Conflict over Natural Resource Exploitation in a Mountainous Community: The Trade Off Between Economic Development and Disaster Risk Mitigation --A Case Study

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ABSTRACT

This research illustrates the conflict in the decision-making process in the case of the Ichinose community, Chizu, Tottori prefecture, Japan. The dispute is modeled as a static structure for each of two phases, one from 1985 to 2002, and the other from 2002 to date (2005). The GMCR model (Graph Model for Conflict Resolution) is used to systematically describe the process of changes in the structure of this conflict. The conflict escalated in the second phase of this dispute although there must have been many creeping metaphases before escalation of the conflict. The role of information and sudden social shock (as a natural disaster impact) can be interpreted as a cause of the structural change of the conflict. An effective dispute resolution mechanism has been emphasized in local-level development processes.

1. INTRODUCTION

Conflict over natural resources is a very common phenomenon across the world, particularly in mountainous regions. The exploitation of mineral resources has a direct impact on the local environment. On the other side, the prospect of economic development of a local area by and large depends on the potential use of mineral resources. However, mining- and quarry-related issues also have a complex impact on economic, environmental and social factors. Sometimes, the unscientific exploitation of natural resources triggers the probability of disaster and in consequence, people's survivability comes under threat. In many development projects, multiple players with different interests often evolve in conflict. Commonly, conflict occurs if different parties wish to affect their aspirations as much as possible, thus leading to a trade-off state. Quite typically, disaster mitigation and economic development needs to be traded off. It is true, however, that crucial conflict can possibly challenge the concerned parties to increase their coping capacity, which could entirely change the quality of the conflict. We may well interpret conflict as "a perceived divergence of interests, or a belief that the parties' current aspirations cannot be achieved simultaneously" (Pruitt and Rubin, 1986). Conflict can be a potential obstacle to sustainable development. There is a missing link between development policy and conflict resolution mechanism, which needs to be explored scientifically.

Game theory has been widely used to model well formulated conflicts and to predict possible equilibria. However, this theory has difficulties due to its very strict assumption of reality. As in game theory, the player's preference must be represented by real-valued utilities (called 'cardinal utilities'). In reality, however, it is very difficult to measure the utility of players. On the other hand, the Graph Model for Conflict Resolution (GMCR) provides a convenient and flexible approach to modeling a strategic conflict. Basically, this model is based on game theory that has been further extended by Fraser and Hipel. In this model, instead of cardinal utility, the decision maker's ordinal preference can be ranked from most preferred to least preferred. The model assumes that all preferences are transitive. It gives analytical insight into problems within which possible strategic interaction among the decision makers (DMs) can be systematically analyzed in order to ascertain possible compromise resolutions, or equilibria. Additionally, modeling possible outcomes as 'nodes' and feasible transitions from each node to another as 'links' of a graph structure has the following advantages: (i) the graphical representation helps 'assumed non-scientific players (stakeholders)' easily understand the structure of the modeled conflict and (ii) unlike a classical set of game theory, the game can easily be interactively operated by assumed players by use of computer-based calculation software.

2. MODELING

We propose to apply GMCR to formulating and analyzing the static structure of a real-world conflict. The major advantage of this model is the ease with which it models the interplay structure among multiple players who have their own effective strategies (called "moves") from a particular outcome and who can only order possible outcomes in terms of preference.

GMCR (Fang et al., 1993) is founded upon a mathematical framework utilizing concepts from graph theory, set theory and logical reasoning. It represents a conflict as moving from one state to another state (the vertices of a graph) via transmissions (the arcs of the graph) controlled by the decision makers. Mathematically, this multi-player conflict game can be formulated in the following way:

KEY WORDS: conflict, graph model, dispute resolution mechanism, local level development

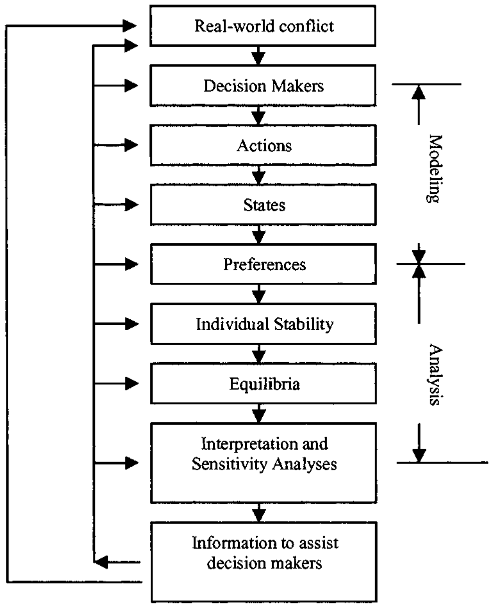

Fig. 1 Applying the Graph Model for conflict resolution
Source: Fang et al., 1993

