Strategic Analysis of Sustainable Forest Management with Graph Model for Conflict Resolution

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Abstract. This paper describes conflicts over forest resource management. To illustrate the conflict condition, the GMCR method is used to get an equilibrium solution to resolve the conflict. The players or key stakeholders in this situation are the Government (Ministry of Forestry), Forest Industries Company and Environmental Activists. Each player has a desire formulated as an option. The combination of these options will produce scenarios sorted according to player preferences. After that, stability analysis with the solution concept was carried out. The results show that both the Government and companies will seek funds to accelerate the development of the timber industry and reduce environmental impacts.

1. Introduction

The complexity of forest management problems generally occur because the claim of importance between the parties concerned. Claims of this interest include industry, research, recreation, ownership, etc. The forest management policies require to consider and accommodate several objectives of the various stakeholders involved and the conflicts of interest that occur between them. A stakeholder’s participation in decision making will be very helpful in identifying problems, developing alternative management options, and prioritizing choices, as well as providing opportunities from different perspectives and resolving conflicts.

Conflict strategy is a decision problem that involves several importance groups or decision makers (DMs), each of which has different preferences related to scenarios or circumstances that might take place during the evolution of the conflict. Settlement of the forest management disputes can be interpreted differently by producers, government, or groups of citizens. Lots of formal modeling techniques are developed related to decision support in conflict resolution. The main attention here is the graph model for conflict resolution (GMCR) (Fang et al. 1993; Kilgour and Hipel 2005).

2. Problem

The complexity of problems in forest management is a claim of importance between the parties concerned. These claims lead these parties to a prolonged conflict that requires a method of settlement.
(conflict resolution) that can be accepted by the parties. For this reason, research on various criteria for analyzing forest management policy decisions will help conflict resolution that has occurred so far.

3. Methodology
The simplicity and flexibility of the Graph Model for Conflict Resolution (GMCR) makes this theory used quite oftenly. In a conflict, the systematic procedure for GMCR decision makers follows two main stages which consist of modeling and analysis.

In the modeling stage, important elements of the model such as decision makers, options and preferences are identified based on an understanding of the situation, then the information obtained will be used in the analysis phase. In this phase, stability is predicted based on the perspective of each decision maker. Based on the analysis of interpretation and sensitivity, decision makers will be able to understand the meaning of resolution in the conflict.

The concept of graph theory, set theory and game theory is used in this technique. Decision support systems consider their decision makers, their choices and priorities (Hipel et al., 1997). Players in the contention of this research are the government, entrepreneurs and environmentalists.

4. Forest Resource Management Conflict
Like how we adopt from Kuang (2014), it is also assumed that there are three main decision makers in the conflicts that occur in the management of forest resources, which is: Government (GOV), Forest Industries Company (FIC), and Environmental Activists (EA). Every decision maker has different attitudes and choices, with the following explanation.

4.1. Government
As one of the biggest contributors to the country's foreign exchange, the government must be wise towards stakeholders around the forest by not ignoring forest ecosystems. Thus, the government has two choices: (1) to provide a budget and cooperate with Environmental Activists; promote high-tech research and its application, and prevent degradation and deforestation. (2) impose policies on logging procedures.

4.2. Forest Industries Company
Besides expectations and advantages, there are various problems and uncertainties that always threaten the world of the timber industry. Companies must carefully take into account all the influencing factors such as timber prices, investment climate, or market access. Because of the pressure from environmental activists, the government tends to tighten policies on forest resource management. Related to that, the company has two choices, (1) increase investment (including for community development) and the use of new technologies, and (2) cancel plans to work in the timber sector.

4.3. Environmentalist Activists
One of the roles of environmental activists is to control the rate of degradation and deforestation. Regarding this, environmental activists have two choices: (1) support government policies, and (2) enforce pressure or legal action.

