Strategy for the Development of Investment Decision-Making Framework for Road Asset Management for Queensland Department of Main Roads

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Project: 2001-010-C
Investment Decision Framework for Infrastructure Assets Management

Research Program: C
Delivery and Management of Built Assets

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1. Project Title

Investment Decision-Making Framework for Infrastructure Asset Management

2. Project Summary

The aim of this project is to develop a systematic investment decision-making framework for infrastructure asset management by incorporation economic justification, social and environmental consideration in the decision-making process. This project assesses the factors that are expected to provide significant impacts on the variability of expenditures. A procedure for assessing risk and reliability for project investment appraisals will be developed. The project investigates public perception, social and environmental impacts on road infrastructure investment. This research will contribute to the debate about how important social and environmental issues should be incorporated into the investment decision-making process for infrastructure asset management.

3. Background

Australia has billions of dollars worth of civil infrastructure assets as roads, bridges, railways, buildings and other structures. Road assets alone are valued at around A$ 140 billion. These assets are owned an or managed by state departments, public works, local councils, contractors, consultants or a contribution of or more of these groups. As condition of assets deteriorate over time, billions of dollars are spent annually which amounts to and expenditure in the order of A27$ million per day.

Generally, budgets for road maintenance are allocated based on past year's expenditure or "as seen" performance. Some of the issues that arise in road asset management include: to what extent we could predict the rate of deterioration of infrastructures accurately for fund allocation purposes under the variation of climatic condition, vehicle variation, soil condition and etc., and to what extent to which the risk-adjusted expenditures for road asset management investment could be estimated in such uncertain circumstances. The accuracy of funding required to maintain infrastructure assets and the level of confidence in the allocation of fund needs to be well informed at the stage of budgeting, otherwise it may lead to underestimate or overestimate funding.

Based on the comprehensive literature review and on-going discussion with staff and senior staff of Queensland Department of Main Roads, a systematic investment decision-making framework which includes economic justification, social and environmental consideration and risk-adjusted expenditure has been developed. This framework is presented in Figure 1. Details of Figure 1 are discussed in the next section.

4. Aims of Project

The aim of this project is to develop a systematic investment decision-making framework for infrastructure asset management which takes economic justification, social and environmental consideration and risk-adjusted expenditure in to account.

To accomplish the goals, three research tasks have been identified. These research tasks include:

