16. Technology, Innovation and Supply Chain Management

Competitive Session

System Dynamics Modelling for Stakeholder Management

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ABSTRACT: This article presents a system dynamics model for stakeholder management in complex projects. The model development is illustrated using a case related to a complex New Zealand transport infrastructure project. Experiments conducted using the model showed that although the proposed transport project is capable of reducing traffic congestion in the short term, it will not serve the purpose in the long term. Policy experiments conducted using the model revealed that policies aimed at reducing traffic congestion could also reduce the conflict between stakeholders; however, they showed some unintended consequences in the system which highlighted the complexity of the problem situation.

Keywords: System Dynamics, Project Management, Stakeholder Management

1. Introduction

There is an increasingly common argument in the environmental management literature that much of the environmental and resource management is the management of conflict (Mitchell, 2010). Such conflict can exist between different users and uses of a resource, between the users of a resource and those who would conserve it, and between decision-makers and those who want more of a say in those decisions (Jackson, 2001). Most of these stakeholder conflicts relate to disputes or conflicts pertaining to the environment, public lands, or natural resources.

Large scale development projects are examples of stakeholder conflicts where differing perspectives of multiple stakeholders present a challenge to the managers. These projects usually occur over relatively long time horizons and when they are in the public domain, the stakeholders of the project feel 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). In such projects it is important to identify and analyse the positions and interests of stakeholders involved in it. Managing this situation demands the application of specialist knowledge, skills, tools and techniques for stakeholder analysis.

In his classic book Strategic Management: A Stakeholder Approach, Freeman (1984) defines stakeholders as any group or individual who can affect or is affected by the achievement of the firm’s objectives. Twenty six years since Freeman’s work, stakeholder theory has been applied to issues ranging from organisational restructuring to wildlife management, from R&D management to watershed management and from business ethics to logistics management. Along with theoretical
developments and practical applications, some stakeholder analysis tools were also developed (e.g. Mitchell et al., 1997). However, a review of the stakeholder literature found that the criticism by Ramirez (1999) is still true today: “Stakeholder analysis tools tend to be straightforward: matrices or lists of criteria or attributes. Complex and ever changing, however, are the challenges of establishing commonly agreeable definitions of issues or problem situations, defining the boundaries, and identifying the relevant stakeholders” p. 104. Therefore the research objective is to develop a systems model aimed at addressing the criticism raised by Ramirez (1999) that stakeholder analysis tools lacks the ability to analyse the complex and dynamic nature of environmental conflicts.

2. Overview of Stakeholder Management Literature

The development of the stakeholder concept in the management literature can be classified into different stages. The origin of the term ‘stakeholder’ in management literature can be traced back to 1963, when the word appeared in an international memorandum at the Stanford Research Institute (cited in Freeman, 1984). Stakeholders were defined as those groups without whose support the organisation would cease to exist. After its origin, the concept diversified into four different fields namely, corporate planning (e.g. Taylor, 1971), systems theory (e.g. Ackoff, 1974), corporate social responsibility (e.g. Sethi, 1971) and organisation theory (e.g. Rhenman, 1968).

The next landmark in the development of stakeholder literature was the book by Freeman (1984), Strategic Management: A Stakeholder Approach. After this book, the literature developed around three different aspects namely, descriptive/empirical aspect, instrumental aspect and normative aspect. Donaldson and Preston (1995) brought these three aspects together in their stakeholder theory of corporation.

Further, the stakeholder literature started spreading its wings to interesting areas like dynamics of stakeholders (e.g. Mitchell et al., 1997) and stakeholder theories (e.g. Jones & Wicks, 1999). Several empirical studies (e.g. Elias, 2008) were also conducted to validate the theoretical claims relating to the stakeholder concepts. Today, the stakeholder literature is still evolving with several theoretical developments (e.g. Greenwood and Van Buren III, 2010) and empirical studies (e.g. Wolsink & Breukers, 2010).
2.1 Tools for Stakeholder Analysis

Experts have developed several tools for stakeholder analysis. Initially, some of the prominent stakeholder analysis tools came from the field of strategic management. For example, Freeman (1984) himself contributed a stakeholder analysis framework consisting of rational, process and transactional level analysis. Johnson *et al.* (2008) popularised a stakeholder mapping tool using a power – interest matrix that was developed by Mendelow (1991) for assessing the acceptability of strategic options. Mitchell *et al.* (1997) developed a strategic model to analyse the salience of stakeholders based on the attributes of power, legitimacy and urgency.

