Environmental Conflicts, Stakeholders and a Shared Mental Model

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Abstract
Environmental conflict management involves the management of multiple stakeholders with conflicting stakes. In this paper, an attempt is made to develop a shared mental model of stakeholders in an environmental conflict. The Transmission Gully project, a large-scale transport infrastructure project in the Wellington region of New Zealand is used as a case study. Selected stakeholders of this project tried to generate this shared model, in the form of a causal loop diagram. This model is analysed qualitatively to provide different insights into potential system behaviours.

Keywords: Stakeholders, Environmental Conflict, Systems Thinking and Modelling

Introduction

Developing a shared mental model of stakeholders in conflict is a challenge in environmental conflict management. According to the US government's environmental policy and conflict resolution statute of 1998, the term environmental conflict or dispute is defined as a dispute or conflict relating to the environment, public lands, or natural resources. Jackson (2001) explains about three different types of environmental conflict. Conflict can exist between different users of a resource. It can exist between the users of a resource and those who would conserve it. Conflict also exists between decision-makers and those who want more of a say in those decisions.

Large-scale development projects are good examples of environmental conflicts as they generate heated conflict between different stakeholders. When these projects are in the public domain, the stakeholders of the project believe that they have a right to be involved in the decision process, because they will be affected by the ultimate policy choice (Gregory and Keeney, 1994). While managing such environmental conflicts, it is useful to develop a shared systems model of stakeholders, which will capture the different mental models of stakeholders.

While taking a systems approach to understand such problem situations, researchers in the field of Systems Thinking and Modelling have acknowledged the importance of involving stakeholders in building systemic models. Researchers like Vennix (1996) used group model building where team members exchange the perceptions of a problem and explored such questions as: what exactly is the problem we face? How did the problematic situation originate? What might be its underlying causes? How can the problem be effectively tackled? Also, over the last four decades, more and more practitioners and consultants have started to involve clients in system thinking and modelling projects (Rouwette *et al*., 2002).

Group model building was successfully applied in many areas involving stakeholders. Some interesting examples of application include management of housing associations (Rouwette *et al*., 1999), transportation and air quality management (Stave, 2002), quality in health services (Cavana *et al*., 1999) and fleet management (Vennix, 1996). Insights gained from most of these exercises point to the usefulness of group model building in developing a shared mental model of stakeholders involved.

In this research, a group model building exercise was conducted, by bringing together various stakeholders, like different users, environmentalists, decision makers and other important stakeholders of the proposed Transmission Gully motorway project. This paper presents this group model building exercise that was used to generate a shared systems model of selected stakeholders in this environmental conflict. We start by presenting the background to the conflict situation, a large-scale transport infrastructure project called Transmission Gully in the Wellington region in New Zealand. Then, the different steps of the group model building exercise as applied to the project are presented. Further, the causal loop model generated through this group model building is analysed in terms of the feedback loops formed in the model.

The Case of Transmission Gully Motorway

The Wellington Regional Council managed the project that was used in this study. The Wellington Regional Council had been seeking a suitable solution to the increasing problems of congestion, safety and community severance along the existing State highway route between Paremata and Paekakariki. A possible solution to these problems was the construction of the Transmission Gully motorway, a 27-km inland route. The vision of the Wellington Regional Transport strategy, as explained in the Wellington Regional Land Transport Strategy, 1999 –2004 (Wellington Regional Council, 1999) was ‘a balanced and suitable land transport system that meets the needs of the regional community’, and it in turn demands, the proposed Transmission Gully motorway to be environmentally and economically sustainable.

The case of the Transmission Gully project presented an interesting example of environmental conflict. This study found that the idea of the Transmission Gully project was conceived as early as 1915. Later in 1940, the US army, camped at Queen Elizabeth Park during World War II, found the present highway insecure and proposed an alternate route through the Transmission Gully. The American government offered to fully fund the project, but due to political reasons, the New Zealand government rejected the offer. Our identification of the milestones of this project during the last 90 years, revealed the importance of such stakeholder behaviour that resulted in the delay of this project.

Over 90 years since its inception, the Transmission Gully project continued to make headlines in the New Zealand media. The conflict between different stakeholders that kept on surfacing, presented increasing challenges to the transport planning managers of the Wellington Regional Council. This complex situation faced by the managers of large-scale development projects in public arena like the Transmission Gully could ease, if they could use the ‘systems thinking’ frameworks to develop and analyse shared mental models of stakeholders.

Analysis of the Stakeholders

As a preliminary step to begin the process of group model building, a stakeholder analysis was conducted for the Transmission Gully project. For this purpose, a stakeholder analysis methodology, based on the stakeholder literature (e.g. Freeman, 1984; Mitchell *et al.*, 1997) was applied. This methodology consisted of the nine steps: (i) Developing a stakeholder map (Figure 1) of the project; (ii) Preparing a chart of specific stakeholders; (iii) Identifying the stakes of stakeholders; (iv) Preparing a power versus stake grid; (v) Conducting a process level stakeholder analysis; (vi) Conducting a transactional level stakeholder analysis; (vii) Determining the stakeholder management capability of the project; (viii) Analysing the salience of stakeholder; and (ix) Analysing the changing positions and interests of stakeholders.

