Understanding Whole-of-System Sustainability in the Motueka Catchment

Participatory Modelling with an Influence Matrix

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Executive Summary

This report documents the results of a participatory modelling trial with a group of researchers and community members in the Motueka Catchment. This Motueka Community Reference Group (CRG) – a stakeholder group in the Motueka Integrated Catchment Management (ICM) research programme – trialled both the development of an Influence Matrix (iMatrix) methodology and a participatory process to build and interpret the matrix. This model building process provides a structure to aid the dialogue process. Using some elementary mathematics, it helps to organise and evaluate quite complex ideas and information generated by participants using some elementary mathematics. The generalised steps involved in building an iMatrix are: (i) goal and factor identification, (ii) factor aggregation, (iii) scoring of factors within the iMatrix, (iv) identification of priority factors, and (v) interpretation of model results.

We have applied the influence matrix approach to the problem of identifying pathways to an emerging vision of the future at catchment scale, i.e. whole-of-system sustainability. The iMatrix approach, however, could also be successfully used across local, regional and national scales and issues, and adapted for use with any combination of economic, social, and ecological factors based on either qualitative or quantitative scoring methodologies.

In this trial, the CRG generated a list of 171 factors that they consider most likely to affect the delivery of their future vision for sustainability of their catchment. Each member then applied an influence matrix (iMatrix) methodology to score the effect that each of an aggregated list of 28 factors has on the other factors. The researchers then used the iMatrix results to identify and rank the factors most likely to affect their vision for future sustainability of the environment and people of the Motueka catchment. This process is the first step in developing an integrated simulation model for sustainability in the catchment.

This report documents (a) the methodology and logic of the matrix calculations to identify and prioritise four fundamental classes of influence factors: critical, active, buffer and passive factors (b) the participatory model, strengths, weaknesses and repeatability and (c) comments on how the results could be applied in a practical planning context, for example by territorial or regional councils.

Developing the influence matrix in a participatory process showed how an extensive list of ecological, economic, social, institutional, and non-local factors is perceived by participants to interact. The CRG's influence model for the Motueka catchment showed that the achievement of long-term goals identified by the CRG members was dependent on these factors:

- *Critical* (operational process) factors: ecosystem services, human demographics (population change), policy / regulatory interventions / governance and the extractive and conversion activities of primary industries.
- The *active* factors driving change and development in this catchment are perceived by the CRG to relate to policy / regulatory interventions and commodity markets.
- Important *passive* factors (indicator variables) in this catchment are perceived to be secondary effects (especially introduced species), social inequality, changes in markets,

social interventions, population change (especially related to tourism) and the maintenance of some ecosystem services.

- Highest ranked *buffer* factors, which have the capacity to absorb change, were pest management, income tax and GST, landscape change processes and natural assimilation and purification.

This report will be of interest to policy makers as it not only illustrates how this method could be applied, but provides a fully worked example that gives a community, whole-of-system perspective on where to concentrate management effort in order to achieve catchment-level economic, social and ecological sustainability outcomes.

1. Introduction

Over the last two decades there has been a growing awareness of the need for stakeholders and scientists to work more closely together so that decision-making that has been traditionally based on benefit-cost analysis can be weighted more heavily with social, cultural, institutional and ecological values. These participatory methods can then be used in operational contexts where scientists, policy makers and stakeholders work together (Bingham, G. et al., 1995; Costanza, R., Funtowicz, S. O., & Ravetz, J. R., 1992). Mediated modelling and variations on this theme that come under the more general heading of system dynamic modelling are being increasingly used in planning and policy contexts of this kind (van den Belt, M., 2004).

An influence matrix is commonly used in complex problem solving contexts. The influence matrix describes and scores the relationships among factors affecting the system in question (Vestor, F. 1976). It helps researchers to better understand the functional role and system-wide importance of those factors that strongly influence system behaviour. It provides a framework for reducing a complex problem to its component parts.

A similar approach, although usually less structured is used in mediated system dynamic modelling. Typically, for a given issue, a group of stakeholders choose a set of factors that they believe affect system behaviour and these are used to build an initial system dynamic model. However, sensitivity testing of the model will reveal that some factors have very little influence on the behaviour of the system and these are then removed from the model (Costanza, R. & Ruth, M., 1998). This reduction process helps to remove unnecessary complexity from the model so that it is possible to focus attention on collecting data for those critical variables that have the greatest influence on the system and are also usually strongly influenced by it.

As with mediated and more general system dynamic modelling approaches, the influence matrix provides a method for reducing a complex problem by using numerical methods to focus attention on the functional role of different system factors or variables. It can also be used to classify whole-of-system factors based on their functional role in a system (Figure 1). This system of classification is based on differences in the way each factor influences other factors and is influenced by other factors (Figure 1). In conceptual terms, *critical factors* are the key operational process factors leading change in the system; *active factors* drive change independent of other factors; *passive factors* are indicator variables and *buffer factors* have a capacity to absorb change.

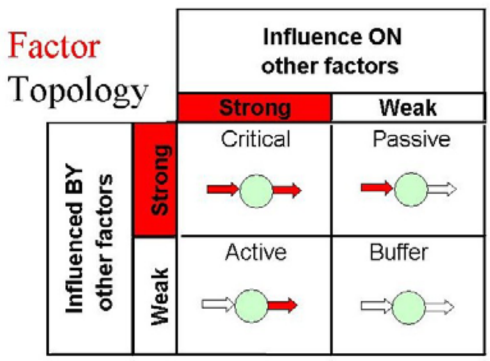

Figure 1 Different types of system variables or factors (Vester, F. 1976)

In this report we record the results of an influence matrix (iMatrix) model-building project based on a case study in the Motueka Catchment of New Zealand in conjunction with the Integrated Catchment Management (ICM) research programme. The influence matrix methodology has been used to engage members of a science-led community reference group (CRG) in participatory model building. The aim of this co-working has been to actively involve scientists and community members in thinking about the future of the Motueka catchment based on collective goals, envisioning, sharing understanding and model building. The model building provides a structure to aid the dialogue process by helping to organise and evaluate lots of ideas and information generated by the group using elementary mathematics.

Our use of the influence matrix in the area of ecosystem services research follows earlier application of this method in the study of urban ecosystems. The influence matrix was first developed in Germany in 1975 as part of a UNESCO-funded research programme[1] by a group of scientists under the leadership of Frederic Vestor. The pilot study was published in 1976 in Urban Systems in Crisis: understanding and planning human living spaces - the biocybernetic approach. In Vestor's approach to modelling complex systems, the iMatrix is but one of nine steps involved in building a sensitivity model (Vestor, F., 1976; Vestor, F., 1988; Vestor, F. & Guntrum, U., 1993; Vestor, F., 2002).