Further development of stakeholder analysis tools can be traced to a variety of literature streams. For example, in project management literature, a stakeholder analysis tool called ‘stakeholder circle’ (Bourne and Walker, 2005) was used to map and visualise, stakeholder power and influence. In systems thinking literature, a stakeholder analysis tool called ‘rapid stakeholder and conflict assessment’ based on cognitive mapping was used (Hjortso *et al.*, 2005). This literature also provides examples for stakeholder analysis that used soft systems methodology, a methodology developed by Peter Checkland for system redesign (Checkland, 1981) and viable systems model, a generic model of a viable organisation based on cybernetic principles developed by Stafford Beer (Simmons *et al.*, 2005). Some stakeholder analysis tools are also available in other literature streams like business ethics (e.g. Vandekerckhove and Dentchev, 2005).

In addition to these basic methods, authors in this literature have also used more advanced tools for analysing stakeholders. Wolsink and Breukers (2010) used the Q methodology, which applies inverted factor analysis to reveal rationales, narratives or perspectives so as to systematically compare the patterns in stakeholder views. Memon and Wilson (2007) used the concept of ‘governance’ and the related notion of multi-layered forest management decision making as an overarching framework for analysis of conflict between different stakeholder groups with contrasting perceptions about ‘appropriate’ use of indigenous forests. Finn *et al.* (2009) used multi-criteria analysis techniques to weight the relative importance of different environmental objectives and to compare the degree to which environmental effectiveness was achieved. Holz *et al.* (2006) grouped the ‘multi-criteria decision management’ tool into three approaches namely weighting criteria,
aspirational methods and holistic evaluation. They introduced a new aspirational tool referred to as Target Ordering, which explores preferences through criteria targets rather than applying a weight to the criteria themselves. Lange and Hehl-Lange (2005) introduced a virtual landscape model during a participatory planning workshop involving different stakeholders. During this workshop different alternatives were discussed, and changes suggested by the stakeholders were incorporated in this 3D model, resulting in better visualization and communication among different stakeholder groups.

Most of the stakeholder analysis tools available in the management literature tend to be simplistic and straightforward. This issue was highlighted by Ramirez (1999) who felt the need for stakeholder analysis tools which are capable of analysing complex and dynamic problem situations related to stakeholder conflicts. This research project tries to address this gap by developing a systems model for analysing a complex and dynamic problem situation related to a transport infrastructure project in New Zealand.

3. Methodological Framework

The methodological framework used in this study is based on the system dynamics methodology. System dynamics was developed in the second half of the 1950s by Jay Forrester and his seminal book, *Industrial Dynamics*, continues to be a significant statement of philosophy in this field.

System dynamics is a methodology for studying and managing complex systems involving multiple relationships, interdependencies and feedback, such as one finds in business and other social systems, through the development of representational models that can be used to reflect aspects of reality. Then, just as an airline uses flight simulators to help pilots learn to fly in different environmental conditions, system dynamics methodology can be directed to developing management flight simulators, often computer simulation models, to help learn about dynamic complexity, in general, and to understand the sources of policy resistance, and design more effective policies in particular. System dynamics has been applied to issues ranging from corporate strategy to the dynamics of diabetes, from the cold war arms race between USSR and US, to the “combat” between HIV and the human immune system (Sterman, 2000).

In this study, prior to the development of the system dynamics model two preliminary phases were completed. In the first phase the problem was structured using an 8 step stakeholder analysis
(first step of stakeholder map is presented in figure 1) and the development of a behaviour over time graph (figure 2). In the second phase, a causal loop model (figure 3) was developed using a group model building process (Vennix, 1996) involving key stakeholders. This article gives more emphasis to the two phases that followed. These phases include the development of a system dynamics model and the experiments conducted using the model (Table 1). [Insert Table 1–Methodological Framework here]

4. The Case Wellington’s Basin Bridge Project

Wellington’s Basin Reserve currently functions as a large roundabout with signals. The streets in this area have several functions, and congestion is affecting State Highway 1 traffic, local traffic, freight, pedestrians, cyclists and bus travel. The regional transport planners feel that if something is not done now, things can get worse. Greater Wellington Regional Council, Wellington City Council and the New Zealand transport agency (NZTA) have agreed that north-south traffic needs to be separated from east-west traffic in this area, and following extensive investigations and community engagement, the NZTA has made the decision to proceed with Basin bridge option: Option A. But this project is quite complex since it affects different stakeholders in different ways and it presents an interesting example of stakeholder conflict.