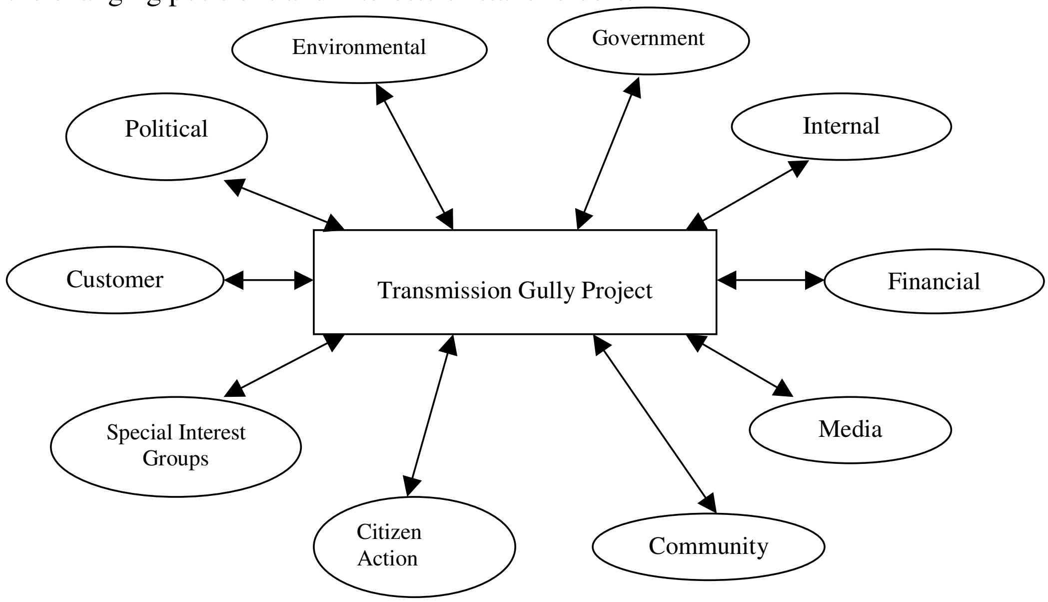


Figure 1. Stakeholder Map of the Transmission Gully Project

This stakeholder analysis helped in structuring the problem by systematically identifying the stakeholders and their stakes. It came to the conclusion that the managers of the Transmission Gully project understand their stakeholder map. Also, the process level analysis gave a high rating for the processes with which they deal with their stakeholders. But according to this study, the effectiveness of the transactions between the project managers and stakeholders was relatively low. A detailed application of all these steps to the Transmission Gully project is available in Elias *et al.* (2002).

Group Model Building

Key stakeholders belonging to the different categories, as identified in the stakeholder map (Figure 1), were brought together to participate in the group model building exercise. Among the different methods available for group model building, the method used in this paper is based on the systems thinking methods outlined in Cavana *et al.* (1999). In this qualitative group model building approach, hexagons are used for systems thinking. For this research, four steps of group model building were used:

Step 1: Hexagon generation
Step 2: Cluster formation
Step 3: Variable identification and
Step 4: Causal loop development

Maani and Cavana (2000) have explained this procedure systematically in their Systems Thinking and Modelling methodology, based on Hodgson's (1994) use of hexagons for issue conceptualisation and Kreutzer's FASTbreakTM process (1995) for using hexagons to develop causal loop diagrams.

Step 1: Hexagon Generation

This step consists of generating hexagons for each issue, opportunity or obstacle identified by the stakeholders. To help the stakeholders in generating hexagons, an organising question was used in the first group model building session. The organising question was: *'What are the factors that should be considered while deciding whether the Transmission Gully project should go ahead or not?'*

Coloured hexagons were used as a facilitation tool. Yellow hexagons were used for recording ordinary issues, opportunities or obstacles identified by the participants. Pink hexagons were used when they generated a strongly held/felt issue, opportunity or obstacle. The stakeholders who attended the session generated a total of 93 hexagons.

Step 2: Cluster Formation

As the second step, the stakeholders identified hexagons that have something in common. These hexagons were grouped together to form clusters and a descriptive name was given to each cluster. In the workshop, the stakeholders made 18 such clusters. The descriptive names given to each of these 18 clusters include: Treaty issues, physical environment, consequential traffic, needs, distribution of costs and benefits, money, regional strategic issues, alternative modes, political issues, quality of life, hazards, alternative routes methodology, practicality, regional economic development, energy, Kapiti sustainability and social & community issues. Two of these clusters are presented in Figures 2 and 3.