Let $N = \{1, 2, ..., n\}$ be the set of players and $K= \{K_1, K_2, ..., K_u\}$ be the set of states of the conflict, and n-tuple $\{D_i\}$ (i =1, 2..., n) be the set of directed graphs where $D_i = (K,V_i)$. Set of arcs V_i means player i's possible move between states. Let k_lk_m be the arc from state k_l to state k_m. If $k_lk_m \in V_i$, it implies that player i can move from state k_l to state k_m unilaterally. Payoff function P_i specifies player i's preference order for states. If $P_i(k_l) > P_i(k_m)$, player i prefers state k_l to state k_m. The Graph Model for Conflict Resolution (GMCR) is presented by 4-tuple $\{N, K, V, P\}$, where $N=\{1, 2, ..., n\}$, $K=\{1, 2, ..., k\}$, $V=\{V_1, V_2, ..., V_n\}$ and. $P = \{P_i \setminus i \in N\}$.

One advantage of the graph model over more traditional game theoretical approaches is that it can represent irreversible moves. In such cases, a decision maker can unilaterally move from state k to state q but not from q to k. DM i's graph can be represented by i's reachability matrix, R_i, which displays the unilateral moves available to DM i from each state. For $i \in N$, R_i is the u x u matrix defined by

$$R_i(k,q) = \begin{cases} 1 \text{ if DM } i \text{ can move (in one step)} \\ \text{from state } k \text{ to state } q \\ 0 \text{ otherwise} \end{cases} \quad \cdots\cdots\cdots(1)$$

Where $k \neq q$, and by convention $R_i(k, k) = 0$.

In GMCR, players can make a transition of conflicts. When a player does not have an incentive to move from a particular state, the state is called stable for the player, and the state is called equilibrium.

$$G = (S, (Ai: i \in N)) \quad \cdots\cdots(2)$$

The main stability definitions currently used in graph model analysis include Nash Stability (Nash), General Metarationality (GMR), Symmetric Metarationality (SMR), Sequential Stability (SEQ), Limited Move Stability (L_h), and Non-Myopic Stability (NM) (Kilgour and Hipel, 2005).

In this paper, two solution concepts are employed.

Nash Stability

State k is the Nash stable for player i iff i cannot improve his payoff by changing his own strategies. In the other words,

$$S_i^+(k) = \{\varnothing\} \quad \cdots\cdots(3)$$

Sequential Stability

State k is sequentially stable for player i iff for every $k_1 \in S_i^+(k)$, there exists $k_2 \in S_j^+(k_1)$ with $P_i(k) > P_i(k_2)$.

GMCRII (Hipel et al., 1997; Hipel, Kilgour, Fang and Peng, 2001) provides a simple strategic representation of conflict, with minimal information requirements that can be analyzed for a range of stability patterns that represent different styles of decision making in a real-world conflict (**Fig. 1**).

3. BACKGROUND OF THE CONFLICT

Ichinose, a mountainous community, is located in Chizu (Tottori prefecture) in Japan. It is a very small community having 32 households. Due to potential land resources, the local government planned to explore the rock resources from this area for the construction of roads and other civil work. Thus, the rock quarry became a resource base for local development. Around 30 years ago, one local quarry company (Hisamoto Company) entered this area in support of the local government, and this contract agreement intended to include safety measures from the company side. Confrontation evolved when the local company refused to take what seemed to be possible action for disaster mitigation work ordered by the local government. The history of the conflict is described here in different time periods (**Table 1**).

4. MODEL OF THE CONFLICT

4.1 Two phases of the conflict

We divide the whole process of the conflict into two phases plus the instantaneous period of change in the structure that is interpreted to have occurred between the end of the first phase and the start of the second phase. To model the static structures of both the first and second phases, GMCR is used as follows.