5. System Dynamics Modelling

In this phase, a dynamic model was developed using the *ithink* software (Richmond and Peterson, 1997). This model was based on the casual loop model presented in figure 3. It included the steps:

5.1 Defining Variable Types and Constructing a Stock-flow Diagram

The stock flow diagram developed in this research is presented in figure 5. The two stock variables in the traffic sector were attractiveness of driving and Basin Bridge construction. Attractiveness of driving represented the level of attractiveness of driving a car from Wellington to Kapiti coast with and without the Basin Bridge. Basin Bridge construction was a dummy variable to model the fact that once the Basin Bridge was constructed, it would remain there, even if the position of political stakeholders or any other factors that contributed to its construction changed. In essence, the traffic sector provided the values of some important traffic variables like travel time and traffic volume between Wellington and Kapiti coast.
In the interests of the community stakeholder sector all the variables were modelled as auxiliary variables. Variables like traffic volume and travel time in the traffic sector were connected to auxiliary variables like number of accidents per annum, annual accidents costs and annual travel costs in this sector. In essence, this sector generated community costs as a summation of annual accidents costs and annual travel time costs.

The interests of environmental stakeholder sector also used auxiliary variables only. Based on the variables generated by the traffic sector like speed, travel time and traffic volume, this sector modelled carbon dioxide emissions and fuel consumption. These variables were then converted into dollar values to model annual fuel costs and annual carbon dioxide costs. Finally, the summation of annual fuel costs and annual carbon dioxide costs was taken as environmental costs.

The stakeholder positions sector modelled the changing positions of environmental, community and political stakeholders of the Basin Bridge project. The positions of community and environmental stakeholders were modelled as graphical functions and were affected by changes in community costs and environmental costs respectively. The positions of environmental and community stakeholders affected the position of political stakeholders and the position of political stakeholders decided whether the Basin Bridge would go ahead or not, thus completing the overall major feedback loop.

During the group model building session (section 5.2) the stakeholders generated 35 variables belonging to 18 clusters. In the system dynamics model, however, some of these variables could not be included due to lack of data. Also, the model boundary was drawn to include only those variables capable of capturing the causal structure of the system. This causal structure was able to explain the problem situation as shown in the Reference Mode (figure 2).

5.2 Developing a Simulation Model

In this step, all the variables in the stock flow diagram were provided with an equation. Based on the system dynamics approach, stock variables were modelled as accumulations (e.g. Attractiveness of driving = Attractiveness of driving (t - dt) + (-Change in attractiveness of driving)* dt), and rate variables as changes to the stocks that occur during a time period (e.g. Change in attractiveness of
driving = (Travel time-desired travel time) * EXP (-0.2 * travel time)). In addition to this, the model consists of auxiliary variables (e.g. Volume–capacity ratio=Traffic volume/actual highway capacity), including graphical relationships.

The dimensional consistencies of these equations were checked so that it was possible to convert the dimensions of the variables on the right-hand side of the equation to those on the left-hand side. Also, all the equations in the model were documented.

**5.3 Reproducing Reference Mode Behaviour**

This step involved putting in provisional values for the parameters at first, to try and reproduce the general pattern of the reference mode (behaviour over time of the main variables). When the reference mode is reproduced, it is generally called the base case version (Figure 6) of the model (Maani and Cavana, 2007). In this base case traffic volume, travel time and CO₂ emissions are increasing, while speed and attractiveness of driving are decreasing. This is similar to the behaviour of the variables presented in the reference mode (figure 2). [Insert Figure 6 - Graphical Output of the Base Case about here]

**5.4 Validating the Model**

According to Forrester and Senge (1980), it is very important to build confidence among the users of a model regarding its soundness and usefulness. Keeping this in mind, the base case version of the model was subjected to a range of validation tests suggested by Coyle (1996).