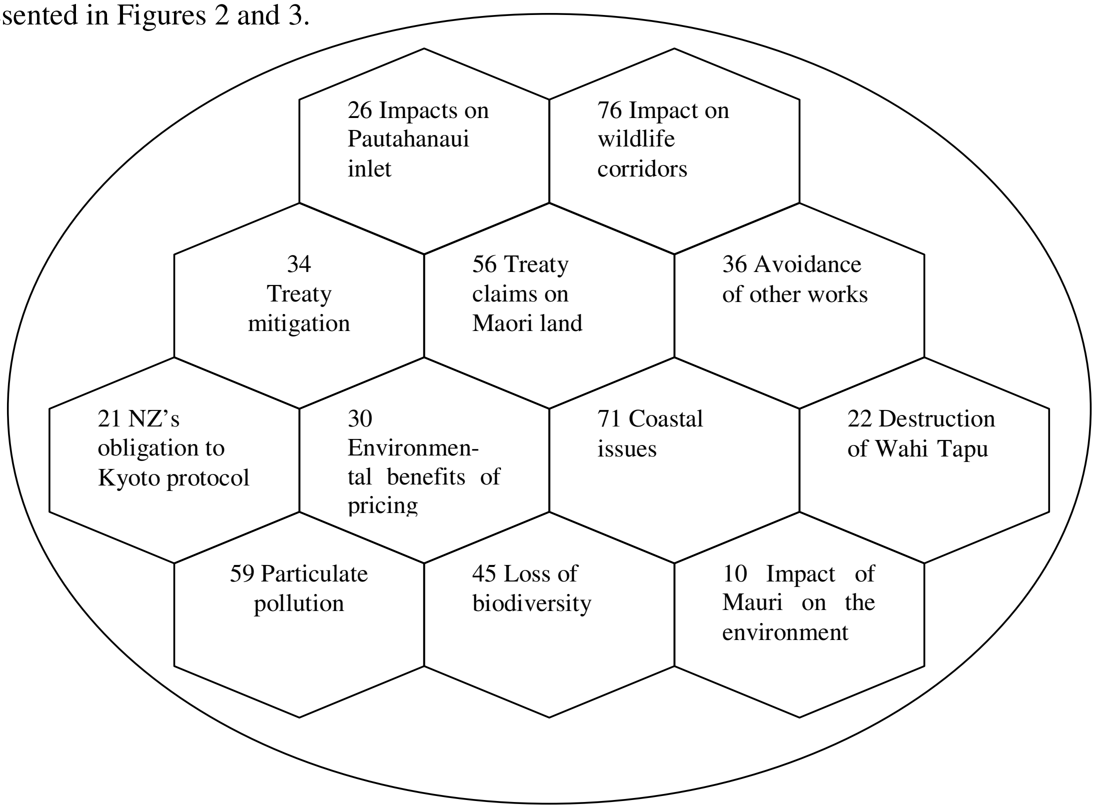


Figure 2. Physical Environment Cluster

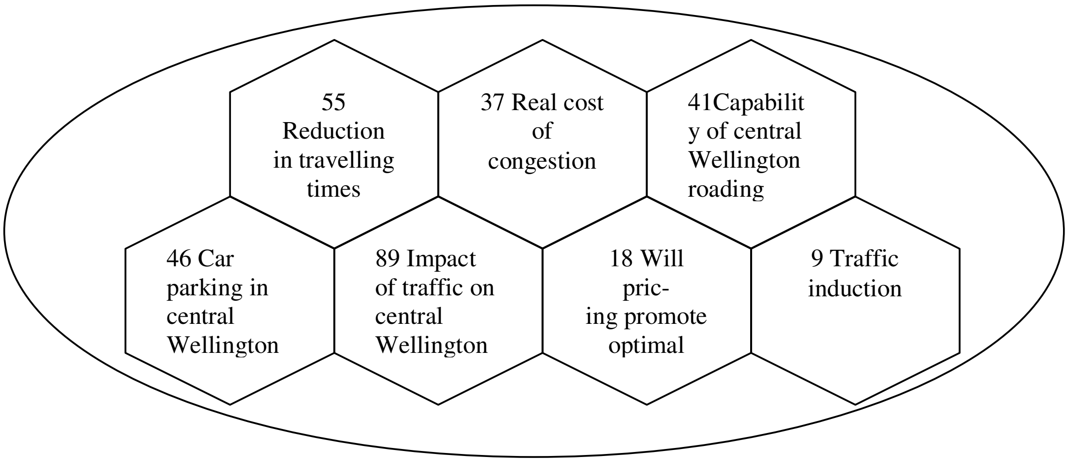


Figure 3. Consequential Traffic Cluster

Step 3: Variable Identification

In the next session, the stakeholders identified a few variables associated with each cluster. Blue hexagons were used to represent the variables. These variables are presented in Table 1.

Cluster	Variable
Hazards	1. Hazard Cost Index
	2. Number of days that the Road is Closed due to Hazards p.a.
Alternative routes	3. Perceived Effectiveness of Alternative Routes
	4. Actual Effectiveness of Alternative Routes
Methodology	5. Goals
	6. Benefit Cost Ratio
Physical Environment	7. Water Quality Index
	8. Local Air Quality
	9. Global Air Quality
	10. Land Take
	11. Biodiversity
Distribution of Costs & Benefits	12. Distribution of Economic Costs
	13. Distribution of Economic Benefits
Money	14. Cost of each Alternative
	15. Allocation of Costs
Alternative Modes	16. Actual Effectiveness of Alternative Modes
	17. Perceived Effectiveness of Alternative Modes
	18. Number of Passenger Kilometres p.a.
Kapiti Sustainability	19. Kapiti Sustainability
Social and Community Issues	20. Social Impact on Community
	21. Number of and Severity of Accidents p.a.
Treaty Issues	22. Comparative Compliance Cost of Treaty Obligations
Consequential Traffic	23. Change in Trip Volume and Distribution
Needs	24. Population
	25. Average Number of Trips per Person per day
Energy	26. Regional Energy Consumption per trip
	27. Total Regional Transport Energy Consumption

Regional Economic development	28. Regional GDP
	29. Regional Economic Cost of Congestion
	30. Travel Time
Political Issues	31. Political Will
	32. Community Demands
Quality of Life	33. Quality of Life Index
	34. Hanson's Accessibility Index
Regional Strategic Issues	35. Public Perception of Regional Land Transport Strategy

Note: The participants felt that no variables were required for the cluster 'practicality'.