The ICM research programme comprises an interdisciplinary initiative based around the Motueka River catchment near Nelson, New Zealand (see http://icm.landcareresearch.co.nz). As one mechanism for scientists in the programme to ground their research in the catchment, the research programme has formed a community reference group (CRG) composed, at the time of this study, of 7 members from the Motueka community, 1 Tasman District regional council staff member and 5 scientists (2 from Cawthron Institute[2] and 3 from Landcare Research). In connection with this modelling research, the CRG members kindly agreed to trial the iMatrix methodology and provide feedback on their experiences. It is important to keep this research context in mind when thinking about the results of this study. This research is only a first step in the development of this participatory modelling approach.

The authors comprise the programme leader, an ecological economist and modeller, and two participatory process researchers. The remainder of this report covers our participatory approach and a synthesis of the Community Reference Group (CRG) iMatrix model results.

[1] The UNESCO research programme was called "Man and the Environment".

[2] Cawthron Institute is a private research organisation specialising in the study of freshwater and marine ecosystems, and a partner in the ICM research programme.

2. Method

Our research method involves two strands – the participatory process and iMatrix modelling method. Firstly, we describe the participatory process and some of the refinements that were made in order to assist group members in goal setting, factor selection and iMatrix model building. Secondly, we outline the mathematical steps involved in the evaluation of the iMatrix. While we explain these two strands of this research trial separately, our aim was to blend them together so that the model building was an aid to the envisioning and dialogue process.

In practice this was quite a challenging goal to achieve because of (i) time constraints that limited our preferred method of building the influence matrix, and (ii) the conceptual challenges for participants involved in building a mathematical model for the first time. The following narrative represents our first effort (with some refinements) to develop a participatory modelling approach.

2.1 Participatory Process

The participatory task accepted by the CRG members was to think about what they would like their catchment community to be like in the future and how they might make progress from a management perspective towards such a collective vision. Having undertaken an envisioning exercise, the group then set themselves to identify those factors and issues that might influence progress towards their collective vision. The influence matrix was then used to help quantify the strength of interactions between different factors. The scoring of factors in the iMatrix was begun collectively by the group, however we soon realised that this was a very time intensive approach so we changed our strategy. In summary the participatory process followed the steps described in detail below.

(i) Envisioning the future

Members of the CRG were invited to contribute towards the development of a collective vision for the future of the Motueka catchment and its community. This vision statement is written below. The first sentence of this paragraph was supplied by those facilitating the workshop session. The remainder of the vision statement was developed and refined in a brainstorming session by recording ideas on a white board and then using this as a check list to formulate a collective vision statement. This vision statement was achieved in our first workshop and took about 30 minutes. We then moved onto the task of identifying factors that might influence progress toward this vision statement and its goals.

> Vision Statement - The residents of the Motueka Catchment want to manage their Catchment so as to ensure they continue to enjoy … *a safe place to play and live, its pristine character and beauty, its identity, economic and ecological balance, its economic viability for business development, its exceptional climate, biological, community and landscape diversity & coastal integrity.*

(ii) Factor selection and aggregation

Factors thought to be responsible for influencing progress toward the various goals of the vision statement were identified in a brainstorming session and recorded on a white board. While our aim in this session was to identify factors by collective brainstorming, the facilitators guided the discussion in an effort to identify a full range of ecological, economic and social factors. Further refinements were made to the brainstorming methodology over the two workshop sessions to improve the overall balance of ecological, economic and social factors chosen. Further details of these changes and the rationale behind them are given in the discussion section of this report.

(iii) Dialogue and individual-based scoring of the iMatrix

The influence matrix is completed by filling in numbers that represent a qualitative assessment of the strength of influence that exists between row and column factors. We measure the strength of this influence on a scale of 0 – 5 as shown in Table 1.

There appears to be no advantage in having more scoring options (e.g. a score strategy of say 1- 10). Most people find it easy to differentiate between low, medium and high as a scoring strategy. By comparison they find it much more difficult to discriminate valid scores between 0 and 10. A scoring strategy of 0 – 5 provides a score of zero for no influence. It also gives the low, medium and high scoring range and the option to move either side of the average (3 in this case). Experiments with different scoring strategies showed that a scoring strategy with more options gives the same overall ranking of factors, but changes the distance between them. There appears to be no advantage in having a more complicated scoring strategy, and a broader band of scores can take longer to apply.

There are different approaches that can be used to fill in the influence table scores. In this trial we experimented with both group dialogue based scoring methods and individual scoring methods. The details of these trials and an evaluation of their merits is contained in the discussion section of this report.

Table 1 *Scoring Strategy*

0	No influence
1	Has an influence but its only weak
2	The influence is stronger than 1 but less than
3	Has an average sized influence
4	The influence is stronger than 3 but less than
5	Has a strong influence

(iv) Evaluation of results

It is possible for the participating group members to be involved in the mathematical evaluation of the iMatrix. This is possible because the maths involved would be accessible to most people as it only involves addition of row and column scores to produce totals and the division of row totals by the column totals of the same factors. Once these two operations have been completed, the row and column scores are then sorted in a preferred numerical order. This level of mathematical simplicity is one of the strengths of the iMatrix as a modelling tool and can be automated using a spreadsheet like EXCEL. Being so accessible it means that the calculation of the results can be shared by all group members and this in turn builds ownership and confidence of the model and its outputs. Once again, being constrained by available time, the CRG iMatrix was mathematically evaluated by one of the facilitators and the results reported back to the CRG group members.

2.2 How the iMatrix Model Works

An influence matrix is a square matrix with identical factors in the same rank order in rows and columns. The matrix is constructed by using a scoring strategy to quantify the strength of influence of row factors on individual column factors. Once constructed, the spreadsheet calculations described above identify factors which are critical, passive, active or buffer as defined in the factor typology shown in and described above Figure 1. It is possible to rank the row and column factors using row (1) and column (2) sum scores as derived below. By contrast the factor typology is produced by mathematically combining the row and column sum scores to produce multiplier (5) and quotient scores (4).

Assume that we have an influence matrix (M_{ij}) of dimensions 15 rows by 15 columns. To evaluate this matrix we sum the rows (i) and columns (j) of the iMatrix to calculate the row (1) and column sums (2).

Row sum (RS) = $\sum_{i=1}^{i=15} M_{ij}$ (1)

Column sum (CS) = $\sum_{j=1}^{j=15} M_{ij}$ (2)

The factor typology is calculated using three lines of numerical information. First, we calculate the absolute numerical difference (AND) between the RS and CS scores for each factor:

Absolute Numerical Difference (AND) = $RS - CS$ (3)

For a particular factor, if AND is close to zero, the functional character of that factor tends towards being critical or buffer. By contrast, a higher AND score indicates the functional character of that factor tends towards being passive or active.

The quotient score is used to identify whether a particular factor is active or passive:

Quotient Score (QS) = AS / PS (4)

High quotient scores (i.e. where the row sum is much larger than the column sum for that factor) indicate active functional character, meaning a strong influence on other factors. A low quotient score indicates passive functional character in which the factor is strongly influenced by other factors compared with the strength of its influence on other factors. Factors with intermediate quotient scores will tend to be more critical or buffering in functional character.

