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Alternative to Comprehensive Ecosystem Services Markets: The Contribution of Forest-Related Programs in New Zealand

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Alternatives to comprehensive ecosystem services markets: the contribution of forest related programs in New Zealand

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Summary

Due to the public goods characteristics of many ecosystem services and their vital importance to human welfare, various mechanisms have been put in place to motivate private landowners in the provision of ecosystem services. A common approach is to try to develop a comprehensive ecosystem services market where landowners can receive payments from beneficiaries of ecosystem services. Much research has been directed at developing methods for valuing the range of ecosystem services so that they can be incorporated into ecosystem services markets. However, valuation methods are difficult, expensive and time consuming. Other approaches to the provision of ecosystem services such as payments for ecosystem services usually focus on a single service like water or biodiversity. However, in the provision of a particular ecosystem service, there are spill-over effects of providing other ecosystem services, and thus studying those spill-over effects may provide a simple and cost-effective way of ensuring the provision of a wide range of ecosystem services. In New Zealand, there are a variety of forestry programs which provide incentives to landowners to plant trees on their lands to meet particular objectives, but which also produce other ES. This research aims to evaluate the cost-effectiveness of the provision of a wide range of ES by these approaches, the New Zealand Emissions Trading Scheme, the East Coast Forestry Scheme, and the QEII National Trust.

Keywords: ecosystem services market, spill-over effect, cost-effectiveness, New Zealand

1. Introduction

Humans have profoundly altered many ecosystems in ways that would not have occurred naturally. These changes have altered many of the ecosystems and their functioning, at scales ranging from local to global. Some valuable ecosystem goods and services (here after ES) such as fish stocks from the North Atlantic Ocean collapsed less than two decades ago, and the ozone layer that protect us from harmful ultraviolet rays has been impaired by higher concentrations of chlorofluorocarbons resulting in increased skin cancer cases in the Southern Hemisphere **(Turner *et al.*, 2008)**. Degradation of ES and resulting disservices to human wellbeing has raised serious concerns among people around the globe that something must be done to protect ES. In this regard, the first global assessment of ES published in 2003 not only provided an up-to-date impact on the state of ES, but also it urged every government to formulate policies and programs for ensuring a wide range of ES on private lands **(MEA, 2003)**. In this regard, various incentive mechanisms have been developed for motivating landowners in the provision of ES which are largely public or quasi public goods. **(Fisher *et al.*, 2009; Tietenberg, 2006)**.

Mechanisms for the provision of ES vary from stiff command and control to providing subsidies and tax incentives for desirable environmental outcomes or imposing penalties for damaging ones, promoting land ethics and creating markets for ES **(Kroeger & Casey, 2007)**. Among these, economists prefer market mechanism over others arguing they coordinate demand of people who are willing to pay for these services and those who are willing to supply them, and thus result in the efficient provision of ES at least cost to society **(Perrings, 2009)**. However, development of private ES market is problematic as ES exhibit non-rivalry and/or non-exclusiveness characteristics which makes it difficult to define and enforce ownership over these resources **(Fisher *et al.*, 2009; Tietenberg, 2006)**. As a result, ES markets are mostly government created where government defines the commodity to be traded such as a discharge allowance as in the case of water trading program in the States **(Woodward & Kaiser, 2002)** or an offset credit in the carbon cap-and-trade programs, and regulates their trading **(Ribaudo *et al.*, 2010)**. There has been much effort directed at developing methods for valuing the range of ecosystem services **(Bateman *et al.*, 2002; Rolfe, 2006)** so that they can be incorporated into ES markets. However, creating markets requires a huge task of mapping and modelling flows of ES, valuing them, and establishing credible institutions that monitor progress of ES over time. Hence, what is required is a simple and cost-effective way of ensuring the provision of a wide range of ecosystem services on private land.