Table 1. Variables identified by the Group Model Building Participants

Step 4: Causal Loop Development

In this session, stakeholders tried to establish the links between variables. They first identified two variables that were related and provided a directed arrow between each pair of related variables. To generate a directed arrow, they placed a positive (+) sign near the head of the arrow if an increase (or decrease) in a variable at the tail of an arrow caused a corresponding increase (or decrease) in a variable at the head of the arrow. If an increase in the causal variable caused a decrease in the affected variable, a negative (-) sign was placed near the head of the arrow. An initial version of the causal loop diagram was thus developed. It is shown in Figure 4. At the end of the group model building exercise, a general agreement that this model represented their shared view was obtained from the stakeholders who participated in this meeting.

A broad analysis of this causal loop diagram can be done by identifying the main sectors and loops present in this diagram. As far as the sectors are concerned, stakeholders identified traffic sector, environmental sector, community sector and economic sector interacting in this system. A closer look at this diagram also reveals some important feedback loops.

In the traffic sector, stakeholders were able to generate a feedback loop connecting average number of trips per person per day, travel time, community demands, political will, Transmission Gully construction, and change in trip volume and distribution. Analysing the links show that this is a reinforcing loop.

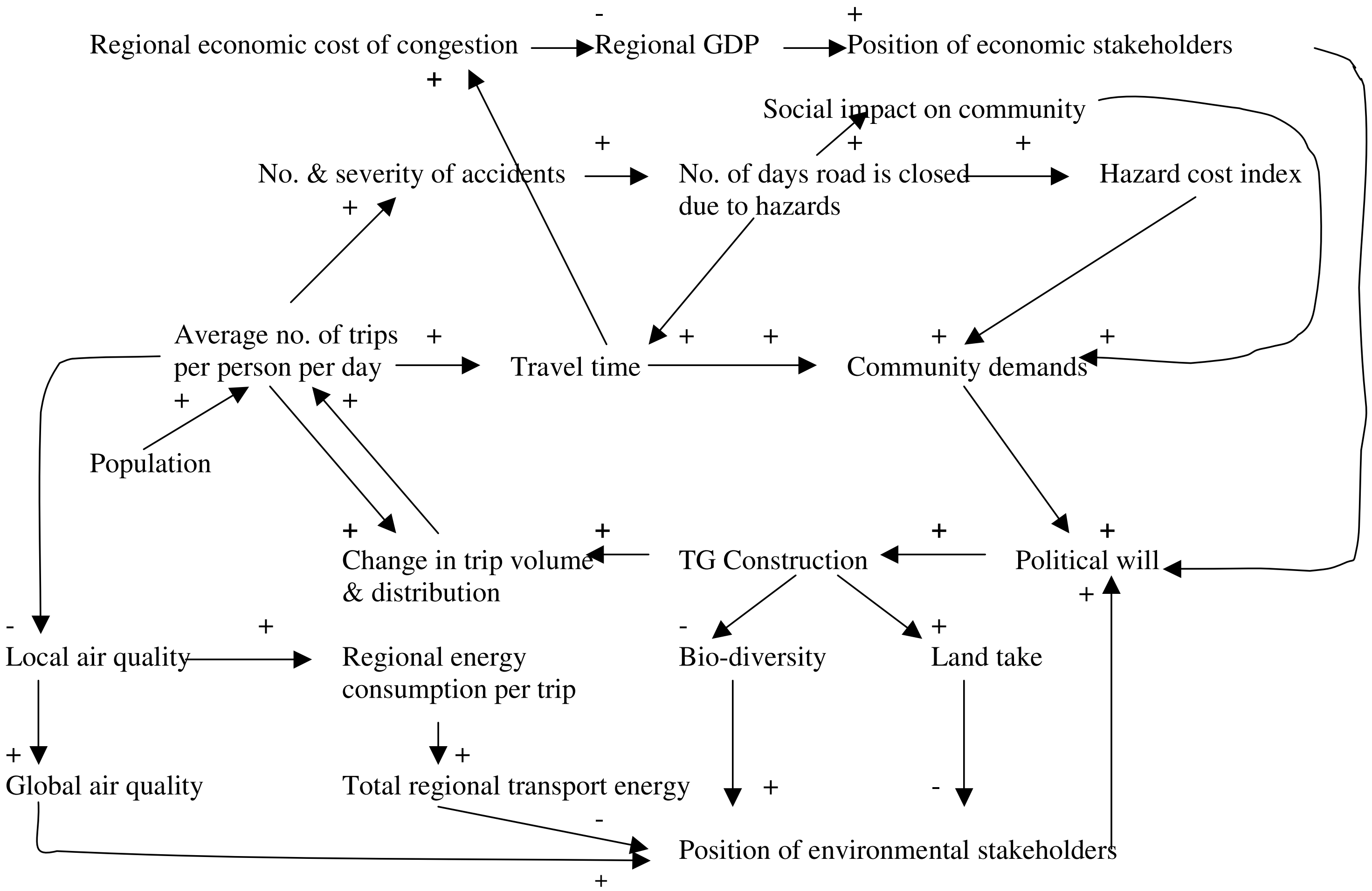


Figure 4. Initial Causal Loop Diagram

The second loop connects average number of trips, local air quality, global air quality, position of environmental stakeholders, political will, TG construction, and change in trip volume and distribution. Variations of this loop can be formed by taking a route via regional energy consumption per trip and total regional transport energy instead of local air quality and global air quality. In this sector a few other loops were also generated by connecting TG construction, biodiversity or land take, position of environmental stakeholders, and political will. Analysing the links show that all these are balancing loops.

The stakeholders were able to form another loop by connecting average number of trips per person per day, number and severity of accidents, number of days the road is closed due to hazards, social impact on community, community demands, political will, TG construction, and change in trip volume and distribution. Analysing the links show that this is a reinforcing loop.