The multiplier score is used to identify whether a factor is critical or buffer:

Multiplier Score (MS) = $AS \times PS$ (5)

High multiplier scores indicate critical functional character, meaning a strong influence on other factors and strongly influenced by other factors. Low multiplier scores indicate buffering functional character in which the factor is weakly influenced by other factors and has a weak influence on other factors. Factors with intermediate multiplier scores will tend to be more passive and active in functional character. In both cases, we use the AND score to decide borderline cases.

3. Insights from the Motueka CRG iMatrix Process

The influence matrix is a tool that can be used to capture a group or stakeholder perspective on a problem. Through a structured dialogue process, the iMatrix helps to identify and prioritise key elements of a problem. The challenge facing the members of the CRG in this modelling trial involves management of the Motueka catchment towards preferred future goals as stated in their collective vision statement.

3.1 The Motueka Community Reference Group Vision Statement

The Motueka community reference group vision statement quoted in section 2.1 contains multiple goals. Assuming that this statement is representative of broader community values, it provides an important foundation for thinking about management policy, as illustrated through its goals shown in Table 2.

An important comment on these results is that Table 2 represents a multiple-goal statement, far broader in scope than a set of simple economic goals. This implies that management of the catchment towards future goals will involve consideration of a broad range of economic, environmental and social factors. The development of an iMatrix has the potential to help us to see how individual factors and groups of factors contribute to this broad vision of the future.

Table 2 Community reference group (CRG) goals

Goals
A safe place to play and live
Pristine character and beauty
Maintaining identity
Economic balance
Ecological balance
Viability for business
Exceptional climate
Biological diversity
Community Diversity
Landscape Diversity
Coastal integrity

3.2 Selection and Aggregation of Factors

The members of the CRG identified 171 factors (Appendix 1) over two extended workshop sessions. The reason for this extension into two sessions was that the first attempt to identify factors resulted in a group of factors that was incomplete in terms of representing a balanced selection of economic, social and ecological factors. In order to help stimulate ideas for a broader selection of factors, in the second workshop we introduced some simple line drawn illustration of the parts of an economic system as a prompt for generating factors. This seemed to help increase the generation of ideas for factors by giving the group members some systematic reference points to work from. We found it difficult to come up with simple portrayals of an ecological and social system. However, this methodological adjustment is important from a process perspective because it highlighted that the selection of factors was not entirely independent of assistance from those facilitating the meeting.

These resulting 171 factors were then grouped into ecological, economic, social, institutional, policy and non-local classes (A). A square iMatrix of 171 factors would result in a matrix of 29,241 cells and this would take a very long time to score. To reduce the time required to score the iMatrix a group member aggregated the 171 factors into a smaller number of 28 grouped factors (Appendix 2). This aggregated group of factors was then presented to the CRG members and a number of small refinements were made. The factor aggregation process and validating by CRG members was necessary in order to ensure that all of the group members understood what was meant by each of the twenty eight terms chosen to represent groupings of the 171 factors. Even though this step was taken, most group members still struggled to remember which of the 171 factors were included in the 28 factors when they were scoring the matrix. To help ease this problem we produced an aggregation table like Appendix 1 that could be used like a dictionary as a reminder of which factors were grouped together to form the 28 aggregated factors.

3.3 Scoring the iMatrix

The iMatrix can be scored in a dialogue-based group context. While this approach is desirable it is also time consuming, even though we found that the time taken to agree on a score decreases rapidly with experience. Group dialogue, building collective scores and sharing of knowledge are the main advantages of this approach that can give important insights into local views, tensions and awareness. Differences over scores between members of the group were resolved through discussion so that the final iMatrix represents a consensus view. A citizens' jury or deliberative approach could also be adopted if time permitted and a high level of consensus over each of the influence scores was desirable. Given that it was only possible for our group to meet together on a monthly basis for 2 – 3 evening meetings, this time constraint required that we come up with a quicker, albeit less participatory, method of scoring the matrix.

The CRG scored several rows of the iMatrix collectively so that there was a group understanding of the scoring process. Then CRG members were asked to score the 28 x 28 matrix individually before to the next meeting. Individually scored iMatrices were then compiled into an averaged group table. Individual scoring allows a group of people to efficiently build a collective model without the time overhead involved in lengthy dialogue. The main advantage of this approach is that individual scores are used, unaffected by the need for debate and consensus. We note that with the group scoring approach, dialogue plays a critical role in value formation. In the individual scoring approach, any differences over scores are not discussed or scores modified and therefore the final iMatrix will tend to reflect individual rather than collective views. A combination of dialogue-based and individual scoring methods could also be used, for example to identify the sensitivity of the results to the scoring approach adopted, although we did not try this approach.

Table 3 shows the general layout and form of the CRG iMatrix that has been produced by averaging the results of iMatrices built by the individual CRG group members. Because of the small text in this table it is difficult to read the individual factor names. For this reason we have shaded the various sections of the row and column factors to show that they are the same and make the identification of different groups of factors easier. In both the rows (from top to bottom) and columns (from left to right) the groups of factors are: ecological, economic, social, governance, policy and non-local influences.