4.1.1 Phase I

This conflict is modeled by use of GMCR II. March 1985 saw the start of phase I and is the point in time for which the modeling and analysis was conducted. Two players have been identified in this conflict i.e., the local company and the local government. The local government consists of the prefectural government and the town office. At that time, players, their relative options, and the status quo are listed below (**Table 2**). Mathematically, there are a total of 32 (2^5=32) possible states, but after removing all infeasible states, there are 14 feasible states in total (**Table 3**). Some states are infeasible because they are mutually exclusive. In Tables 2 and 3,'Y' means 'Yes' and indicates that the option is taken for a corresponding state, and 'N' means 'No', where the option is not taken. The local company's ranking state from most preferred to least preferred was $5 \succ 1 \succ 13 \succ 9 \succ 3 \succ 11 \succ 7 \succ 6 \succ 2 \succ 14 \succ 10 \succ 4 \succ 12 \succ 8$, and the local government's preference order was $10 \succ 8 \succ 9 \succ 7 \succ 14 \succ 12 \succ 13 \succ 11 \succ 2 \succ 1 \succ 6 \succ 45 \succ 3$ The desirability of each state of each player is structured in the following way. A

Table 1. Chronology of the Conflict

Year	Occurrence	Action taken
1985	On March 23, a landslide occurred and the debris fell into the River Sendai (43,000 m^3).	Notification by the local government • Clearance of the piled-up waste from the river. • Taking emergency measures.
1996	Again on September 27, another landslide occurred, the debris fell into the River Sendai (30,000 m^3), and a large crack was discovered along the ridge.	Notification by the local government • Clearance of the piled-up waste from the river. • Order for emergency measures. • Notification for suspension of rock quarry operation.
1998	On September 24 and 25, due to heavy rainfall, another landslide occurred at the quarry site and the earth fell into the River Sendai.	Notification by the local government Clearance of the landslide (securing of a pocket) and construction of a deposit pond.
	Again on October 25, earth (50,000 m^3) that was piled up at the quarry site crumbled due to a typhoon (1825 mm ppt) and fell into the River Sendai. Six houses in the Ichinose community were affected very badly. National highway no. 53 and part of the tunnel was blocked. The JR line and some quarrying equipment of Hisamoto Company were also washed away.	The local government rebuilt the riverbed and the local company cleared the disposed of earth.
2002	On January 25, a big landslide occurred and the piled-up waste was dumped at the waste treatment site. The river flow was blocked due to the landslide (dam formation).	The local government ordered Hisamoto Company to remove the rocks and debris from the site. However, Hisamoto Company refused to do this job and local government thus ordered Hisamoto Company to make reimbursement for expenses incurred in the restoration process in accordance with river loss. The amount claimed was 1,736,604,804 yen and on March 12, the property of the company was totally confiscated.
2004	Owing to the heavy rains caused by typhoon no. 21 on 29th to 30th September, the Sendai River flooded. Furthermore, due to the heavy rains, the left-hand cliff of the mountain collapsed, and soil and rocks fell to the riverbed, which resulted in dam formation. Because of this, ten houses and the community center were completely flooded, the JR line was closed by for one and half days, and mud and rubbish accumulated on the tracks.	Temporary shelters were arranged by the local government and they also established a disaster mitigation office in the Ichinose community to monitor the disaster mitigation work and operate an early warning system. On June 20, a new governor was elected.
2005		Monitoring the Early Warning System (EWS) by the local government.

Table 2. Players and their Options, March 1985 in phase I

Players and their options	Status Quo State
Local company	
1. Rock quarrying and dumping at the site	Y
2. Operating and maintaining the EWS	N
Local government	
3. Allowing rock dumping by local company	Y
4. Operating and maintaining the EWS	N
5. Monitoring safety performance	Y

Table 3. Feasible states of the conflict in phase I

Option \ States		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Local company	1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Local government	3	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
	4	N	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
	5	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y

positive number means that a player prefers that this option be taken, and a negative number means that a player does not prefer that this option be taken. Players have the following options.

Local company's desirability

- The local company wants to quarry rock deposits. (1)
- The local company does not want to operate and maintain the EWS. (-2)
- The local government allows them to dump rock at the site. (3)
- The local government can operate and maintain the EWS. (4)
- The local company does not want to monitor work by the local government. (-5)

Local government's desirability

- The local company can quarry rock deposits and dump rock at another site. (1)
- The local company can operate and maintain the EWS. (2)
- The local government allows the local company to dump rock at the site. (3)
- The local government does not want to operate and maintain the EWS. (-4)
- The local government wants to monitor the local company's work. (5)

Here, we obtained only one equilibrium, i.e., state 9 (both Nash equilibrium and Sequential equilibrium), which was also the status quo state at that time. The graph model helps to describe the actual outcome as equilibrium in this game. It seems that although the local government suspended the local company's quarry work for a while, they again gave approval to continue the rock quarry work. However, the company was not ready to take the proper measures for the disaster mitigation work ordered by the local government. Under this condition, the agreement was not stable and neither did the local government use their power to enforce the agreement. Thus, the delay of a concrete agreement upset the status quo state (modeled as a stable state). Neither the local company nor the local government made potential improvements from the status quo state (**Fig. 2**). This graphic representation provides more flexibility than the other forms, i.e., the normal and option forms of modeling non-cooperative conflicts. The option (Howard, 1971) and the normal forms (Von Neumann and Morgenstern, 1953) are symmetric in the sense that if player i can reach outcome x, then player i can also reach outcome x from outcome y. Therefore, irreversible moves cannot be properly represented using option and normal form (Kilgour et al., 1987).