A detailed analysis of this causal loop diagram was not done since this was only an initial version. Nevertheless, this diagram gave a fair idea about the mental models shared by the stakeholders regarding the Transmission Gully project. Later, this model was refined to develop a more meaningful causal loop model of this system.

Modified Causal Loop Model

After developing an initial version of the causal loop model, the model can then be refined and the reinforcing and balancing loops identified (Maani and Cavana, 2000). In this research, the initial casual loop model was refined by taking two considerations. First, the scope of the model was narrowed down to include the positions and interests of environmental and community stakeholders only. So, the variables relating to the positions and interest of economic stakeholders were not considered in this model. Second, consideration was also given towards the development of a dynamic model at a later stage of this research. It was aimed that, all or most of the variables and linkages present in the modified causal loop model could be used in the dynamic model.

Also, the system dynamics literature was reviewed to identify similar models during the modification of the causal loop diagram. This review found the causal loop model on traffic congestion by Sterman (2000) quite helpful in making sense of the initial causal loop diagram and in modifying it. The modified causal loop model is presented in Figure 5.

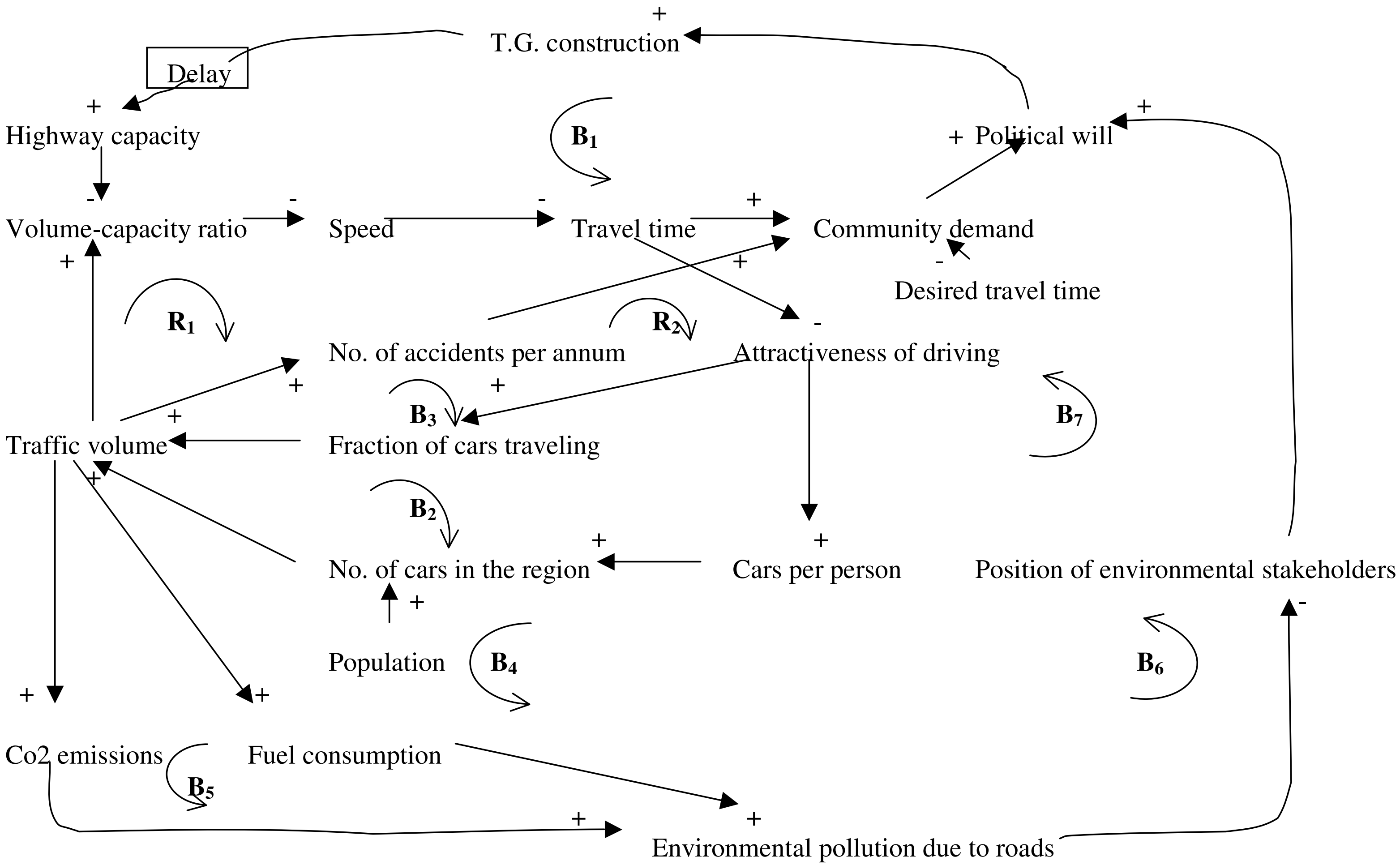
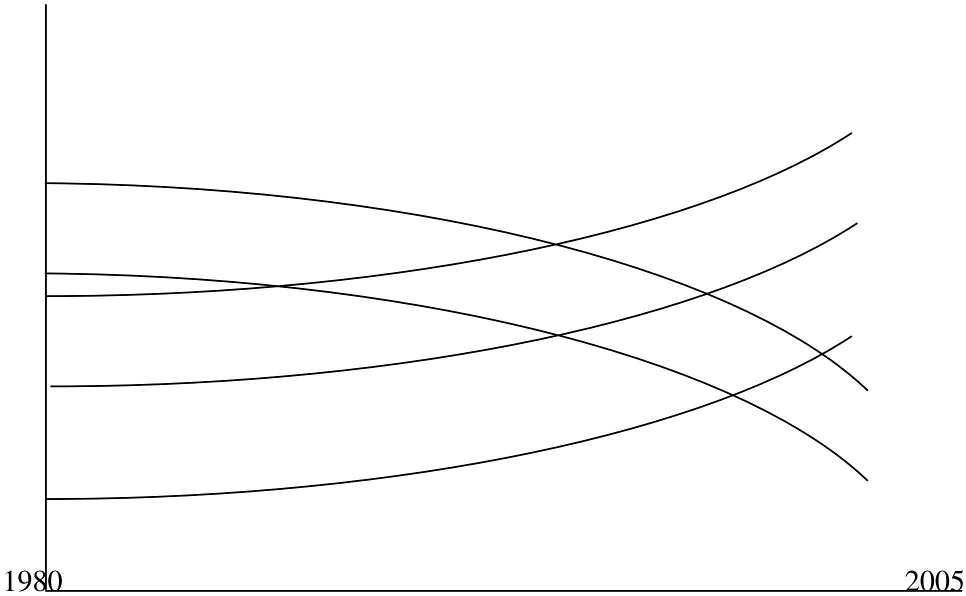