**5.5 Performing Sensitivity Tests**

The system dynamics model developed in this research was subjected to sensitivity analysis. The goal of sensitivity analysis was to learn if the basic pattern of results is sensitive to changes in the uncertain parameters (Ford, 1999). The sensitivity analysis in this research involved varying most of the model parameters and graphical relationships by plus or minus 10%. The results of this sensitivity analysis identified the most sensitive parameters/graphical relationships in the model.

Overall, the model developed is a simulation model which is dynamic in nature. This model is capable of capturing the dynamic interactions between different parts of this environmental conflict. For example, any change in variables in the traffic sector is linked to the stakeholder interests sector, which is further connected to stakeholder positions sector, which is in turn connected back to the traffic sector. The model is also able to recreate the dynamic nature of the problem situation, as
captured in the reference mode presented in figure 2. In addition, this model also captures the complexity of the problem situation by incorporating several variables that affect the problem situation, and by modelling the complex interrelationships and interdependencies between the different parts of this environmental conflict.

6. Model Experimentation

In the last phase of this research project, experiments were conducted on the model using a management flight simulator (Figure 6). The purpose of a management flight simulator is to provide a user-friendly interface with computer model (Maani and Cavana, 2007).

These experiments were conducted in two stages. In the first stage, the modeller conducted experiments on the model. During this stage, three types of experiments were conducted, namely testing the effect of the Basin Bridge bridge on the existing system, conducting policy experiments on the model, and modelling some scenarios using the model. In the second stage, the model was taken to the stakeholders for conducting the same experiments in their presence.

6.1 Effects of the Basin Bridge

The first experiment conducted on the model was to run the model with the Basin Bridge bridge to understand the behaviour if this bridge became a reality. The graphical results of this experiment are in figure 7. These results highlight some interesting projected patterns of behaviour, once the Basin Bridge bridge was available for the motorists (year 5 in this case, allowing delays for its construction).

It showed that some of the congestion related variables (e.g. traffic volume) kept on increasing, even with the introduction of this new bridge. Some variables like travel time decreased significantly once the Basin Bridge was operational, but in the long term it was showing an increasing trend. Some other variables like speed increased significantly once the Basin Bridge was available, but in the long term it showed a decreasing trend. This experiment revealed that once the Basin Bridge bridge was a reality it would ease traffic congestion significantly for a short while. However, in the long term the traffic congestion would slowly return.
6.2 Effects of Car Pooling

The first policy experiment consisted of testing the effects of car-pooling, since the Wellington Regional Council was trying to promote car-pooling. In this experiment, car occupancy was increased from 1 to 5. Results of these experiments for model runs with and without the Basin Bridge bridge were analysed in this study. Table 2 presents the results of these experiments without the bridge.

[Insert Table 2 - Effects of Car Pooling without Basin Bridge about here]

The results of the simulation runs without the Basin Bridge bridge showed a reduction in traffic variables like volume capacity ratio (from 0.94 to 0.20) and travel time (from 28.4 to 15.7 minutes). It also showed a decrease in the variables capturing stakeholder interests like carbon dioxide emissions, fuel consumption and accidents per annum. From a ‘very supportive’ position, the position of community stakeholders was becoming more neutral, since the impacts of congestion on community were reducing. The environmental stakeholders also moved towards a neutral position from a very opposed position.

Attractiveness of Driving

Although this experiment showed some positive effects on reducing congestion, it also highlighted an interesting counter-intuitive behaviour emerging for the attractiveness of driving variable. When the car occupancy factor was increased to a particular level (e.g. 3 in the model run without the Basin Bridge bridge), so that congestion decreased significantly, the attractiveness of driving started to increase. This behaviour, in turn, could increase congestion. This situation could be explained by summing up the intentions of a group of powerful people in a Canadian city as shared by an environmental expert: “Let us improve car-pooling and public transport of this city, so that people will be attracted to these alternative transport means, and stop using their cars; so that we can drive our cars comfortably” (L. Jackson, personal communication).