Table 3 The Community Reference Group iMatrix

	Climate & Atmosphere	Pest Management	Maintain Biodiversity	Maintain Integrity of Ecological Processes	Maintain Soil Health	Natural Assimilation & Purification	Landscape Change Processes	Water Quality & Supply	Scientific Research	Customary Use	Economic Drivers	Economic Inputs	Income Tax & GST	Labour Market	Primary Industries	Property Valuation	Secondary Industry	Tertiary Sector	Family & Community Wellbeing	Human Health	Participation in Economic Life	Population Dynamics	Public Life - Governance	Community Services	Tourism, Leisure, Recreation, Sport	Governance of Social Institutions	Policy, plans, rules, legislation	Non-Local Influences
Climate & Atmosphere	2	3	3	3	4	3	3	4	3	2	2	2	2	2	4	3	2	2	3	3	2	3	2	2	4	1	2	1
Pest Management	0	3	4	3	3	2	3	3	2	2	2	3	2	1	3	3	2	1	2	3	2	2	1	1	2	2	3	2
Maintain Biodiversity	2	2	2	4	3	2	3	3	3	3	2	2	2	2	3	3	2	2	2	2	2	2	2	1	3	2	3	2
Maintain Integrity of Ecological Processes	3	2	3	3	4	3	2	4	3	3	2	2	1	1	3	2	2	2	3	3	2	2	2	1	3	2	3	2
Maintain Soil Health	2	2	3	3	3	3	3	4	3	2	2	2	1	2	4	3	2	1	3	3	2	2	1	2	2	1	3	2
Natural Assimilation & Purification	4	2	3	3	4	2	2	3	2	2	1	1	1	1	2	2	2	1	2	3	1	1	1	1	2	1	3	2
Landscape Change Processes	2	2	2	2	3	2	2	2	2	2	2	2	1	1	2	3	2	2	1	1	2	2	1	2	2	1	3	2
Water Quality & Supply	3	1	3	4	3	3	2	3	3	3	3	3	2	3	4	4	4	2	3	3	2	2	2	2	3	2	3	2
Scientific Research	2	4	3	3	3	2	2	3	2	1	1	3	1	2	4	3	4	3	2	3	1	1	1	2	2	2	4	2
Customary Use	0	1	2	2	1	2	2	2	3	3	1	1	0	1	1	1	2	2	2	2	2	1	2	1	2	1	2	1
Economic Drivers	2	2	2	2	2	1	1	2	2	1	3	3	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2	3
Economic Inputs	2	2	2	2	3	1	3	3	2	2	3	2	3	3	4	4	4	3	3	2	3	3	3	3	3	2	2	2
Income Tax & GST	1	2	1	1	1	1	1	1	2	1	3	3	1	3	4	2	3	3	3	2	2	2	2	3	2	3	3	2
Labour Market	1	2	2	1	1	1	1	1	1	1	2	3	3	2	4	2	3	3	3	2	3	3	2	3	3	2	3	1
Primary Industries	3	4	4	3	4	3	3	4	4	2	2	4	3	3	2	4	4	3	4	2	3	3	3	3	3	2	3	2
Property Valuation	1	2	2	1	1	1	2	2	1	1	2	2	2	2	3	2	2	3	3	2	3	2	2	2	2	2	3	2
Secondary Industry	2	1	2	2	2	2	2	3	3	1	2	3	3	4	3	3	2	3	3	3	3	3	3	3	3	2	3	2
Tertiary Sector	1	1	1	1	1	0	1	2	2	1	1	2	2	3	3	2	3	2	3	4	2	3	2	3	3	2	2	2
Family & Community Wellbeing	1	2	2	2	2	2	2	3	2	1	2	3	2	3	3	2	3	2	2	4	3	3	2	3	3	2	3	2
Human Health	1	2	2	2	1	1	2	2	2	1	1	2	2	3	3	2	3	3	4	3	3	3	2	3	2	2	2	1
Participation in Economic Life	1	1	2	2	1	1	2	2	2	2	2	3	3	4	3	2	3	3	3	3	2	4	3	3	2	2	3	2
Population Dynamics	2	2	2	2	2	2	2	2	2	2	2	2	2	4	3	3	3	3	4	3	3	2	3	3	3	2	2	2
Public Life - Governance	2	3	3	2	2	2	2	3	2	1	2	2	2	3	3	3	3	3	3	4	3	3	2	3	3	3	3	2
Community Services	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3	2	2	3	3	4	3	3	3	3	3	3	3	1
Tourism, Leisure, Recreation, Sport	1	2	2	2	1	1	2	3	1	1	2	2	3	3	3	3	2	3	3	3	3	3	2	3	2	2	3	2
Governance of Social Institutions	2	3	3	4	2	3	3	4	3	2	2	3	2	3	3	3	3	3	3	3	3	3	4	3	2	3	4	2
Policy, plans, rules, legislation	3	4	3	3	3	3	3	4	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2
Non-Local Influences	2	3	3	2	2	2	2	2	2	1	3	3	3	3	4	3	3	3	3	3	2	3	2	3	3	3	3	3

3.4 Factor Ranking based on Row Sum Scores

A simple way to start evaluating the influence matrix is to sum the row and column scores for each factor and then to use these row and column sums to rank the row and column factors. The row or column sums are a measurement of the influence of an individual factor on all other factors in the matrix or system that the matrix represents. The CRG iMatrix factors have been ranked by row sum score in Table 4. Before sorting this table with the row sum score we colour coded the various groups of factors as per Table 3 so that it is possible to get a sense of the overall spread of types of factors according to their row sum scores.

Table 4 shows that *primary industries* have the strongest influence on all other factors in the catchment. It is interesting to note that economic factors tend to have lower row sum scores. Ecological factors have intermediate to higher row sum scores. Social factors have intermediate to lower influence scores. It is also interesting to note that *non-local influences*, *governance of social institutions* and *policy, plans, rules, legislation* all score highly in terms of their row sum.

Table 4 The 28 Aggregated Factors Ranked by Row sum Score

28 Aggregated Factors	Factor Type	Row sum (AS)
Primary industries	Economic	85
Policy, plans, rules, legislation	Policy	83
Governance of social institutions	Governance	82
Economic inputs	Economic	75
Water quality & supply	Ecological	75
Non-local influences	Non-local	73
Public life - governance	Governance	73
Climate & atmosphere	Ecological	73
Population dynamics	Social	72
Secondary industry	Economic	71
Maintain integrity of ecological processes	Ecological	68
Scientific research	Ecological	67
Maintain biodiversity	Ecological	66
Maintain soil health	Ecological	65
Family & community wellbeing	Social	65
Participation in economic life	Economic	64
Economic drivers	Economic	63
Tourism, leisure, recreation, sport	Social	62
Pest management	Ecological	61
Human health	Social	60
Labour market	Economic	59
Income tax & GST	Economic	57
Property valuation	Economic	57
Natural assimilation & purification	Ecological	56
Community services	Social	56
Tertiary sector	Economic	55
Landscape change processes	Ecological	54
Customary use	Social	43

The row sum score provides a useful means of ranking the 28 aggregated factors and 171 disaggregated factors by their system wide influence on other factors. An important question at this point concerns the usefulness of such a list. From a policy or planning perspective it is very helpful to know what the community thinks are key factors and, by inference, key management priorities. However, normally community members are not able to express their interests or concerns in this comprehensive manner, a fact that underscores the need for the development of participatory modelling tools of this kind that assist participants in capturing a whole-of-system perspective. In the absence of such tools, environmental and social policy makers rely heavily on submission processes which can be dominated by those with vested or current interests in the particular planning issue. Economists on the other hand rely on people expressing preferences through the market by the things that they choose or prefer to buy, and the price paid.

These are far from satisfactory approaches to understanding community values for many reasons, not the least of which are the vested interests at stake, and the inability of the market to generate adequate price signals for environmental externalities. By contrast, participatory modelling methods like the iMatrix provide an opportunity for the development of collective perspectives, informed by the sharing of knowledge and based around a whole-of-system evaluation and modelling methods.

An alternative way of ranking the factors shown in Table 4 would be to undertake non-market valuation research to give each an economic value. Instead of system wide influence, non-market valuation studies seek to estimate the value of, for example ecological factors in monetary terms. Relatively few of such studies have been conducted in New Zealand, mainly because of the high research costs involved in gathering such data. Those studies that have been undertaken have tended to focus on individual ecosystem goods, services, or spatially smaller ecosystems.