On 25th January 2002, a large-scale landslide occurred, and this natural disaster accidentally triggered a social shock that forced the game to move on to another phase of the conflict. This is interpreted as, in this instantaneous period, some structural change occurred.

4.1.2 Phase II

The second phase of the conflict started on 25th January, 2002. At that time, the local community became a player in this game and the different issues and sub-issues thus changed the structure of the game. The players and their options, and the status quo state are listed below (**Table 4**). In this conflict, there are a total of 512 states (2^9=512) However, many of the states are not feasible for actual conflict for different reasons. For example, the local community has two options: to stay in the same village with disaster preparedness, or to shift the village with public facilities. Both are mutually exclusive, so they are infeasible options. However, in case of the local government, out of four options, there are two options, i.e., rock and debris clearance from the site, and operation and maintenance of the EWS, both of which are mutually exclusive for the local company. This may be possible with the coordination

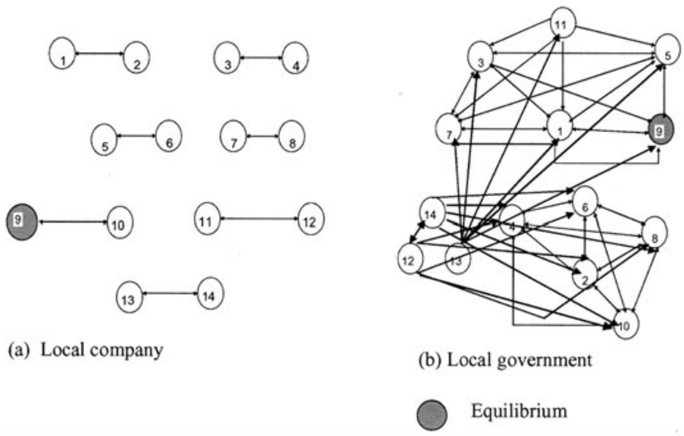

Fig. 2 Integrated state transition graph (Phase I)

Table 4. Players and their options, January, 2002 in phase II

Players and their options	Status Quo State
Local community	
1. Staying in the same village with disaster preparedness	Y
2. Shifting the village with public facilities	N
Local company	
3. Clearing rocks and debris from the site	N
4. Operating and maintaining the EWS	N
5. Appeal to the national government	Y
Local government	
6. Assisting the local community to shift the village	N
7. Order to clear rocks and debris from the site	Y
8. Operating and maintaining the EWS	N
9. Waiting for the national government's judgment	Y

of both players. So, in this case, it is regarded as a feasible state for both players. After removing the infeasible options, a total of 18 states were identified for this conflict (**Table 5**). The player's ranking of states from most preferred to least preferred is as below:

The local community: 13 ≻ 11 ≻ 12 ≻ 17 ≻ 10 ≻ 5 ≻ 3 ≻ 4 ≻ 15 ≻ 2 ≻ 9 ≻ 7 ≻ 8 ≻ 16 ≻ 6 ≻ 14 ≻ 18 ≻ 1

The local company: 1 ≻ 10 ≻ 2 ≻ 6 ≻ 12 ≻ 4 ≻ 8 ≻ 11 ≻ 3 ≻ 7 ≻ 13 ≻ 5 ≻ 9 ≻ 17 ≻ 15 ≻ 16 ≻ 14 ≻ 18

The local government: 18 ≻ 1 ≻ 13 ≻ 5 ≻ 9 ≻ 11 ≻ 3 ≻ 7 ≻ 12 ≻ 4 ≻ 8 ≻ 17 ≻ 15 ≻ 16 ≻ 14 ≻ 10 ≻ 2 ≻ 6

The player's preferences over the states defined by the combination of options can be ranked by using option prioritizing (**Table 6**). In this case, option prioritizing is defined by the importance and desirability of two properties of a state from the viewpoint of the player. The desirability state of each player is assumed as follows.

