causal loops is the first step in building a dynamic model. The preparation begins with setting the objectives to be achieved from research activities. This objective will help limit the scope of research. Because research that is not limited in purpose will cause bias and the breadth of the field of study so that the aspects under study become out of focus. Therefore, in term of human and tiger conflict mitigation models, the objectives achieved are based on five aspects of livelihood compilers that become the framework of this research, namely:
1. Human resources capital: minimize human casualties
2. Physical capital: reduced access of tigers to the village around the park and reduced human access to the park
3. Natural Resources capital: minimization of tiger habitat disturbances and the development of tiger populations according to carrying capacity
4. Financial capital: increased income of people around the forest
5. Social capital: declining illegal activities that threaten tiger conservation

The stated goals will become output of research on human and tiger conflict mitigation model. To make these objectives become a sub model of the dynamic model, then all the objectives achieved must be quantifiable. It can be seen from the value achieved in quantity (such as: increase) or decrease (such as: minimal, reduced) in accordance with the context of each of goals that have been set.

3.2. Key variable formulation

The formulation of variables in mitigating human and tiger conflicts is arranged according to the results of studies and theories. The formulation was further checked by relevant parties through the FGDs held in Tapaktuan and Bahorok. At the initial stage, the prediction of the possible value of the interests of each stakeholder is presented in Table 1.

### Table 1. Supporting variables for HTC mitigation efforts

| No | Variable                                      | Forest Comm. | Local Gov. | MoEF | Private / Plant. | NGO |
|----|-----------------------------------------------|--------------|------------|------|------------------|-----|
| 1  | Socialization of mitigation technology        | 3            | 2          | 3    | 2                | 3   |
| 2  | Agroforest/ Mixed garden                      | 3            | 1          | 3    | 3                | 2   |
| 3  | Patrol way                                    | 3            | 3          | 3    | 0                | 2   |
| 4  | Tiger feed                                    | 0            | 1          | 3    | 1                | 3   |
| 5  | Tiger population survey                        | 3            | 2          | 3    | 3                | 3   |
| 6  | Clearing shrub                                | 3            | 1          | 2    | 3                | 1   |
| 7  | Forest restoration                            | 0            | 1          | 3    | 0                | 3   |
| 8  | Forest patrol                                 | 3            | 2          | 3    | 2                | 3   |
| 9  | Ecosystem service incentive                    | 3            | 1          | 1    | 2                | 2   |
| 10 | Eco-friendly of agriculture practice           | 3            | 2          | 3    | 3                | 3   |
| 11 | Management of pasture                          | 1            | 1          | 3    | 2                | 3   |
| 12 | Capacity building of conservation              | 2            | 2          | 3    | 0                | 3   |
| 13 | Indigenous knowledge                           | 3            | 2          | 3    | 1                | 3   |

| No | Variable                                      | Total | Weight | Average |
|----|-----------------------------------------------|-------|--------|---------|
| 1  | Socialization of mitigation technology        | 13    | 0.09   | 2.6     |
| 2  | Agroforest/ Mixed garden                      | 12    | 0.08   | 2.4     |
| 3  | Patrol way                                    | 11    | 0.08   | 2.2     |
| 4  | Tiger feed                                    | 8     | 0.06   | 1.6     |
| 5  | Tiger population survey                        | 14    | 0.10   | 2.8     |
| 6  | Clearing shrub                                | 10    | 0.07   | 2.0     |
| 7  | Forest restoration                            | 7     | 0.05   | 1.4     |
| 8  | Forest patrol                                 | 13    | 0.09   | 2.6     |
| 9  | Ecosystem service incentive                    | 9     | 0.06   | 1.8     |
| 10 | Eco-friendly of agriculture practice           | 14    | 0.10   | 2.8     |
| 11 | Management of pasture                          | 10    | 0.07   | 2.0     |
| 12 | Capacity building of conservation              | 10    | 0.07   | 2.0     |
| 13 | Indigenous knowledge                           | 12    | 0.08   | 2.4     |

Note: 1: low, 2: moderate, 3: high

The value of rate from both areas are combined as the average value of all stakeholders. From the assessment of several variables that can support human and tiger conflict mitigation efforts, the four most important variables in mitigation efforts based on average value are:
1. Survey of tiger populations (2.8)
2. Eco-friendly of agriculture commodity (2.8)
3. Forest Patrol (2.6)
4. Socialization of mitigation techniques (2.6)