Thus, these results showed that, generally, car-pooling was quite effective in decreasing traffic congestion, decreasing environmental and community stress due to traffic and in decreasing the conflict between stakeholders. Other system dynamic researchers have also reported the usefulness of car-pooling (e.g. Stave, 2002). So, in general these results supported the efforts of Wellington Regional Council in promoting car-pooling.
This policy experiment also raises the issue of increasing attractiveness of driving when car-pooling is overdone. For the policy makers of the Wellington Regional Council, this presents a challenge for maintaining a delicate balance between popularising car-pooling and controlling congestion.

6.3 Effects of Public Transport Improvements

As the second set of policy experiments, the effects of public transport improvements in the Wellington region were studied. Experiments were conducted by increasing the public transport improvements from 1 to 5. To elaborate, a value of 2 for public transport improvement meant the Wellington Regional Council increasing its public transport improvement efforts, including funding, by two times; 3 means three times and so on.

The results of these experiments were similar to the results of the previous policy experiment on car-pooling. They yield positive results, in terms of reducing congestion, decreasing accidents, decreasing environmental stress and in moving the positions of community and environmental stakeholders to a more neutral stand. However, as in the earlier policy experiment, the counter-intuitive behaviour of increasing attractiveness of driving with increasing public transport improvements was also visible clearly.

6.4 Scenario Analysis

The third type of experiments conducted in this phase involved a scenario analysis. This was conducted using the following steps given in Schoemaker (1993): (i) Planning general scope of scenarios; (ii) Identifying key drivers of change and keynote uncertainties; (iii) Constructing forced scenarios; (iv) Checking for internal consistency, plausibility and credibility (v) Constructing learning scenarios; and (vi) Simulating scenarios with the model.

The three learning scenarios constructed in this study were called: (a) Do Nothing; (b) Cleaner Greener Aotearoa; and (c) Kapiti—Exploding with People and Cars. The results (Table 3) showed that ‘Cleaner Greener Aotearoa’ scenario paints a glossy picture of many aspects related to this environmental conflict. However, attractiveness of driving was an exception and its increase was a concern. Nevertheless, if attractiveness of driving is controlled within reasonable limits, such a
scenario could go a long way in resolving the issues related to the conflicts between the stakeholders of the Basin Bridge project. [Insert Table 3 - Scenario Analysis with Basin Bridge about here]

The ‘Kapiti - Exploding with People and Cars’ scenario painted a grim picture of the environmental conflict relating to the Basin Bridge project. This scenario showed some chaotic behaviour in terms of congestion, interests of environmental and community stakeholders, and their positions in this environmental conflict. Overall, such a systematic process of construction and analysis of scenarios helped in learning more about the behaviour of the system under three different sets of conditions.

6.5 Experiments in the Presence of Stakeholders

In the last phase of this study, experiments were conducted in the presence of fifteen key stakeholders who were involved in this study. These fifteen stakeholders included three transport planners, a policy manager, four environmental stakeholder, three political stakeholders and four community stakeholder. In these sessions, the following issues were discussed: (a) Usefulness of the model; (b) Soundness of the model; (c) Its ability to capture complexities; (d) Effect of such an exercise on positions and interests of stakeholders; and (e) How that stakeholder would use the model

All of the fifteen stakeholders found this exercise generally useful. One community stakeholder was an exception, who felt that this exercise muddies the waters, since it re-emphasises the complexity of the issues. Regarding the soundness of the model, the stakeholders were generally comfortable, although each of them suggested some problems or improvements in the model. Regarding the ability of this exercise in capturing the complexity of the system, all the fifteen stakeholders agreed that the model was able to capture the complexities of the system.

On the question of whether an exercise like this study could change the positions and interests of stakeholders who were involved in this exercise, the fifteen stakeholders, in general, felt that such a change is possible. For example, the transport planner felt that environmental stakeholders might change their positions, but not immediately. An environmental stakeholder felt that the results of this exercise would strengthen the present position of environmental stakeholders. The policy manager opined that political stakeholders tend to have simplistic views and this exercise could help in expanding their understanding and thus changing their positions. A political stakeholder observed that
the politicians would change and so does their positions. The community stakeholders’ opinion was different and one of them said that political stakeholders might become more confused and would hide behind these findings. Based on the explanations of planning theorists (e.g. Healy, 2003) such changes can be attributed to the interactive processes used in this study that facilitated stakeholder discussions and deliberations, providing a dialogical space for various perspectives and issues.