Clearly, there are times when we need specific valuation research of this kind. However, in New Zealand at least a whole-of-system non-market valuation study has never been undertaken. Instead, researchers needing to take a systems perspective of ecosystem services, for example, at a catchment, regional or national scale have had to use benefit transfer valuation estimates derived from international studies (Patterson, M. G. & Cole, A. O., 1999; Cole, A. O. & Patterson, M. G., 1998).

3.5 The Factor Typology

From a community perspective, what are critical factors that policy makers and planners need to concentrate on in order to make progress towards a community vision for the future of the Motueka catchment? What are the drivers of change in the catchment? How can we assess or measure the current state of the catchment community, its economy and environment? What are important buffers in the catchment system that may seem unimportant now, but will one day be required when the system is disturbed and pushed to upper or lower bounds? These are all important questions that need to be considered in regards to the long term management of the catchment. The influence matrix is able to provide insight into all of these questions based on a collective, whole-of-system perspective.

Table 5 The CRG Factor Typology

Factors	**Type**	***Factors***	**Type**
Primary Industries	Critical	Scientific Research	Active
Policy, plans, rules, legislation	Critical	Economic Drivers	Active
Water Quality & Supply	Critical	Human Health	Passive
Secondary Industry	Critical	Property Valuation	Passive
Economic Inputs	Critical	Tertiary Sector	Passive
Population Dynamics	Critical	Family & Community Wellbeing	Passive
Maintain Biodiversity	Critical	Community Services	Passive
Maintain Integrity of Eco Processes	Critical	Labour Market	Passive
Participation in Economic Life	Critical	Tourism, Leisure, Recreation	Passive
Maintain Soil Health	Critical	Customary Use	Passive
Climate & Atmosphere	Active	Pest Management	Buffer
Non-Local Influences	Active	Income Tax & GST	Buffer
Governance of Social Institutions	Active	Landscape Change Processes	Buffer
Public Life - Governance	Active	Natural Assimilation & Purification	Buffer

Evaluation of the CRG iMatrix has produced the factor typology shown in Table 5[3]. The data used to produce these results is recorded in separate tables located in Appendix 3. The factors types listed in Table 5 have been sorted in descending order according from the strongest to weakest influence scores. For example, the most critical factor of all is primary industries and the most active factor is climate and atmosphere. We comment on the significance of these factors below.

(i) Critical Factors

Critical factors have a system-wide influence on other factors and a high level of sensitivity to change in the system. Critical factors are important operational processes in the system; usually associated with growth and development; and closely coupled with the function of active, passive and buffer factors. For this reason it is difficult to consider critical factors in isolation from other system-wide factors. The CRG iMatrix has identified 10 critical factors listed here in order of highest to lowest multiplier scores: *primary industries, policy, plans, rules, legislation, water quality and supply, secondary industries, economic inputs, population dynamics, maintaining biodiversity, maintaining the integrity of ecological processes, participation in economic life* and *maintaining soil health.*

Given that primary industries in the Motueka catchment are the backbone of the local economy (contribution to catchment GDP $27.9 million in 2001) next to forestry (contribution to catchment GDP $23.6 million 2001) it is not surprising to discover that primary industries are the most critical factor. However, it is interesting to discover that *policy, plans, rules, legislation* takes second place, a fact that underscores the critical role played by regional government in the eyes of the CRG members. It is also not surprising to find that *water quality and supply* is the third most critical factor, given the central role of primary industries in the catchment and the history of water allocation issues that the community has had to collectively deal with. It is also important to note the number of ecosystem services that have turned out to be critical factors in this analysis.

[3] To understand the meaning of the 4 factor types, please refer to the factor typology shown in and explained in the text above figure 1

(ii) Active Factors

Active Factors are responsible for driving change and development in the system. They have a strong influence on other system factors. From a simple cause and effect perspective, the identification of these system drivers helps us to understand a lot about the behavioural characteristics of a system from the type of resource base and disturbance regime that drives it. For example, is the system primarily growth or disturbance driven? The CRG iMatrix has identified 6 active factors listed here in order of highest to lowest quotient scores: *climate and atmosphere, non-local influences, governance of social institutions, public life – governance, scientific research* and *economic drivers.*

Given that the catchment economy is so strongly based on primary industries it is not surprising to discover that the catchment system as a whole is strongly influenced by *climate and atmosphere* as a driver. Because of the dependence of the catchment economy on external markets for the sale of primary produce, we would expect that *non-local influences* such as exchange rates, interest rates and degree of foreign ownership would be an important driver and in this analysis it is the second most active factor.

(iii) Passive Factors

Passive Factors are highly sensitive to change and we call these factors indicator variables because of the manner in which they respond to strong influences. Passive factors can perform different roles in the system. For example, a passive factor could be a stock, the state of which performs an important feedback function for the system. Typically, we would expect to find passive factors in the final-demand or consumption end of the economy as they have weak forward influence and thus are not associated with growth processes in the same way that critical and active factors are. Passive factors can also play important signal damping functions for the system. The CRG iMatrix has identified 8 passive factors listed here in order of highest to lowest quotient scores: *human health, property valuation, tertiary sector, family and community wellbeing, community services, labour market, tourism, leisure, recreation and sport, customary use.*

(iv) Buffer Factors

Buffer Factors have the capacity to absorb change without drastically altering their own state or that of other factors in the system. All complex systems go through stages of growth, development and state change that adjust in extent and frequency. System buffers provide headroom for sudden growth and change shocks on the one hand, and compensation for lack of growth and change on the other hand. The CRG iMatrix has identified 4 buffer factors listed here in order of highest to lowest multiplier scores: *pest management, income tax and GST, landscape change processes* and *natural assimilation and purification.*

The factor typology from the CRG iMatrix does seem to be lacking in range of passive and buffer factors identified through this analysis. For example, the passive factors are mainly social in nature. We would expect that there are also important ecological and economic passive factors. However passive factors chosen provide a very useful indication of what the CRG members consider as indicator variables for the catchment social (*human health, property valuation, family and community wellbeing, community services, customary use)* and economic wellbeing (*community services, labour market, tourism, leisure, recreation and sport, property valuation*). However, it would have been good to see some ecological indicators as well. Their absence is probably related to aspects of our participatory process design, especially the factor selection and aggregation stages since both of these two process stages determine the final selection of factors that go into the iMatrix structure. Further research is really needed to better understand the extent to which the results of the iMatrix model are dependent on our process design.

There is one further dimension to the identification of factor types using an iMatrix. The factor types of the iMatrix (critical, active, passive and buffer) have analogues in system dynamics modelling (processes, drivers, stocks and feedback regulation). Given this similarity, it is possible to use the results of an iMatrix modelling exercise as a basis for building a system dynamic model of the catchment and its ecological, economic, cultural and social sub-systems. This remains a horizon for future research at the time of writing this report.

3.6 Evaluation of the Process Design

We have documented the results of an iMatrix modelling trial based on a participatory process that was a first stage design with some refinements. We acknowledge that the iMatrix itself is only a potential aid to a participatory process and we have endeavoured to better understand how these two (participation and modelling) can be successfully applied together. A number of lessons can be drawn from this research effort.