Local community's desirability

- The local community intends to stay in the same village with disaster preparedness. (1)
- The local community does not want to shift from their place. (-2)
- The local company should clear the rocks and debris from the site. (3)
- The local company should operate and maintain the EWS. (4)
- The local company should not appeal to the national government. (-5)
- The local government should not assist the local community to shift the village. (-6)
- The local government should clear the rocks and debris from the site. (7)
- The local government can operate and maintain the EWS. (8)
- The local government wants to wait for the national government's judgment. (9 IF -3, -4)

Local company's desirability

- The local community does not intend to stay in the same village with disaster preparedness. (-1)
- The local community wants to shift from their place. (2)
- The local company does not want to clear the rocks and debris from the site. (-3)
- The local company does not want to operate and maintain the EWS. (-4)
- If the local government will appeal to the national government's judgment, then they will file a case. (5)
- The local government can help the local community to shift the village. (6)
- The local government can clear the rocks and debris from the site (7)
- The local government can operate and maintain the EWS (8)
- The local government should not appeal to the national government (-9)

Local government's desirability

- The local community does not intend to stay in the same village with disaster preparedness. (-1)
- The local community can shift their village. (2)
- The local company can clear the rocks and debris from the site. (3 IFF 1)
- The local company can operate and maintain the EWS. (4 IFF 1)
- The local company should not file a case. (-5)
- The local government can assist the local community to shift

Table 5. Feasible states of the conflict in phase II

Options \ States		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Local community	1	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-
	2	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	-
Local company	3	N	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	N	N	N	-
	4	N	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	N	N	-
	5	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
Local government	6	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	-
	7	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	Y	N	Y	-
	8	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	-
	9	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y

Table 6. Option prioritizing

Local community	Local company	Local government
-6	-9	3 IFF 1
7	-3	4 IFF 1
8	-4	9
3	5	6
4	6	2
1	2	-1
-2	-1	7
9 IF -3, - 4	7	8
-5	8	-5

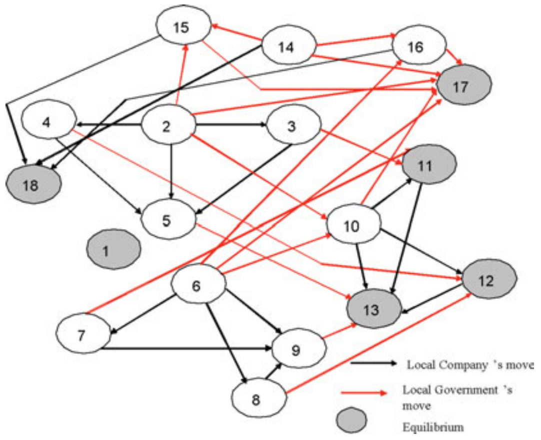

Fig. 3 Integrated state transition graph (Phase II)

their village. (6)
- The local government can clear the rocks and debris from the site. (7)
- The local government can operate and monitor the EWS. (8)
- If the local company does not cooperate, then they can wait for the national government's judgment. (9)

5. STABILITY ANALYSIS AND SOLUTION CONCEPTS

To understand the behavior of each player in this conflict, situation stability analysis has been conducted. In this analysis, the status quo state does not appear as an equilibrium state. States 1, 11, 12, 13, 17 and 18 are possible equilibria in this conflict. Since the local community was not ready to move from their location, equilibrium 1 was found not to be a possible solution in this game. The game did not proceed in a cooperative way perhaps due to mistrust and miscommunication among the players. From **Fig. 3**, we can trace the irreversible moves and common moves. From equilibria 17 and 18, none of the players had the potential to move for a better solution. It is assumed that neither the local company nor the local government had the appropriate information from the other side. Otherwise, a new proposal either from the local company or the local government side could have brought the conflict to state 11, 12 or 13, or this could also have changed the structure of the game.

6. CONCLUSIONS

The integration of disaster risk management and conflict resolution has not been well explored so far, but this aspect must be addressed in integrated disaster risk mitigation policy. As referred to in the above, we could qualitatively analyze how the structure of the conflict changed over time. Our interpretation is that the intervening social shock caused by the repeated landslides triggered the contextual shift in the development of the conflict. We may also infer that some political climate change such as a new governor being elected and coming to office could also have contributed to this quantum jump in the structure of the conflict. The conflict escalated in the second phase of this game, and there remained no further scope to deescalate the conflict. In this case, a third party can change and improve the situation. A lesson could be derived from this study that before taking on any quarry-related project, local government must engage the local community to ensure their interests are served through participatory planning. At each stage, verification of ongoing work should be assessed, and information must be shared among different stakeholders. This study also emphasizes that incorporating a dispute resolution mechanism, if well managed, will further ensure the success of local-level development processes.

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