All the fifteen stakeholders agreed that learning would affect positions; and most of them said that this change might not happen immediately. They also said that they would use the model for different purposes (e.g. as a discussion tool, for making submissions, for arguing with politicians). Thus the experiments with the stakeholders resulted in some valuable feedback about the model. This process also helped in improving the validity of the model. Overall, the model experimentation phase illustrated the use of this systems model in analysing dynamic, temporal behaviour of the variables related to this environmental conflict. The results of these experiments also highlighted the complex, counterintuitive behaviour of the system.

7. Conclusions

The System Dynamics model model captured some complex interconnections between the different variables related to stakeholder conflict. It also captured the structure of the system in terms of the feedback loops operating in the system. These feedback loops, as illustrated in the causal loop model (Figure 3) and stock flow diagram (Figure 5) can be used to explain the complex behaviour of the system variables over time.

Based on hard systems approach (Maani and Cavana, 2007) models are simplified representations of reality but not reality itself. System dynamics models are essentially simulation models which represents simplified versions of complex real world problems. The model developed in this study is also a dynamic model that imitates the interests and positions of stakeholders in conflict. Moreover, this model also captured the dynamic interactions between the different sectors of the system. For example, any change in variables like travel time and traffic volume in the traffic sector affected variables like carbon dioxide emissions and accidents per annum in the stakeholder interests sector. These variables further affected variables in the stakeholder positions sector like the
positions of environmental stakeholders. These changing positions influenced whether the project would go ahead, which affected the traffic sector, thus completing the overall feedback main loop.

The system dynamics model developed in this study was used to conduct experiments about the project. The results of the experiments showed that the transport project would ease traffic congestion in the short term. But, in the long term it was not found to be an effective solution since the variables related to traffic congestion showed an increasing trend. Policy experiments and scenario analysis were also conducted using the model. These experiments showed that policies aimed at reducing traffic congestion can also reduce the conflict between stakeholders. But, it also highlighted a counterintuitive behaviour (Sterman, 2000) of a variable named attractiveness of driving. While some policies and scenarios helped in decreasing variables related to traffic congestion, it also increased attractiveness of driving, which in turn encouraged more cars and more traffic, and this resulted in more traffic congestion. Such results revealed that complex problems cannot be solved with simple solutions; instead they need to be approached holistically and some of these variables have to be managed delicately.

References


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<tr>
<th>Phases</th>
<th>Steps</th>
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<tbody>
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<td>Problem Structuring</td>
<td>(i) Developing a stakeholder map</td>
</tr>
<tr>
<td></td>
<td>(ii) Preparing a chart of specific stakeholders</td>
</tr>
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<td></td>
<td>(iii) Identifying the stakes of stakeholders</td>
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<td>(iv) Preparing a power versus stake grid</td>
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<td>(v) Conducting a process level stakeholder analysis</td>
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<td>(viii) Analysing the dynamics of stakeholders</td>
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<td>(ix) Developing a BOT graph</td>
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<td>(ii) Forming clusters</td>
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<td>(iii) Identifying variables</td>
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<td>(iv) Developing a causal loop model</td>
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<td></td>
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<td></td>
<td>(v) Reproducing Reference Mode Behaviour</td>
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<td></td>
<td>(vi) Validating the model</td>
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<td></td>
<td>(vii) Performing Sensitivity Tests</td>
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<tr>
<td>Model Experimentation</td>
<td>(i) Testing the effects on the existing system</td>
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<td></td>
<td>(ii) Conducting policy experiments on the model</td>
</tr>
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<td></td>
<td>(iii) Modelling scenarios using the model</td>
</tr>
<tr>
<td></td>
<td>(iv) Conducting experiments using the model in the presence of stakeholders</td>
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</table>

Table 1. Methodological Framework
Note: Position of community, environmental and political stakeholders is a number indicating the position of those stakeholders towards the Basin Reserve project. This is modelled as a 7-point itemised rating scale. 1 = extremely opposed; 2 = very opposed; 3 = opposed; 4 = neutral; 5 = supportive; 6 = very supportive; 7 = extremely supportive.