Firstly, the use of an iMatrix must have some clearly defined question or problem context. In this connection the CRG group members focused on envisioning the future and addressing the problem of how to make progress from the present towards their future goals as recorded in their collective goal statement. For this reason we believe that defining the problem statement for example through an envisioning process forms a useful starting point for building an influence matrix in a participatory manner as it provided an opportunity to develop a collective vision and goals.

The outcome of the problem statement or envisioning phase determines to some extend the scope of factors that are chosen for building an influence matrix. The greater the number of differing goals held by a community group then the proportionately larger will be the factors selected. For example, if the problem statement were related to economic growth, then the selection of factors could focus on variables that influence economic growth.

Secondly, the goal statement of the CRG was quite broad and this resulted in too large a number of factors. Aggregating 171 into 28 probably negatively influenced the ability of some group members to score the iMatrix due to the difficulty of remembering what original factors were represented in each amalgamated group.

Thirdly, the selection of factors was another area in which we need to make some adjustments to our process method. Initially we started with a brain storming session. However, after the first workshop of this kind it was evident that we did not have a good balanced selection of factors – given the breadth of the goal statement. What was clear was that neither researchers; council representatives, or community members – either individually or collectively, had a framework that enabled them to list a good balanced selection of factors.

Accordingly, in a second workshop the facilitators introduced frameworks to help participants think across ecological, economic and social systems. For economics this was fairly straightforward as we used a simple model provided by our ecological economist. This model portrayed an economic system with appropriate inputs – primary, secondary and tertiary industries – and outputs. This worked well for people, and the resulting list was comprehensive. However, things were not as straightforward for the ecological and social systems. For ecology we used line draw pictures of a highly generalised ecological system including land, vegetation, sky and atmosphere. This model seemed to provide a useful reference point by which the participants could more systematically think about their selection of factors.

The participatory factor selection process adopted to develop this influence matrix allowed a robust exchange of views among community members and researchers about the factors influencing the Motueka catchment. The style of facilitation by the researchers also influenced the selection of factors. For example, the researchers structured thinking by the group around ecological, economic and to a lesser extent social foci. This contributed towards lessons in the use of frameworks and pictures in participatory approaches. Where the system is easily bounded as in economics, and a common language has been developed, it is relatively easy to gain a fairly comprehensive set of factors. However, this is harder in the more complex ecological and social areas, and the final list of factors is influenced by the facilitative frameworks used.

Fourthly, a final stage in our process design was the evaluation of results. Unfortunately, we did not have time available for all of the members of the CRG to be involved in mathematically evaluating their collective iMatrix. We feel that this would have been a preferred option because it would help to give clearer understanding of how the results were derived, thus proving that the results were not the outcome of some black box method. The lead author completed the maths and reported the results back to the group.

It was interesting to note that this was the time at which the purpose of the model building suddenly made sense for a number of the CRG members. This is a common experience for university students that have used this modelling method. Usually, they don't have full understanding of the modelling method until they have evaluated their own results for the first time. It is at this point that it all suddenly starts to make sense. This is an important insight for two reasons: (i) while facilitating a model building exercise of this kind you need to count on the fact that most people are not going to be able to comprehend the point of this exercise until very late in the model building process. It is therefore important to explain the process and possible applications at the start, (ii) the interpretation of the results requires a reasonable level of understanding of the methodology (how you got the results). This is a weakness of the modelling approach as the necessity of experiencing the method before you completely understand and appreciate the results means that the value of the iMatrix outputs is more limited to the uninitiated.

3.7 Applications of the iMatrix Approach

Policy makers in regional government are faced with the same task at a regional scale in both strategic planning and resource management as the CRG was in its Motueka case study. In regional government, future goals are guided by national policy but predominantly by encouraging active community and stakeholder involvement in planning processes through the Local Government Act's Long Term Council Community Plan (LTCCP) development, and the Resource Management Act's regional policy statements and regional plans. The iMatrix is a tool that has potential to be used particularly in longer term LTCC planning processes. With an iMatrix approach of the kind outlined in this report it is possible for representative groups of communities, planners and researchers to move beyond the 'envisioning' and 'values' steps of community engagement towards bringing order into the maze of complex issues that surround long term planning, especially for the multiple goals typically associated with sustainability.

The outputs of an iMatrix evaluation process can be used as a basis for the development of dynamic simulation models that can be used to develop even deeper understanding of strategically important issues or problems. However, much can already be achieved by understanding the functional role of different factors and setting priorities with rankings of factors based on their system wide influence. For example, critical and active factors could be prioritised as a particular focus for research or policy effort.

A concern that is often expressed about the use of the influence matrix as a planning tool is that its use is based on the incomplete understanding of those who build the model. The answer to this concern lies in the fact that the iMatrix is not intended for independent use. It is one of a range of tools that need to be used to make well informed decisions. Its value lies in its simplicity and accessibility to a very wide group of people.

A further advantage is that it provides an accessible system wide unit of measurement (influence) that can easily be used across all of the domains of the sustainability problem (ecological, economic, social, institutional and cultural factors). This advantage of the iMatrix tool is one of the primary weaknesses of conventional benefit-cost analysis. It is operationally and theoretically difficult to monetise ecological, social and cultural factors.

By contrast, with the influence matrix it is possible to explore all of the dimensions of sustainability in one model. Furthermore, the model building method could also be applied to square matrices that are constructed using empirical data collection methods common in the development of environmental accounts.

The outputs of a participatory process such as this are dependent on the questions being addressed and the representativeness of the group addressing the questions. However, the process of engagement and the priority factors identified through the iMatrix process provide reassurance to the entire community that resource management plans are aligned with long-term community aims and informed by a community view of sustainability. The iMatrix approach is also relevant to the formation of national policy because it can provide crucial feedback on community level preferences.

Future research on the use of the influence matrix in the area of ecosystem services or triple/quadruple bottom line accounting should address two operational matters. Firstly, it would be useful to test how well the method represents community knowledge and interests by engaging in replicated case studies. Secondly, it would be useful to explore how the results from the iMatrix algebra are influenced by the methods used to facilitate the participatory process.

4. Conclusions

The influence matrix approach employs simple algebra and a participatory planning process to help stakeholders identify and quantitatively rank a series of factors that they perceive to be important influences on the health and sustainability of their environment, community, livelihood, and well-being. In this project we have applied the influence matrix approach to the problem of integrated and sustainable resource management at a catchment scale. The iMatrix approach, however, is applicable to a number of applications, including both qualitative and quantitative economic, social, and environmental accounting.

In drawing conclusions from this research trial we want to give consideration to both our exploration of the iMatrix as a potential participatory modelling method and the results of the CRG iMatrix. Our overall conclusion from the use of this methodology is that it has potential for further development and use in participatory planning contexts. However, after this initial pilot trial we acknowledge that: (i) the model results and process methodology are inextricably interwoven (ii) that scientists and community members in the CRG group show an equal propensity to miss out potentially crucial factors during the factor selection process.