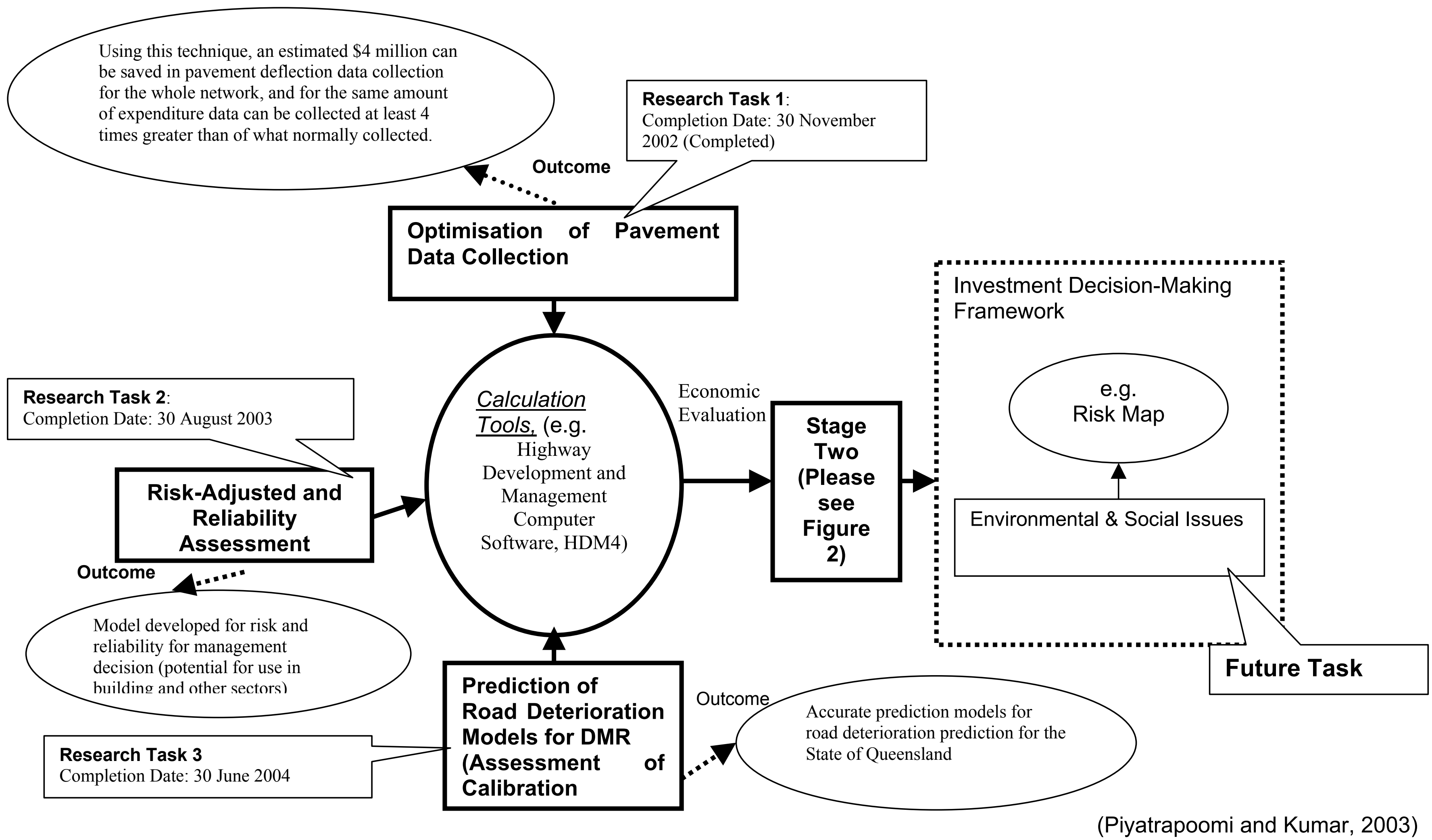


Figure 1: Investment Decision-Making Framework for Infrastructure Asset Management

Research Task 1: The Development of a Procedure for the optimisation of Pavement Deflection Data Collection

Research Task 2: The Development of a Method for Risk-Adjusted Expenditure and Reliability Assessment

Research Task 3: The Development of Pavement Prediction Models of road conditions for Queensland

Future Task: The Development of a Procedure to Incorporate Social, Environmental and other Related Issues in the Decision-Making Framework

Details of each research task are given below.

Research Task 1:
The Development of a Procedure for Optimising Data Collection
(Status of project: Completed)

For road asset management, current conditions of built assets and deterioration rates are basic information for the estimation of fund allocation for maintenance and rehabilitation work. Road authorities worldwide collect various road condition data each year. These include pavement roughness data, rut depths, surface cracking, potholes, structural strength of pavement and etc. However, it is high in cost in data collection especially collecting pavement strength data. Road asset management requires an accurate prediction of changes in pavement strength. Current methods used for pavement strength data collection require test instruments to stop to apply loading to pavement surface and measure pavement strength response and then move to other pavement locations which is time consuming, traffic needs to be delayed while conducting the tests. Pavement strength data collection is important for pavement management and project prioritisation. However, due to the expense involved in data collection, pavement strength is usually not determined for the network level. Many researchers suggested that pavement strength even derived from less intensive intervals could be very useful at the network level for project prioritisation purposes. The objective of this study is to develop a method for optimise pavement strength data collection at the network level. The outcome from this study is the optimal test intervals for pavement deflection testing. A procedure for the optimisation of pavement deflection data collection for the network level will be developed as a result of this study.

The results from the optimisation assessment developed in this study indicate that for the same amount of expenditure, pavement strength data can be collected at least four times greater than what are normally collected. Thus, more informed pavement strength data can be obtained and can result in more effective allocation of fund for maintenance and rehabilitation programs.