2. New Zealand Context

The New Zealand government has adopted a variety of mechanisms for combating the effects of climate change and ES degradation. It has amended the Emissions Trading Scheme (ETS) in the Climate Response Change Act and has set a target of a 50% reduction in 1990 green house gas emission levels by 2050 **(MfE, 2011)**. The ETS covers all sectors in the country, but the forestry sector is the first to participate in the scheme beginning in February 2008. ETS puts a price on the carbon sequestration service of trees and provides income to landowners for the carbon sequestered in their forests. In the forestry sector, there are market based initiatives such as the ETS and the Permanent Forest Sinks Initiative (PFSI) which give farmers an opportunity to earn carbon credits tradable in the domestic and international markets respectively, and grant based schemes such as the Afforestration Grant Scheme (AGS) and the East Cost Forestry Project (ECFP) which provide grants to individuals or groups for planting trees or protecting scrubs and indigenous trees **(MAF, 2011a)**. These forestry programs or payments for ecosystem services (PES) implemented in other parts of the world usually focus on a single ES. For example, the ECFP focuses on soil conservation; ETS focuses on climate regulation; and PES focus on watershed or biodiversity conservation. However, in the provision of a particular ES, there are spill-over effects. For example, planting exotic trees on eroding slopes not only prevents soil erosion and stabilises slopes, but also it enhances other ES such as water quality, air quality, biodiversity, climate regulation through carbon sequestration, and aesthetics **(Cawsey & Freudenberger, 2008; Maunder *et al.*, 2005; Myers, 1997; O'Loughlin, 2005)**. However, it may also reduce water yields **(O'Loughlin, 2005)** which may be an issue in catchments that have water shortages during summer. Hence, studying those spill-over effects may provide a simple and cost effective way of ensuring a wide range of ES. However, we do not know the actual or likely impacts of forestry programs on the provision of a wide range of ES nor the costs of implementing those programs per unit of total ES generated. This research aims to evaluate the cost-effectiveness of the provision of a wide range of ES provided by a market approach, the New Zealand Emissions Trading Scheme; a grant based approach, the East Coast Forestry Scheme; and an NGO approach, the QEII National Trust. We focus on the following research questions:

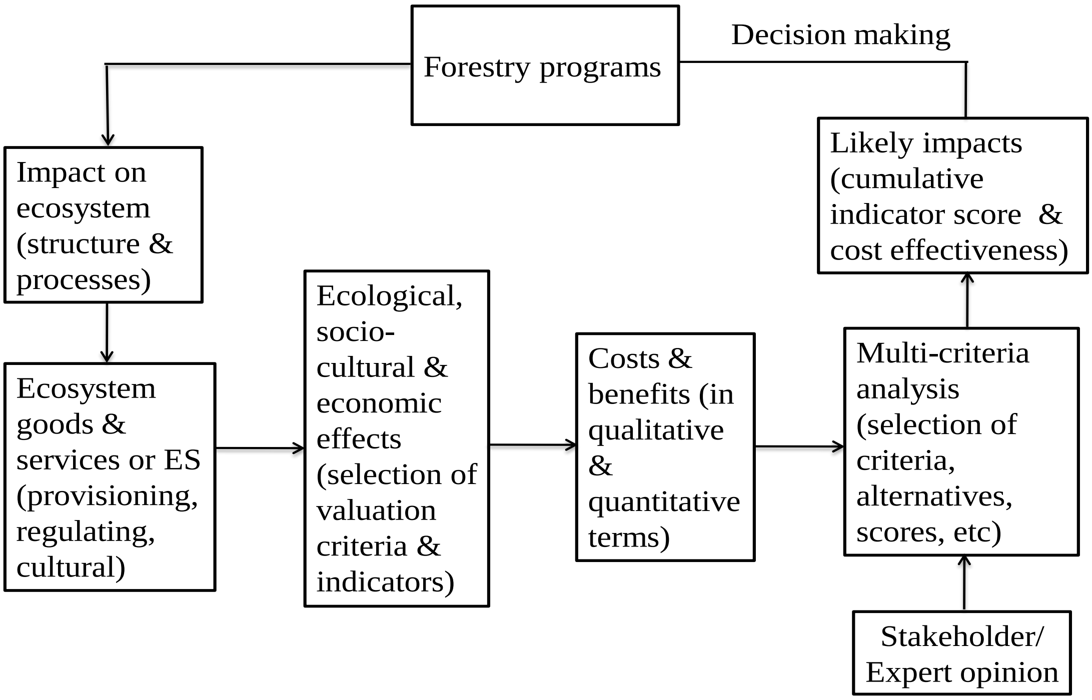
- Do single or limited focus programmes provide broad ES outcomes?
- Are there differences in ES outcomes between the various policy approaches?
- Which approach is most cost effective in the provision of ES?

3. Conceptual framework

The conceptual framework for the study is presented in Figure 1. Implementation of forestry programs will have an impact on ecosystems, which through ecosystem structures and processes modify ES that are of concern to different stakeholders. This research adopts the view that ES include all ecosystem structures, functions and processes that benefit humans, directly or indirectly **(Fisher *et al.*, 2009)**.

The research uses an ecosystem services approach (ESApp) put forward by Millennium Ecosystem assessment (MEA) that links well functioning ecosystems and human welfare **(Turner *et al.*, 2008)**. ESApp is useful for undertaking ES analysis as it includes not just few ES that are traded in markets (tangibles) but also it incorporates all other ES (intangibles) that are generally ignored in ES assessments. Hence, the main steps in this framework include identification of ES that are affected by forestry programs; selection of criteria and indicators; quantification of flows of ES in physical terms; elicitation of preference weights for ES; aggregation of ES outputs (cumulative indicator score); and costs of producing ES per unit of area.