All the tables below are adopted from Kuang, 2014. Table 1 presents the choice of each decision maker. In the conflict, a situation is formed when each decision maker chooses an option. Of all possible situations, the situation is not supposed eliminated.
Tab

Table 1. Decision Maker’s and his Option.

| No. | Government (GOV) | Option |
|-----|-----------------|--------|
| 1.  | Budget          | Provide a budget and cooperate with environmental activists |
| 2.  | Policy          | Make tighter law policies related to concession and logging permits |

**Industrial Forest Company**

| Option |
|--------|
| 3.     | Investment     | Use of new technology and community development and establish cooperation with Environmental Activists |
| 4.     | Retired        | Retire from timber management business |

**Environmentalist Activist**

| Option |
|--------|
| 5.     | Support       | Seek funds and cooperate with the government |
| 6.     | Pressure      | Pressure or take legal action |

- Forest Industrial Company will not take the action of - Investment and Retire - at the same time.
- If the government does not prepare a budget and timber industry companies, do not support Environmental Activists, they do not have money to support.
- If the government makes a new policy, Industrial forest companies will either increase the investment or retire.
- If the government makes a new policy related to the sustainability function, Environmental Activists will not put pressure on the government.

After removing the situation is not suitable, there are 14 remaining viable situations that show all possible scenarios. As shown in Table 2. In this table, "A" indicates that the option selected by DM and "D" means not selected. An asterisk (*), means it can be "A" or "D". A state is formed when each DM chooses a strategy. For example, state $c_i$ is created when a forest industry company decides to retire as shown by "A" against option 4. The choice of other available options does not affect the conflict as indicated by an asterisk (*) that opposes this option, where star means "A" or "D".

**Table 2. Decision Maker, Option and Feasible States.**

| GOV  | 1. Budget | D | D | D | A | D | A |
|------|-----------|---|---|---|---|---|---|
|      | 2. Policy | D | D | A | D | D | A |
| IFC  | 3. Investment | D | A | A | D | A | A |
|      | 4. Retire | D | D | A | D | A | D |
| EA   | 5. Support | D | D | D | A | A | A |
|      | 6. Pressure | D | D | D | D | D | D |

**Feasible States**

$c_1$ $c_2$ $c_3$ $c_4$ $c_5$ $c_6$ $c_7$

| GOV  | 1. Budget | A | D | D | A | D | A |
|------|-----------|---|---|---|---|---|---|
|      | 2. Policy | A | D | D | D | D | *|
| IFC  | 3. Investment | A | D | A | D | A | *|
|      | 4. Retire | D | D | D | D | D | *|
| EA   | 5. Support | A | D | D | A | A | A |
|      | 6. Pressure | D | A | A | A | A | A |

**Feasible States**

$c_8$ $c_9$ $c_{10}$ $c_{11}$ $c_{12}$ $c_{13}$ $c_{14}$

The next stage is GMCR modeling where priority options are used to estimate DM preferences. In this method, state is ranked (Kilgour and Eden, 2010). Logical preferences for each DM are illustrated in Tables 3, 4 and 5. Options from decision makers: Budget, Policy, Investment, Retire, Support, and
Pressure are represented by numbers 1, 2, 3, 4, 5, and 6. Preference statements are shown from the most important at the top to the unimportant at the bottom.

Table 3. Main Preference Sequence for Government.

| Order Statement | Explanation |
|-----------------|-------------|
| * 4             | GOV gives the best priority to the state where: IFC does not retire |
| * 2             | GOV gives priority to the state where: EA does not put pressure |
| 1 if 6          | GOV gives priority to the state where: If EA pressures, GOV prefers to provide special budgets |
| * 2             | GOV does not make new policies |
| 1 if 3          | GOV gives priority to the state where: GOV will like to provide funds if IFC makes more investments. |
| * 1             | GOV gives priority to the state where: GOV does not provide a budget. |
| 3               | GOV gives priority to the state where: IFC does more technology and community development |
| 5               | GOV gives priority to the state where: EA supports. |

Table 4. Main Preference Sequence for Industrial Forest Companies.

| Order Statement | Explanation |
|-----------------|-------------|
| * 4             | GOV gives the best priority to the state where: IFC does not retire |
| * 2             | GOV gives priority to the state where: GOV does not carry out new policies |
| * 6             | IFC gives priority to the state where: If EA does not apply pressure. |
| * 3             | IFC gives priority to the state where: IFC does not invest |
| 1               | IFC gives priority to the state where: GOV provides a special budget |
| 5               | IFC gives priority to the state where: EA supports. |