Research Task 2:
The Development of a Method for Risk-Adjusted Expenditure and Reliability Assessment
(***Estimated completion date: 30 August 2003)***

The aim of this research task is to develop a method for the calculation of risk-adjusted expenditure for maintenance and rehabilitation. A probability-based method is adopted since the variability of road asset conditions can be modelled statistically and can systematically be incorporated in the assessment through probability-based risk and reliability methods. By using the optimisation method of data collection developed in Research Task 1, road asset conditions can be collected at the network level, statistically modelled and used for the assessment of fund allocation. By taking into account the variability of road asset conditions, climatic conditions and other factors, risk-adjusted expenditure can be estimated. The outcome of this study is the procedure of risk-adjusted assessment for maintenance and rehabilitation works.

For demonstration, a risk-adjusted expenditure has been calculated for maintenance and rehabilitation work for a 92 kilometre section of the national highway of Queensland. In this study, only the variability of pavement strength was considered in the risk-adjusted calculation. Risk-adjusted expenditures were calculated for 5-year, 10-year, 15-year, 20-year and 25-year periods for maintenance and rehabilitation works. The results show that risk-adjusted expenditures at 95% level of confidence were 18.09, 11.81, 4.74, 3.82 and 3.52 per cent greater than the mean expenditures for 5-year, 10-year, 15-year, 20-year and 25-year periods, respectively. It must be noted that only the variability of pavement strength was taken into account in the calculation. However, there are several other factors whose the variability needs to be ascertained and combined together with the strength factor to get realistic risk-adjusted expenditure. It is necessary to incorporate the variability of other factors that significantly affects the variability of expenditures into account. This is the research work proposed for stage-two research. Figure 2 shows the framework and the relationship between stage-one and stage-two toward the development of the investment decision-making framework.

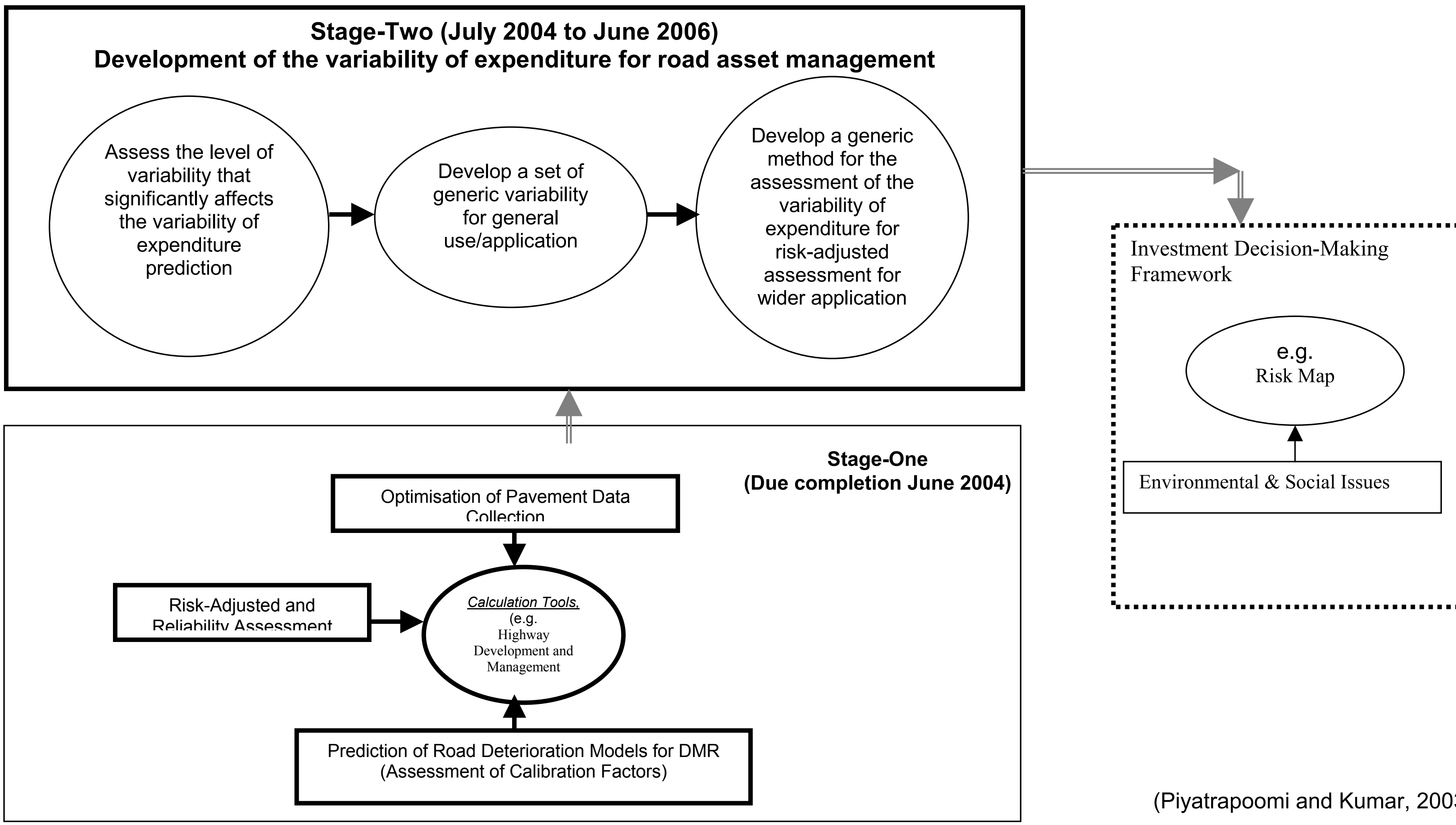
Research Task 3:
The Development of Pavement Prediction Models of road conditions for Queensland (Assessment of Calibration Factors)
(Estimated completion date: 30 June 2004)