Figure 1: Conceptual framework for the study **(Henkens *et al.*, 2007)**



3.1 ES from forests

MEA recognises four distinct categories of ES as provisioning, regulating, supporting, and cultural ES **(MEA, 2003)**. However, as supporting ES such as nutrient cycling and primary production are intermediate to the production of other ES **(Barkmann *et al.*, 2008; Layke, 2009)**, they are excluded in this study (Table 1). This helps to avoid the double counting problem which is seen in majority of ES studies reviewed **(Fisher *et al.*, 2009)**. The range of ES listed in Table 1 can be obtained from a natural forest. However, commercial plantations have been established in many parts of world for meeting timber demands and to prevent natural forests from deforestation. About one fourth of worldwide planted forest area is occupied by introduced species in 2010 **(FAO, 2010)**. In the New Zealand context, plantation forestry plays a major role in the landscape covering about 1.8 million hectares area of which *Pinus radiata* alone covers 89 percent **(MAF, 2009)**.

There are mixed views with regards to the contribution of plantations in the provision of ES. Some consider commercial plantations poor in biodiversity or even as "biological deserts" **(Stephens & Wagner, 2007)**. Others see plantations as not just a provider of timber, but as providers of several ES such as carbon sequestration, erosion reduction, water and nutrient retention, creation of habitats, aesthetics, and recreation **(Cawsey & Freudenberger, 2008; Maunder *et al.*, 2005; Myers, 1997; O'Loughlin, 2005).** Studies conducted in New Zealand have shown wider benefits of *Pinus radiata*, mainly stabilising slopes and preventing mass movements due to soil reinforcement by well developed root systems about 10 years after planting **(O'Loughlin, 2005);** reducing small flood events **(Davie & Fahey, 2005)**; providing many ES and contributing to indigenous biodiversity **(Maunder *et al.*, 2005)** or in some cases even providing better habitat for indigenous fauna than many pest infested indigenous forests **(O'Loughlin, 2005)**.

Table 1: Various ES that a forest ecosystem may provide

ES category	ES Examples	Description of ES
Provisioning ES	Food	Forest ecosystem supplies food (e.g. wild fruits)
	Fibre	Forest ecosystem supplies extractable renewable raw materials (e.g. fuelwood, fodder, logs)
	Biological products	Forest ecosystem supplies biological resources that can be developed into biochemical for medicinal or commercial use
	Ornamentals	Forest ecosystem supplies a variety of resources that can be used as ornamentals (e.g. furs, orchids, butterflies)
Regulating ES	Climate regulation	Forest ecosystem regulates albedo, air temperature, and precipitation and acts as both source of and sink for greenhouse gases
	Disease regulation	Forest ecosystem regulates abundance of pathogens
	Pest regulation	Forest ecosystem regulates abundance of pests
	Water regulation	Forest ecosystem regulates timing and volume of river and groundwater flows
	Water purification	Forest ecosystem purifies and breaks down excess nutrients and pollution
	Erosion control	Forest ecosystem helps in erosion control by stabilising soil
	Natural hazard regulation	Forest ecosystem regulates and protects against extreme natural events (e.g. floods, landslides, storms, droughts)
Cultural ES	Educational values	Forest ecosystem provides opportunities for scientific research and learning
	Conservation values	Forest ecosystem provides existence values for species including important values relating to biodiversity
	Aesthetics	Forest ecosystem provides aesthetic (scenery) & amenity values
	Heritage values	Forest ecosystem provides cultural, historical, spiritual, religious qualities (e.g. sacred forest)
	Recreational values	Forest ecosystem provides opportunities for recreational uses (e.g. hiking, biking, camping, ecotourism)

Source: Adapted from **(Hanson *et al.*, 2010; Hearnshaw & Cullen, 2010; Krieger, 2001; Nasi *et al.*, 2002)**

On the other hand, a study in New Zealand has shown that pastures planted with *Pinus radiata* have reduced annual water yield by at least 30 percent **(O'Loughlin, 2005)** and, in southern Chile, watersheds planted with *Pinus radiata* led to reduced water yields **(Lara *et al.*, 2009)**. Hence, in catchments that have water shortage during summer, reforestation may reduce water yields below critical level required to maintain a flow, for household consumption and/or irrigation. Studies in New Zealand have shown that landslides are more likely to occur in deforested lands **(Dymond *et al.*, 2006)**. Dymond *et al.* (2006) have illustrated that forest with native and exotic cover in New Zealand reduces landslide susceptibility by 90 and 80 percent respectively.