Furthermore, the model represents a sample of local community perspectives and knowledge and a degree of synthesis with participating researchers. With this context in mind we conclude that: (i) the collective vision statement of the CRG members is aligned to the basic dimensions of sustainable development, (ii) the ranking of factors using the row and column sums provides a valid and useful method of summarising the perceived system wide value of these factors that complements existing non-market valuation and policy development methodologies and (iii) the factor typology draws our attention to the following results from the CRG iMatrix:

- *the critical role of primary industries, regional government and numerous ecosystem services in shaping the future of the catchment*
- *the central role of climate and atmosphere as drivers of change in the catchment in concert with non-local influences and a range of other active factors*
- *the state of the catchment system being linked with key social and economic indicators (passive factors) including human health, property values, family and community wellbeing*
- *pest, waste management and landscape change processes as playing an important buffering role.*

Thus, the current state of the Catchment was shown to be linked to the wellbeing of a range of economic and social factors like: human health, property values, service industries, families, community services and tourism. Overall, the model highlighted the importance of key ecological and social factors. These results are important for policy makers who are seeking to understand how heavily to weight economic decision-making with ecological, social and cultural factors.

Both researchers and community members alike commented that while they struggled with some aspects of the model building process, they thought that the insights that came from participating in the development of this model made the hard work well worthwhile. Finally, we believe that future research on the iMatrix process methodology should focus on better understanding the interdependencies between process and model development. Developing a more seamless fit in this area should pave the way for more extensive use of participatory modelling approaches.

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6. Appendices

Appendix 1 Selection and aggregation of iMatrix factors

The Motueka Community Reference Group has identified 171 factors considered to have an influence on progress towards future goals (Table 2). We initially grouped these factors into 6 main classes for the purpose of helping to formulate the influence table in a more organised manner.

1. *Ecological Factors*
2. *Economic Factors*
3. *Social Factors*
4. *Institutional Factors*
5. *Regulatory Factors*
6. *Non-local Factors*

Aggregation of the factors reduced the number of factors to 28. Below is a concordance that provides a list of our 171 factors (Column 2) alongside and sorted by their aggregated group names (Column 3). In some cases the group members found it difficult to identify individual factors of a causative nature so some of the listed 171 are more issue statements than influence factors. No attempt was made to correct this problem in recognition of the fact that in some cases it is not clear what causal factors are. Therefore it was necessary to simply state the issue of concern.

Group Names	Disaggregated Factor Names (171)	Aggregated Factors Names (28)
Ecological	Burning fields (producing smoke)	Climate and Atmosphere
	Climate	Climate and Atmosphere
	Pine Pollen	Climate and Atmosphere
	1080 poison	Pest Management
	Ants (introduced pests)	Pest Management
	Bio Security	Pest Management
	Giardia	Pest Management
	Gypsy moths	Pest Management
	Pest control methods	Pest Management
	Pop. Pressure (plant & animal pests)	Pest Management
	Tb Vectors (possum, ferrets, pigs, deer)	Pest Management
	Biodiversity	Maintain Biodiversity
	Changing crop seed mixes	Maintain Biodiversity
	Environmental integrity	Maintain Biodiversity
	Forestry	Maintain Biodiversity
	National Parks	Maintain Biodiversity
	Ecological Time	Maintain Ecological Processes
	Changing land use	Maintain Soil Health
	Does forestry cause erosion	Maintain Soil Health
	Erosion (coastal & river)	Maintain Soil Health
	Fertiliser & chemical use	Maintain Soil Health
	Landscape	Maintain Soil Health
	Nutrient levels	Maintain Soil Health
	Silt levels	Maintain Soil Health
	Soil Productivity	Maintain Soil Health

Group Names	Disaggregated Factor Names (171)	Aggregated Factors Names (28)
	Soils	Maintain Soil Health
	Pasture	Maintain Soil Health
	Population Pressure (stocking rate)	Maintain Soil Health
	Other Pollution	Natural Assimilation & Purification
	Coastal erosion	Landscape Processes
	H20 for local economy (shortages?)	Water Quality & Supply
	Changing water quality	Water Quality & Supply
	Demand for water	Water Quality & Supply
	Irrigation	Water Quality & Supply
	Limits of Aquifers	Water Quality & Supply
	Rainfall	Water Quality & Supply
	River flows	Water Quality & Supply
	Run-off	Water Quality & Supply
	Water pollution	Water Quality & Supply
Economic	Eeling	Customary Use
	Exchange Rates	Economic Drivers
	Tourism Pressure	Economic Drivers
	Urban development	Economic Drivers
	Inputs - Chemicals	Economic Inputs
	Inputs - Electricity	Economic Inputs
	Inputs - Fuels	Economic Inputs
	Inputs - Natural Assets	Economic Inputs
	Inputs - Road Infrastructure	Economic Inputs
	Inputs - Transport	Economic Inputs
	Roads (improving)	Economic Inputs
	Taxes	Income Tax & GST
	Employment	Labour Market
	Cropping	Primary Industries
	Dairying	Primary Industries
	Deer Farming	Primary Industries
	Farming	Primary Industries
	Fisheries	Primary Industries
	Forestry	Primary Industries
	Forestry	Primary Industries
	Goats	Primary Industries
	Gravel extraction	Primary Industries
	Horticulture	Primary Industries
	Horticulture	Primary Industries
	Marijuana	Primary Industries
	Mining	Primary Industries
	Natural and Farmed Fisheries	Primary Industries
	Organics	Primary Industries
	Ostrich / Emu	Primary Industries
	Sheep farming	Primary Industries
	Shell Fisheries	Primary Industries
	Trout	Primary Industries
	Whitebait	Primary Industries
	Coastal corridor economic zone	Property Valuation
	Land prices	Property Valuation
	Land values	Property Valuation
	Subdivision	Property Valuation
	Arts and crafts	Secondary Industry
	Cottage Industries	Secondary Industry