Figure 5. Modified Causal Loop Mode

Behaviour Over Time Charts
One of the tools of systems thinking is behaviour over time (BOT), which is also referred to as ‘reference mode behaviour’. BOT shows the pattern of a variable over an extended period, typically several months to several years. This pattern can indicate the variations and trends in the variable of interest – for example growth, decline, oscillations or a combination thereof. In BOT graphs, the horizontal axis represents time and the vertical axis represents the performance measure of interest. The important elements of BOT are the overall directions and variations, not the numerical value of the variable. Therefore, BOT graphs are usually drawn in a rough sense without exact numerical values attached (Maani and Cavana, 2000).

For developing a reference mode for this research, five variables were used. These variables are traffic volume, travel time, speed, attractiveness of driving and CO_2 emissions. Analysing the data since 1980 from the Wellington Regional Council for 7 to 9 am travel between McKay’s crossing and Linden, it was seen that the traffic volume, travel time and CO_2 emissions were increasing steadily. It was also seen that the speed of travel and the attractiveness to driving was decreasing. This behaviour is shown in Figure 6.



1=Traffic volume, 2= Travel time, 3=CO_2 emissions, 4= Speed, 5 = Attractiveness of driving

Figure 6. Reference Mode

Analysis of the Causal loop diagram
The casual loop model was analysed by identifying the feedback loops formed in the model. Feedback loops can be reinforcing or balancing. The feedback loops identified in this model include two reinforcing and seven balancing ones. The analysis of the seven feedback loops is discussed below:

Loop 1. Constructing Transmission Gully Loop (B_1)
A possible starting point to this causal loop analysis is the variable, traffic volume. In linear thinking, traffic volume is the problem and building new roads is the solution (Sterman, 2000). According to ‘Constructing Transmission Gully Loop’, when traffic volume increases, the volume-capacity ratio increases. An increase in volume-

capacity ratio will decrease the speed of travel, which in turn increases the travel time. When travel time increases, the community demand for building Transmission Gully will increase, strengthening the political will for Transmission Gully construction. Because of this increased political will, if the Transmission Gully becomes a reality, then there will be more highway capacity which in turn will reduce the volume-capacity ratio.

Thus 'Constructing Transmission Gully' is a balancing feedback loop. The objective of the loop, desired travel time is shown explicitly in the model for clarity. If this were the only loop operating in the system, it would achieve its objective. When travel time is more, build new roads like the Transmission Gully, so that travel time decreases towards the desired level. But, this is not the only loop operating in the system and it is worth looking at the other feedback loops to get a better understanding of the system.

Loop 2. Purchasing Cars Loop (B_2)

The second loop operating in the system explains the behaviour of people, when there is a decrease in travel time, due to the construction of new roads. When travel time decreases, there will be an increased attractiveness towards driving cars. When attractiveness to driving increases, people will avoid other modes of travel and this eventually results in an increasing number of car purchases. This increases the total number of cars in the region. When the number of cars in the region increases the traffic volume increases. An increase in travel time will result in an increasing volume-capacity ratio and decreasing speed. This, in turn, will increase the travel time.

So, the car purchasing loop is a negative feedback (balancing) loop resulting in increased travel time due to the increasing attractiveness of driving and increasing number of cars in the region. Population is considered an exogenous variable here and it can be used to calculate the number of cars in the region, by multiplying it with cars per person. To summarise, the effect of this loop is to increase the travel time, negating the effect of decreasing travel time, achieved by the constructing Transmission Gully loop.

Loop 3. Travelling Cars Loop (B_3)

The third loop is quite similar to the second loop. When travel time decreases, the attractiveness of driving cars increases. This will result in more cars travelling on the road which will, in turn will increase the traffic volume and volume-capacity ratio. When volume-capacity ratio is higher, the speed decreases, increasing the travel time.

Like the purchasing cars loop, the travelling cars loop is again a balancing loop. The effect of this loop is to increase the travel time due to an increase in the number of cars travelling on the road. Thus, both the purchasing cars loop and travelling cars loop try to increase travel time, thereby negating the effect of the constructing Transmission Gully loop.