Table 5. Main preference sequence for Environmental Activists.

| Order Statement | Explanation |
|-----------------|-------------|
| 2               | EA gives the best priority to the state where: GOV makes a new policy |
| 6 if * 2        | EA gives priority to the state where: EA conducts actions if GOV does not make stricter logging restrictions |
| * 6             | EA gives priority to the state where: If EA does not put pressure on it, GOV prefers to provide a special budget. |
| 3               | EA gives priority to the state where: IFC makes more investment. |
| 1               | EA gives priority to the state where: GOV provides a special budget |
| 5               | EA gives priority to situations where: provide technical support |

5. Stability Analysis
DM preferences have been determined by priority options, and then the stability analysis results (table 6) are shown using GMCR based on four definitions of stability: Nash stability (R), general metarationality (GMR), symmetric metarationality (SMR), and sequential stability (SEQ). In the conflict, seven situations are counted as equilibrium for all DM, and this stable situation is given the +
symbol. A stable situation is a situation that might occur. Three representatives of the stable and stable Nash situation are described below:

In the $c_1$ situation, the Government regulates the budget and works with the Environmentalists in new technologies to improve efficiency or control logging. In this situation, the Environmentalists will still put pressure on the government and companies, because technology and supervision may take a long time to develop or do and the public wants to see advanced industries without sacrificing the environment.

In situation $c_3$, the Government takes legislative action, and the company invests. In this situation, when companies access the market more, conflicts over management can become more severe. So the Government will make more stringent laws, to ensure that this industry is also monitored. When a number of logging or management restrictions are strictly regulated, there will be intense competition between companies.

Table 6. Results stability of forest resource management conflicts.

| Situation | $c_3$ | $c_7$ | $c_8$ | $c_9$ | $c_{11}$ | $c_{12}$ | $c_{13}$ |
|-----------|-------|-------|-------|-------|-----------|-----------|-----------|
| GOV Budget | D     | D     | A     | D     | A         | D         | –         |
| Policy    | A     | A     | A     | D     | D         | D         | –         |
| IFC Investment | A   | A     | A     | D     | D         | A         | D         |
| Retire    | D     | D     | D     | D     | D         | A         | –         |
| EA Support | D     | A     | A     | D     | A         | A         | –         |
| Pressure  | D     | D     | D     | A     | A         | A         | –         |
| R         |       |       |       |       |           |           | +         |
| GMR       | +     | +     | +     | +     | +         | +         | +         |
| SMR       | +     | +     | +     | +     | +         | +         | +         |
| SEQ       | +     | +     | +     | +     | +         | +         | +         |

In $c_8$ state, the Government will prepare a budget and work with the Company after making stricter restrictions on logging rules, and the Environmentalists will provide technical support. In addition, the company will also make additional investments in research, technology and equipment because of the pressure caused by market competition. In this situation, the Government wants to see fierce competition among companies that must lead to advanced technology, but the government cannot accept that most companies will withdraw from the market when companies can provide community research and development costs. Therefore, both the Government and the company will seek funds to accelerate the development of the timber industry and reduce environmental impacts. This equilibrium shows a tendency: how the timber industry develops from a perspective that looks shorter to longer.

6. Conclusion

In this paper, four main components (DM, state feasibility, possible movements controlled by each DM, and DM preferences) are presented and explained in detail. When the conflict has two DMs, the concept of unilateral motion and unilateral repairs to DM are also provided to identify affordable and preferable situations from the initial state in one step by DM. This concept was then expanded to deal with conflicts with many DM who were involved in the conflict. After that, four basic definitions of stability (Nash stability, general metarationality, symmetrical metarationality, and sequential stability) are given along with their interpretations to carry out stability analysis in conflict strategies with two or more DMs.

A conflict over the management of Forest Resources was proposed, and a stability analysis was carried out based on GMCR. In order to balance industrial development and environmental protection, conflicts between government, companies and environmental activists were investigated. Seven situations of conflict are determined as equilibrium according to the four definitions of stability, and interpretations for this equilibrium are provided.
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