In addition to the four factors above, mitigation efforts are also strongly influenced by socialization activities, especially by GLNP officers, NGOs and conservation cadres. It needs a comprehensive approach from various aspects and involves multi stakeholders [16]. Assessment of mitigation efforts according to key stakeholders in Tapaktuan and Bahorok is then compared with the formulation of key factors that are the main causes of human and tiger conflicts. Each participant has a value of each choice (see Fig. 1)

![Figure 1](image_url)

**Figure 1. Driving factors of human tiger conflict**

The Figure 1 shows some driving factor of HTC that might be similar to other studies. However, after conducting FGD, there were several new things that had not been included in the initial predictions as a driving factor of HTC. There are a different type of driving factor of HTC in Tapaktuan (F\textsubscript{TT}) and Bahorok (F\textsubscript{BH}) and efforts to mitigate conflict by comparing important driving factors HTC for both areas (F\textsubscript{TT}, F\textsubscript{BH}). The value is taken by filtering the value factors ≥ 0.60. From fig.2 we can see there are five factors from both areas reaching the value factor ≥ 0.60. The result is shown such as follow:

1. Decreasing prey (F\textsubscript{TT} = 0.83, F\textsubscript{BH} = 0.69)
2. High habitat disturbance (F\textsubscript{TT} = 0.08, F\textsubscript{BH} = 0.88)
3. Overlapping land (F\textsubscript{TT} = 0.75, F\textsubscript{BH} = 0.31)
4. Deforestation (F\textsubscript{TT} = 0.67, F\textsubscript{BH} = 0.19)
5. Poaching and trading (F\textsubscript{TT} = 0.18, F\textsubscript{BH} = 0.50)

In addition to the four key factors above, there are several things that are very local as causes of conflict in Tapaktuan such as the case of NTFPs and the waning of local wisdom. Whereas in Bahorok the typical is the presence of cattle around the forest. Several other factors influencing conflict in both regions were hunting and trade, land conversion, human population increasing, low income, installation of snares, and socialization of forestry rules

3.3. Black box diagram

Based on result of objectives formulation and key variables, a black box diagram is then made from the HTC mitigation model around GLNP as in fig. 2. The basic theory follows the flow of inputs, processes and outputs. This diagram makes it easy to limit the scope of the research to be carried out and then it can be used to formulate a model that becomes the focus of this research.
Figure 2. Black box diagram HTC mitigation model around GLNP

3.4. Causal loop diagram

Figure 3. Causal loop HTC in Leuser
To facilitate the relationship of factors causing HTC, grouping into five aspects of livelihood is made directly or indirectly. These five aspects include: environment, social capital, economical capital, physical capital, human capital. Generally causal loop of HTC is the whole livelihood factors as part of HTC mitigation are shown in fig. 3. Tiger populations will growth well if the carrying capacity of the habitat is good (+). Factors that can reduce population (-) mainly is forest disturbances. The existence of prey is very important in tiger food webs. Tiger prey is also very dependent on habitat carrying capacity. Competition of predatory animals will also affect the presence of prey [13]. Access to the park, can be a gap factor of human disturbance into forests (+). The influence of infrastructure on community access to the forest is directly affected [14]. The land use model also has an influence on the shape of the landscape. In Panton Luas, Tapaktuan most people still use agroforestry systems that are closer to the natural forest landscape. While in Timbang Lawan, Bahorok people use monoculture patterns.

Regarding human capital awareness will also support conservation efforts by making the community as the main actor in managing conflict mitigation [15]. Forest disturbances are expected to decrease with local wisdom. Furthermore, mitigation techniques will be greatly helped when combined with local wisdom. Financial Capital. The existence of an environmental service incentive initiative is also expected to improve the welfare of communities around the forest. Economic assessment is needed in mitigating effort to reduce conflicts with wildlife [16]. Finally, a good welfare index is expected to reduce the illegal activities of the community, thereby reducing forest disturbances.

4. Conclusions
The occurrence of human tiger conflicts in both locations is has specific driving factor and influenced by the perspective of actor/ stakeholder. The use of causal loop in system thinking help us describing the influence factor of each livelihood element. The most important variables in mitigation efforts based on highest average value in Leuser consist of: 1) survey of tiger populations 2) eco-friendly of agriculture practice 3) forest patrol and 4) socialization of mitigation techniques. There are five variables that considered as driving factor of HTC in Leuser are 1) decreasing prey 2) highly habitat disturbance 3) overlapping land 4) deforestation and 5) hHabitat disturbance.

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