Loop 4. Community Purchasing Accidents Loop (R_1)

The fourth and fifth loops operating in the system explain some of the long-term effects of the Transmission Gully construction on the community. The intention of community stakeholders, when they put pressure on the politicians to build the new road was to decrease congestion. The constructing Transmission Gully loop (B1) explained how travel time initially decreased due to the construction of Transmission Gully whereas the 'community purchasing accidents loop' explains the behaviour of number of accidents occurring on the roads.

When traffic volume increases, the number of accidents in the road will in turn increase. As a result the community demand for constructing the Transmission Gully will intensify, which will increase the political will and the chances of building Transmission Gully. If Transmission Gully is constructed, it will increase the highway capacity and decrease the volume-capacity ratio, thereby increasing speed and decreasing travel time. A reduction in travel time will increase the attractiveness of driving. An increasing attractiveness of driving cars will result in people purchasing more cars, increasing the total number of cars in the region. This will increase the traffic volume and the number of accidents on the roads.

The 'community purchasing accidents loop' is, thus a reinforcing loop. It shows how the number of accidents keeps increasing due to the increasing traffic volume. It also shows that, although Transmission Gully initially results in decreasing congestion, it will contribute to an unexpected side effect of increasing accidents.

Loop 5. Accidents while Community Travelling Loop (R_2)

Accidents while community travelling loop is similar to the community purchasing accidents loop (R_1). An increase in traffic volume can result in an increase in the number of accidents on roads. This may result in the construction of Transmission Gully due to an increasing community demand and political will. This will result in an increased highway capacity, reduced volume-capacity ratio and increased speed. Increased speed will reduce travel time, and a reduction in travel time will increase the attractiveness of driving. This will increase the fraction of cars travelling and thus the traffic volume. An increase in traffic volume tends to increase the number of accidents on roads.

Like the community purchasing accidents loop, accidents while community travelling loop is another positive feedback (reinforcing) loop. The Community purchasing accidents loop showed the behaviour of number of accidents while following the purchasing cars loop (B_2). Accidents while community travelling loop shows the behaviour of number of accidents while following the travelling cars loop (B_3). Both these loops show how the number of accidents keeps on increasing due to an increasing traffic volume.

Loop 6. Fuelling Environmental Pollution Loop (B_4).

The sixth and the seventh loops operating in the system link the effect of traffic variables with environmental pollution and the subsequent behaviour of environmental stakeholders. According to the fuelling environmental pollution loop, an increasing traffic volume increases the amount of fuel consumption, contributing to an increasing pollution of environment due to roads. This increases the concern of environmental stakeholders towards the construction of new roads like Transmission Gully, which in turn decreases the political will to build the Transmission Gully motorway. If the Transmission Gully motorway is not built, the highway capacity will not increase and the volume capacity ratio will rise. This will reduce the speed and increase the travel time. An increasing travel time will reduce the attractiveness of driving which in turn reduces the cars per person and the total number of cars in the region. This will reduce the traffic volume and also the amount of fuel consumption.

The fuelling environmental pollution loop is a balancing loop. Based on this loop, the environmental stakeholders opposed the construction of new roads due to increasing fuel consumption. The fuelling environmental pollution loop explains how this reaction enables them to control the amount of fuel consumption.

Loop 7. Polluting CO_2 Loop (B_5)

The seventh loop, polluting CO_2 is similar to the fuelling environmental pollution loop (B_4). When the traffic volume increases the CO_2 emissions increases, thereby increasing the pollution of environment due to roads. This affects the position of environmental stakeholders negatively, towards the construction of new roads like

Transmission Gully. When the opposition towards Transmission Gully increases, the political will to build it will go down. If Transmission Gully is not built, the highway capacity will not increase but the volume capacity ratio will increase. This results in the reduction of speed and increased travel time. When the travel time is more, the attractiveness of driving will be less, which in turn reduces the cars per person and the total number of cars in the region. This will result in the lesser traffic volume and reduced CO_2 emissions.

Polluting CO_2 loop is again a balancing loop and it affect the system in a similar fashion as the fuelling environmental pollution loop**.** This loop explains how the opposing position of environmental stakeholders towards construction of new roads like Transmission Gully enables them to control the amount of CO_2 emission.

Loop 8. Travelling Cars Consuming Fuel Loop (B_6).

The travelling cars consuming fuel loop is quite similar to the fuelling environmental pollution loop (B_4). The main difference is in the links from the variable, attractiveness to driving. The travelling cars consuming fuel loop takes a route from attractiveness of driving via fraction of cars travelling to traffic volume. The fuelling environmental pollution loop takes a route from attractiveness to driving via cars per person and number of cars in the region to reach traffic volume. The effect of both the loops are similar. It is a balancing loop and explains how this reaction of environmental stakeholders enables them to control the amount of fuel consumption.