Group Names	Disaggregated Factor Names (171)	Aggregated Factors Names (28)
	Fish Processing	Secondary Industry
	Horticultural packaging	Secondary Industry
	Industry	Secondary Industry
	Timber Processing	Secondary Industry
	Wine Processing	Secondary Industry
	Communication	Tertiary Sector
	Contracting	Tertiary Sector
	Education	Tertiary Sector
	Healthcare	Tertiary Sector
	Home stays and Accommodation	Tertiary Sector
	Service sector	Tertiary Sector
	Social Welfare & Services	Tertiary Sector
	Tourism	Tertiary Sector
	Transport	Tertiary Sector
	Urban centres	Tertiary Sector
Social	Corporate farming divisive on local	Family & Community Wellbeing
	Decline in Community Social Activities	Family & Community Wellbeing
	Emerging settlement patterns hard on rural	Family & Community Wellbeing
	Foreign ownership	Family & Community Wellbeing
	Growing socio-economic gap	Family & Community Wellbeing
	Housing Issues - Large Community issues	Family & Community Wellbeing
	Lack of Social Activities	Family & Community Wellbeing
	Rural Communities - Less community	Family & Community Wellbeing
	School rolls	Family & Community Wellbeing
	Schools a major community focus	Family & Community Wellbeing
	Traditional family farms converted to	Family & Community Wellbeing
	Health	Human Health
	Also people with good skills come into the	Participation in Economic Life
	Hard for people to stay in community	Participation in Economic Life
	Influence of Maori owned land	Participation in Economic Life
	Large proportion of Maori leasehold land in	Participation in Economic Life
	Low unemployment	Participation in Economic Life
	Poor Socio-economic groups	Participation in Economic Life
	Young people can be trained locally	Participation in Economic Life
	Young people need to leave area for preferred	Participation in Economic Life
	Youth career opportunities	Participation in Economic Life
	Changing demographics	Population Dynamics
	Community very mobile (people always on the	Population Dynamics
	Farm Workers hard to get	Population Dynamics
	Immigration	Population Dynamics
	Local Economy based on Seasonal Workers	Population Dynamics
	Motueka is growing in terms of population	Population Dynamics
	NZ Holiday Destination	Population Dynamics
	Population is more transitory	Population Dynamics
	Population Pressure (Human)	Population Dynamics
	Population Pressures in Summer	Population Dynamics
	Rural Industries (Main labour force)	Population Dynamics
	Seasonal Workforce	Population Dynamics
	Housing Issues - Cheap Housing in Rural	Public Life - Governance
	Housing Issues - Dormitory effects	Public Life - Governance
	Housing Issues - Lifestyle Blocks	Public Life - Governance
	Influence of Iwi Trusts	Public Life - Governance
	Iwi	Public Life - Governance

Group Names	Disaggregated Factor Names (171)	Aggregated Factors Names (28)
	Life style blocks	Public Life - Governance
	Access to social facilities	Community Services
	Decline in Community Services	Community Services
	Decline in Rural Services	Community Services
	Increasingly good career training opportunities	Community Services
	Local Polytechnics do a good job of career	Community Services
	Mountain bikes	Community Services
	People send children to preferred schools	Community Services
	Policing varies across rural / urban community	Community Services
	Relative opportunities in rural verses urban	Community Services
	Rural healthcare	Community Services
	Catchment topography (views, amenities)	Tourism, Leisure, Recreation, Sport
	Coastal and Mopeku areas growing	Tourism, Leisure, Recreation, Sport
	Coastal Belt Contains Rich Housing	Tourism, Leisure, Recreation, Sport
	DOC Estate	Tourism, Leisure, Recreation, Sport
	Passive recreation verses active	Tourism, Leisure, Recreation, Sport
	Recreational Use	Tourism, Leisure, Recreation, Sport
Institutions	Area health Board	Governance of Social Institutions
	Community boards	Governance of Social Institutions
	Department of Conservation	Governance of Social Institutions
	District health board	Governance of Social Institutions
	ENZA management	Governance of Social Institutions
	Fish and game	Governance of Social Institutions
	Tasman District Counsel	Governance of Social Institutions
Regulatory	Sustainability	Policy, plans, rules, legislation
	Resource Management Act	Policy, plans, rules, legislation
	Government policy	Policy, plans, rules, legislation
	National Park Regulations	Policy, plans, rules, legislation
	Quota-management fishing	Policy, plans, rules, legislation
	Water conservation orders	Policy, plans, rules, legislation
Non-local	School curricula opportunities	Non-Local Influences
	Health care	Non-Local Influences
	Exchange rate	Non-Local Influences
	Interest rate	Non-Local Influences
	Absentee owners	Non-Local Influences
	Demand for produce	Non-Local Influences
	Foreign ownership	Non-Local Influences
	GM crop seed	Non-Local Influences
	Market demand	Non-Local Influences
	World trade regulations	Non-Local Influences

Appendix 2 List of 28 grouped factors

Ecological	Climate & Atmosphere Pest Management Maintain Biodiversity Maintain Integrity of Ecological Processes Maintain Soil Health Natural Assimilation & Purification Landscape Change Processes Water Quality & Supply Scientific Research
Economic	Customary Use Economic Drivers Economic Inputs Income Tax & GST Labour Market Primary Industries Property Valuation Secondary Industry Tertiary Sector
Social	Family & Community Wellbeing Human Health Participation in Economic Life Population Dynamics Public Life - Governance Community Services Tourism, Leisure, Recreation, Sport
Institutional	Governance of Social Institutions
Regulatory	Policy, plans, rules, legislation
Non-local	Non-Local Influences

Appendix 3 Data used to calculate the CRG factor typology

Factors	Type	RS	CS	Diff.	Quotient	Multiply
Climate & Atmosphere	Active	73	49	24	1.49	3577
Non-Local Influences	Active	73	52	21	1.40	3796
Governance of Social	Active	82	59	23	1.39	4838
Public Life - Governance	Active	73	58	15	1.26	4234
Scientific Research	Active	73	63	10	1.16	4599
Economic Drivers	Active	63	57	6	1.11	3591

Factors	Type	RS	CS	Diff.	Multiply	Quotient
Pest Management	Buffer	61	58	3	3538	1.05
Income Tax & GST	Buffer	57	60	3	3420	0.95
Landscape Change Processes	Buffer	54	58	4	3132	0.93
Natural Assimilation &	Buffer	56	52	4	2912	1.08

Factors	Type	RS	CS	Diff.	Multiply	Quotient
Primary Industries	Critical	85	88	3	7480	0.97
Policy, plans, rules, legislation	Critical	83	79	4	6557	1.05
Water Quality & Supply	Critical	75	74	1	5550	1.01
Secondary Industry	Critical	71	78	7	5538	0.91
Economic Inputs	Critical	75	67	8	5025	1.12
Population Dynamics	Critical	72	69	3	4968	1.04
Maintain Biodiversity	Critical	66	68	2	4488	0.97
Maintain Integrity of Ecological	Critical	68	65	3	4420	1.05
Participation in Economic Life	Critical	64	67	3	4288	0.96
Maintain Soil Health	Critical	65	64	1	4160	1.02

Factors	Type	RS	CS	Diff.	Quotient	Multiply
Human Health	Passive	60	78	18	0.77	4680
Property Valuation	Passive	57	72	15	0.79	4104
Tertiary Sector	Passive	55	69	14	0.80	3795
Family & Community	Passive	65	80	15	0.81	5200
Community Services	Passive	56	67	11	0.84	3752
Labour Market	Passive	57	67	10	0.85	3819
Tourism, Leisure, Recreation,	Passive	62	71	9	0.87	4402
Customary Use	Passive	43	50	7	0.86	2150

Contact Information:

If you have questions or would like more information about this thesis please contact.

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