The objective of this study is to develop calibration factors for pavement condition prediction models suitable for Queensland condition. Pavement condition prediction is important for road asset management, and its rate of change varies depending on climatic conditions, traffic loadings, construction techniques, materials etc.. Data of road conditions including roughness, rutting, cracking, pavement strength, climatic condition, vehicle variation will be used for the calibration assessment. The outcome of this study is the calibration factors of a number of possible prediction models for different climatic conditions for the State of Queensland.

Future Task:
The Development of a Procedure to Incorporate Social, Environmental and other Related Issues in the Decision-Making Framework

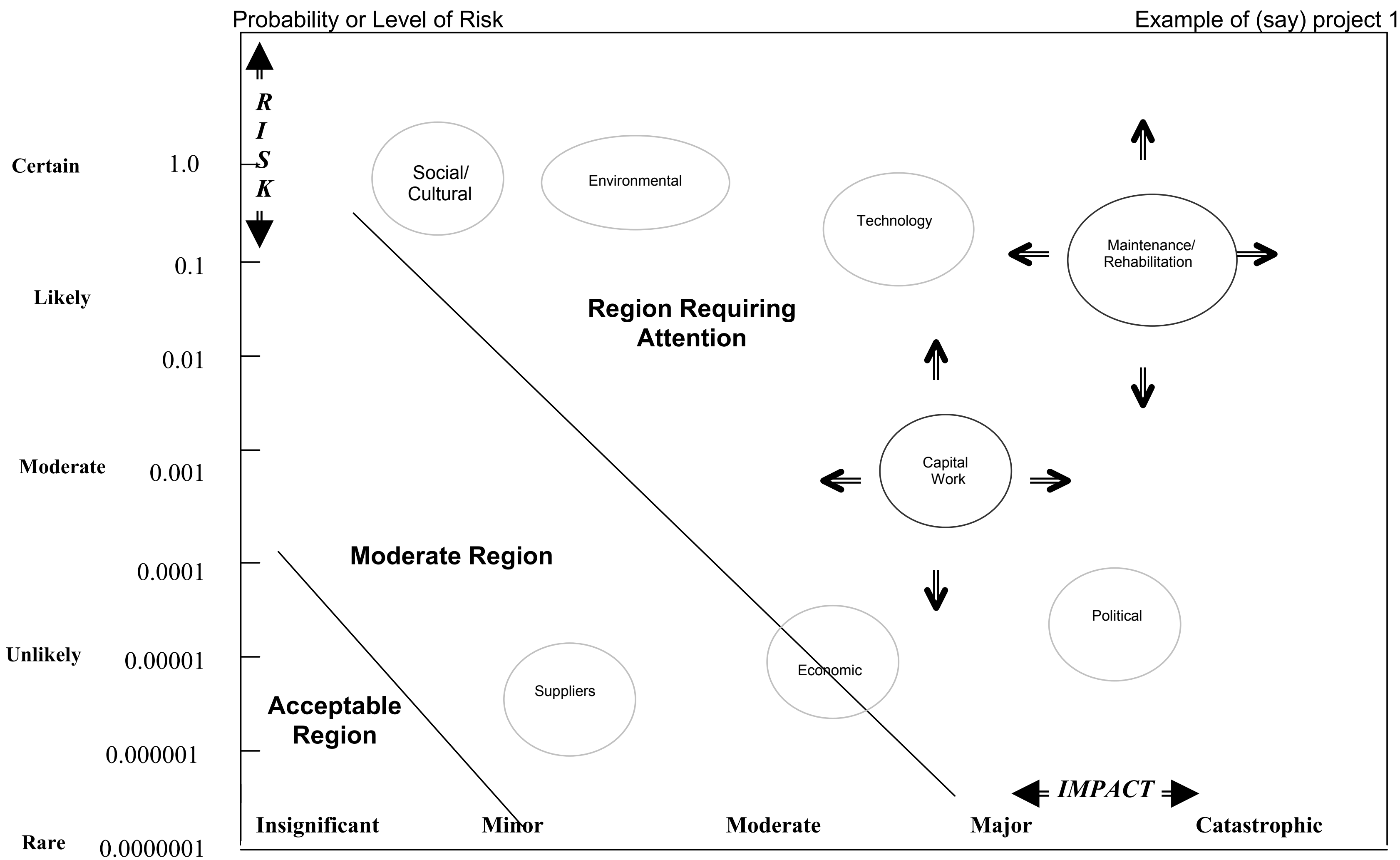
This research aims at developing a procedure to incorporate political, social, environmental and other related issues in the decision-making framework. Detailed risk and impact or assessment of consequences will be examined. A method to incorporate social, environmental and other issues using engineering economic evaluation will be developed. The outcomes of this study include:

1. A decision-making framework incorporating economic, social and environmental criteria in the decision-making process
2. Models for the assessment of environmental issues and social issues for decision-making.



(Piyatrapoomi and Kumar, 2003)

Figure 2: Proposed Stage 2- Development of the variability of expenditure for road asset management



(Modified after Harrington and Rose 1999, and the Australian Defence Organization 2002)