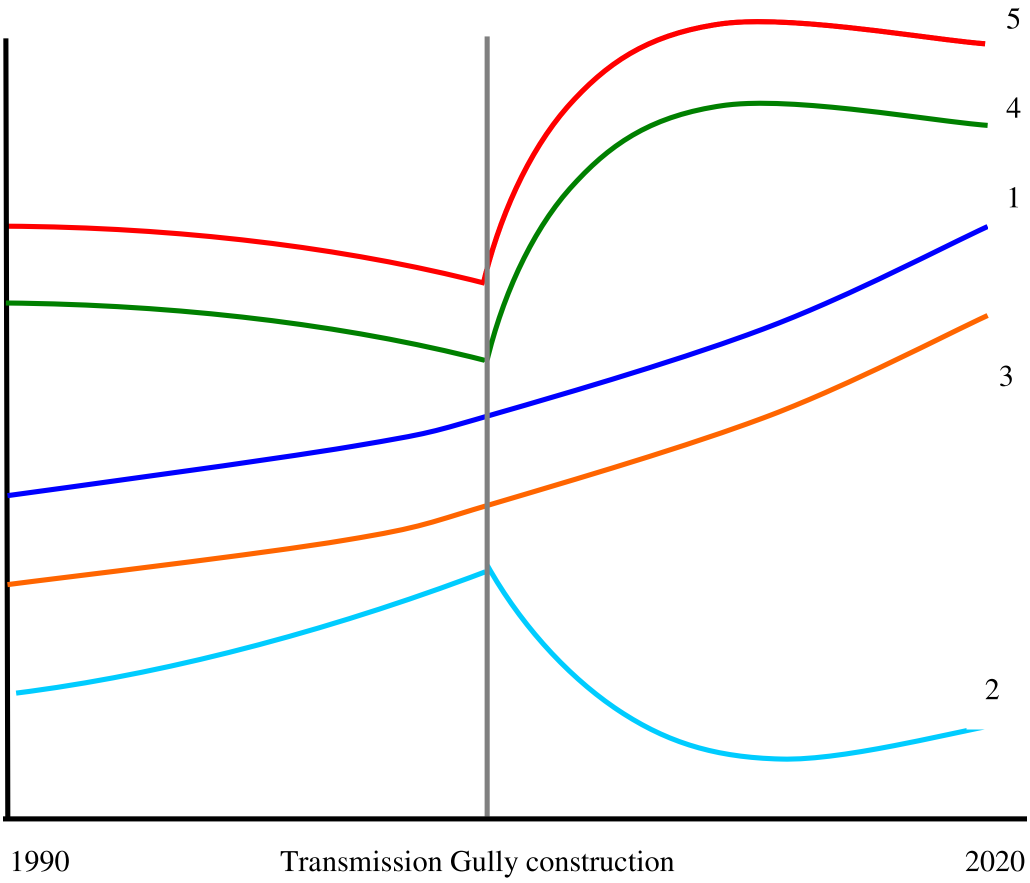
Loop 9. Travelling Cars Emitting CO_2 Loop (B_7)

The travelling cars emitting CO_2 loop is quite similar to the polluting CO_2 loop (B_5). Again, the main difference is in the connections from the variable, attractiveness to driving. The travelling cars emitting CO_2 loop takes a route from attractiveness of driving via fraction of cars travelling to traffic volume whereas the fuelling environmental pollution loop takes a route from attractiveness to driving via cars per person and number of cars in the region to reach traffic volume. The effect of both the loops are similar. It is a balancing loop and explains how the reaction of environmental stakeholders enables them to control the amount of fuel consumption.

Loop Behaviour Over Time

Based on the causal loop diagram, behaviour over time chart was developed to understand the behaviour of some of the main variables over time. In the y-axis the time horizon was divided into two parts. The first part explains the behaviour of variables before the Transmission Gully construction and the second part explains the behaviour of these variables if the Transmission Gully is built. This behaviour over time chart is presented in Figure 7, with an approximate future time of 2020.

Based on the casual loop analysis, the travel time will keep on increasing till the Transmission Gully motorway is constructed and ready to use. Travel time will come down once vehicles start using this additional road. But after some time, travel time will start increasing due to an increasing number of cars on the road. Traffic volume will keep on increasing before and after the construction of the Transmission Gully motorway. The amount of CO_2 emission will behave in a similar way as the traffic volume. Speed will keep on decreasing till the Transmission Gully motorway is ready to use. Then it will increase for some time, but at some later point of time, it will start decreasing. The attractiveness of driving will also behave in a similar fashion like the speed, first it will decrease, then it will increase and after some time, it will start decreasing, due to an increasing travel time.



1=Traffic volume, 2= Travel time, 3=CO_2 emissions, 4= Speed, 5 = Attractiveness of driving

Figure 7. Behaviour Over Time Chart with Transmission Gully Constructed

Conclusion
System thinking and modelling tools are often used to develop an explicit shared model of a complex system amongst a group (Maani and Cavana, 2000). This paper gave an illustration on how group model building was used in developing a shared mental model of stakeholders in the proposed Transmission Gully transport infrastructure project in Wellington, New Zealand. This group model building exercise showed that the hexagon process could be effectively used to generate an initial version of a causal loop diagram. This initial version was further refined to generate a modified casual loop diagram and was analysed in terms of the feedback loops formed.

Based on the feedback loops, behaviour over time charts were developed. The behaviour over time charts gave the indication that, presently variables like traffic volume, travel time and CO_2 emissions are increasing, while other variables like speed and attractiveness to driving are decreasing. It also showed that, it the Transmission Gully becomes a reality, travel time will initially decrease but after some time, it will slowly start increasing. Also, traffic volume and CO_2 emissions will keep on increasing even after Transmission Gully is built. Further, variables like attractiveness to driving and speed will increase initially, once the Transmission Gully was built, but after a certain period of time, they will slowly start decreasing.

In summary, group model building was found useful in this research, for revealing the various interests of stakeholders in this environmental conflict situation. It helped the stakeholders to generate a shared mental model using the hexagon process. Finally, the causal loop model that was developed, gave a solid basis to build a dynamic model of the system.

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