Table 2. Effects of Car Pooling – without Basin Bridge

<table>
<thead>
<tr>
<th>Car Occupancy</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>Volume capacity ratio</td>
<td>0.94</td>
<td>0.47</td>
<td>0.32</td>
<td>0.25</td>
<td>0.20</td>
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<tr>
<td>Travel time (min)</td>
<td>28.4</td>
<td>18.5</td>
<td>16.9</td>
<td>16.2</td>
<td>15.7</td>
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<td>Attractiveness of driving</td>
<td>1.99</td>
<td>1.92</td>
<td>2.63</td>
<td>3.13</td>
<td>3.49</td>
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<tr>
<td>Accidents per annum</td>
<td>14.7</td>
<td>7.4</td>
<td>5.1</td>
<td>3.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Total CO2 emission (tones)</td>
<td>21.3</td>
<td>12.9</td>
<td>9.4</td>
<td>7.5</td>
<td>6.2</td>
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<tr>
<td>Total fuel consumption (litres)</td>
<td>8,539</td>
<td>5,164</td>
<td>3,747</td>
<td>2,983</td>
<td>2,482</td>
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<td>Community costs (NZ$m)</td>
<td>3.34</td>
<td>1.67</td>
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<td>1.01</td>
<td>7.35</td>
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<td>Position of com. stakeholders</td>
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<td>5.3</td>
<td>4.8</td>
<td>4.5</td>
<td>4.3</td>
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<td>Position of env. stakeholders</td>
<td>2.2</td>
<td>3.1</td>
<td>3.5</td>
<td>3.8</td>
<td>4.0</td>
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<tr>
<td>Position of pol. stakeholders</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.1</td>
<td>4.1</td>
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### Table 3. Scenario Analysis – with Basin Bridge

<table>
<thead>
<tr>
<th>Variables</th>
<th>Do Nothing</th>
<th>Cleaner Greener Aotearoa</th>
<th>Kapiti - Exploding with People and Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume capacity ratio</td>
<td>0.47</td>
<td>0.10</td>
<td>0.74</td>
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<tr>
<td>Travel time (min)</td>
<td>18.5</td>
<td>15.0</td>
<td>22.9</td>
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<tr>
<td>Attractiveness of driving</td>
<td>1.92</td>
<td>4.07</td>
<td>1.90</td>
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<tr>
<td>Accidents per annum</td>
<td>14.7</td>
<td>3.3</td>
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</tr>
<tr>
<td>Total CO2 emission (tones)</td>
<td>38.3</td>
<td>9.6</td>
<td>55.3</td>
</tr>
<tr>
<td>Total Fuel consmpn.(litres)</td>
<td>15,332</td>
<td>3,853</td>
<td>22,105</td>
</tr>
<tr>
<td>Community costs (NZ$m)</td>
<td>3.34</td>
<td>7.49</td>
<td>5.29</td>
</tr>
<tr>
<td>Environmental costs (NZ$m)</td>
<td>30.1</td>
<td>9.14</td>
<td>4.34</td>
</tr>
<tr>
<td>TG Construction</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Position of Comm. Stkldrs.</td>
<td>6.3</td>
<td>4.3</td>
<td>6.9</td>
</tr>
<tr>
<td>Position of Env. Stkldrs.</td>
<td>1.5</td>
<td>3.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Position of Pol. Stkldrs.</td>
<td>3.9</td>
<td>3.8</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Note: Position of community, environmental and political stakeholders is a number indicating the position of those stakeholders towards the Basin Reserve project. This is modelled as a 7-point itemised rating scale. 1 = extremely opposed; 2 = very opposed; 3 = opposed; 4 = neutral; 5 = supportive; 6 = very supportive; 7 = extremely supportive.
Figure 1. Stakeholder Map of the Basin Bridge Project

- Environmental
- Governments
- Political
- Internal
- Customer
- Financial
- Media
- Special Interest Groups
- Citizen Action
- Community

2000        2025
1=Traffic volume, 2= Travel time, 3=CO₂ emissions, 4= Speed, 5 = Attractiveness of driving

Figure 2. Reference Mode
Figure 3. Casual Loop Diagram
Figure 4. Stock-flow Diagram
Figure 5. Graphical Output of the Base Case

Figure 6. The Basin Bridge Management Flight Simulator
Figure 7. Model Run With Basin Bridge Option