Figure 3: Plots of risk issues on the Risk Map

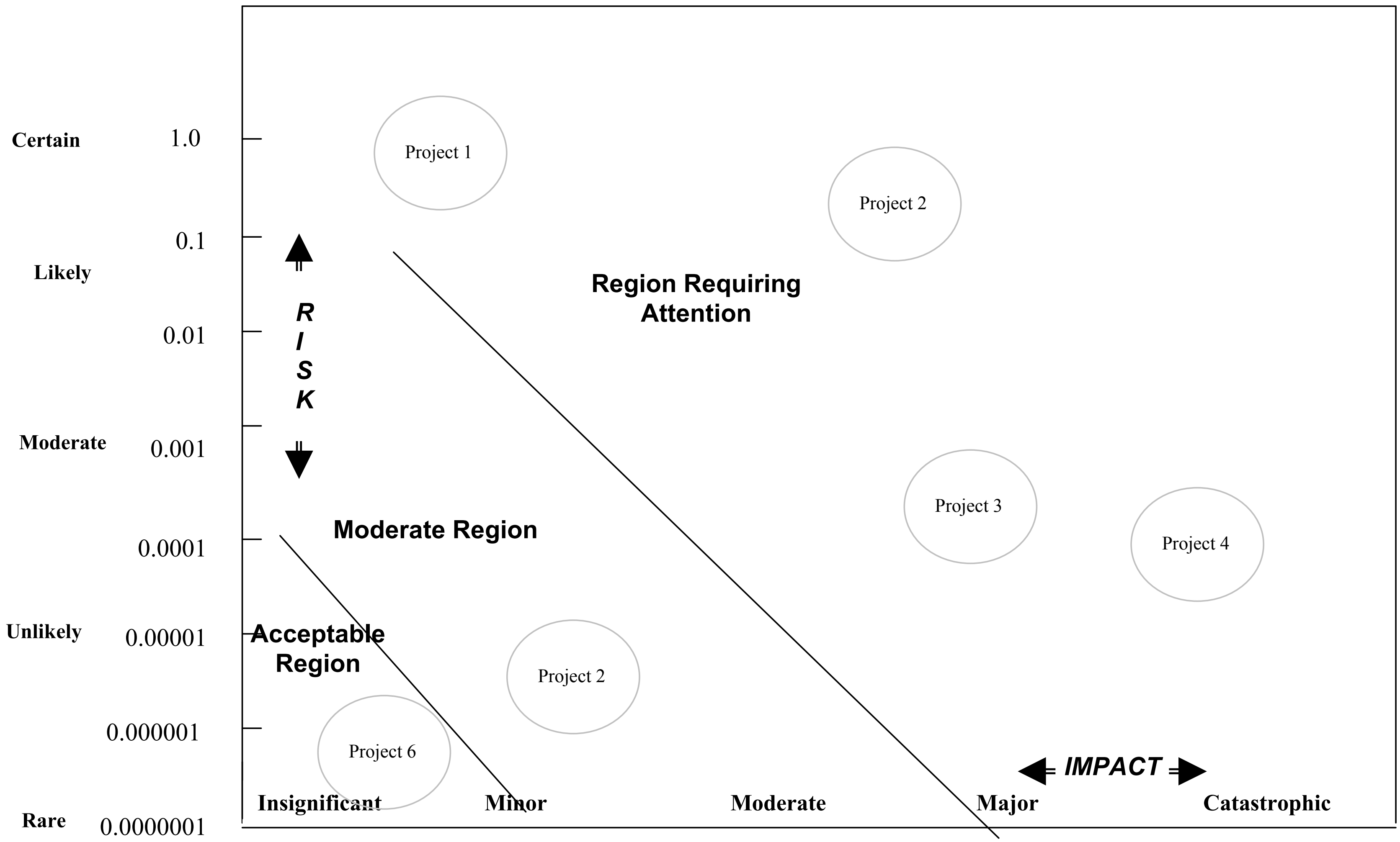


Figure 4: Plots of Different Projects on the Risk Map for Project Prioritisation

5. Summary

This report presents a framework of the study for the development of investment decision-making framework for road asset management. Figure 1 (in page 4) shows how Research Tasks 1-3 are integrated to form a framework for the study. Potentially, a substantial reduction in the cost of data collection will be the main benefit from the optimisation of data collection (Research Task 1). Risk and reliability assessment (Research Task 2) takes into account the variability of data in the analysis for risk-adjusted purposes. Research Task 3 develops prediction models of road deterioration for Queensland conditions. Such prediction models are very important for the effective allocation of funding for road maintenance and rehabilitation. When risks and impacts on economic, social and environmental issues were identified, risks and impacts could be plotted for consideration in a risk map as illustrated in Figure 3 for each project. In the risk map, Y-axis is denoted as risk or probability of occurrence of negative effects, while X-axis is impact levels (ranging from insignificant to catastrophic). Figure 4 illustrates how different projects are to be prioritised. The project that falls into the tolerable region is the most favourable option. Otherwise it is necessary to bring the projects that have higher risks and impacts into the tolerable region in order to minimise risks and impacts. This can be achieved by putting in place risk management prior a decision is made.