3.2 Criteria and indicators

Indicators are a valuable tool as they can help to detect and measure state and trends in flow of ES. For this purpose, indicators for ES are underdeveloped and an agreed list of ES indicators is still lacking **(Layke, 2009)**. It was recognised that indicators for cultural and regulating ES are less developed as compared to provisioning ES **(Hearnshaw & Cullen, 2010; Layke, 2009)**. Despite the difficulty in establishing a comprehensive set of indicators for each ecosystem type, Hearnshaw & Cullen (2010) have recently used a set of indicators for assessing the impact of a water storage project on various ES provided by a Canterbury river system.

For measuring and quantifying ES, de Groot *et al.* (2010) have argued two types of indicators are needed: state indicators that describe how much of ES is present and performance indicators which describe the sustainable use of ES. However, performance indicators are poorly developed due to challenges in quantifying the relationship between ecosystem components, processes and services **(de Groot *et al.*, 2010; Heal & Barbier, 2006)**. For effectively capturing changes in ES of an ecosystem, multiple indicators from environmental and socio-economic perspectives should be considered. This is important as often socio-economic realities are inherently ignored in environmental valuations **(Straton, 2006)** which can lead to wrong policy advice **(Barbier & Heal, 2006)**. Table 2 lists valuation criteria and examples of indicators for the study.

Table 2: Valuation criteria and indicators

ES category	Examples	Indicators	Unit	Indicator type
Provisioning ES	Timber	Roundwood harvested	m^3/ha	Socio-economic
Regulating ES	Climate regulation	Carbon sequestration	tonnes of CO_2 equiv./ha/year	Environ-mental
	Water purification	E. coli levels	10^{15}organisms/ha	Environ-mental
		Nitrogen & phosphorous levels	kg/ha/year	
	Water flow regulation	Water yield	mm/year	Environ-mental
	Erosion control	Sediment yield	sediment in tonnes/ha/year	Environ-mental
Cultural ES	Conservation values	Conservation goal	Unitless	Socio-economic

3.3 Modelling flows of ES

Biophysical models can simulate the likely impacts of land use change on the delivery of ES and their spatial and temporal flows in relation to beneficiaries **(Chan *et al.*, 2006; Hein *et al.*, 2006; Naidoo & Ricketts, 2006)**. These studies on ES assessment have focused on mapping services, their flows, and impact of land use change on flows of ES. It is the biophysical assessment rather than economic analysis that provides stakeholders more accurate information needed for the management of ES. For example, stakeholders who are interested to know the effects of land use changes on low flows during summer in catchments will benefit from biophysical assessment that estimates changes in ES output (water yield) rather than from economic assessment that gives changes in total aggregate value of the catchment's ES **(Heal, 2000).** Thus, it important that ES assessment is carried out at the farm or catchment level using simple biophysical models where most of the management decisions have to be made.

In New Zealand various models have been developed for analysing flows of ES. The WATYIELD model developed by Landcare Research is useful for analysing the effects of land use on water yields and low flows even when there is limited amount of data on climate, soils, and vegetation of a catchment **(Fahey *et al.*, 2004)**. Water quality, which is external to general markets, can be estimated with the CLUES model. This model can estimate effects of land use on total nitrogen, phosphorus, E coli, and sediment loads at catchment, local, and national level **(Semadeni-Davies *et al.*, 2011)**. Another important yet neglected ES, erosion regulation (soil protection) can be evaluated by the erosion model called NZeem®. It calculates erosion rate for each land use type based upon annual rainfall, a land cover factor, and an erosion coefficient that depends upon erosion terrain **(Dymond *et al.*, 2008a)**. Thus, the research will use those models for assessing flows of ES from forests at the catchment level where district councils have to make decisions of natural resources management and use.

On the other hand, cultural ES which include 'non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience' **(MEA, 2003)**, are subjective and vary over space and time. Due to these reasons, it is difficult to predict flows of cultural ES under different land use scenarios. Although there are methods available to value non market ES like revealed preference method which observes individual's behaviour in markets and useful to estimate values of specific ES **(Gürlük & Rehber, 2008; Jim & Chen, 2009)** and stated preference method which directly elicits individual preferences for ES **(Bateman *et al.*, 2002; Bennett *et al.*, 1996)**, they require a great deal of resources and expertise. Further, we hold the view that measuring almost everything in dollar is questionable, especially those ES that have spiritual or emotional attachments **(Kumar & Kumar, 2008)** and fall in the public domain due to public goods characteristics **(Howarth & Farber, 2002)**. As our main research aim is to measure ES outputs that will be generated by forests, we will use the method developed by **Dymond *et al.* (2008b)**.

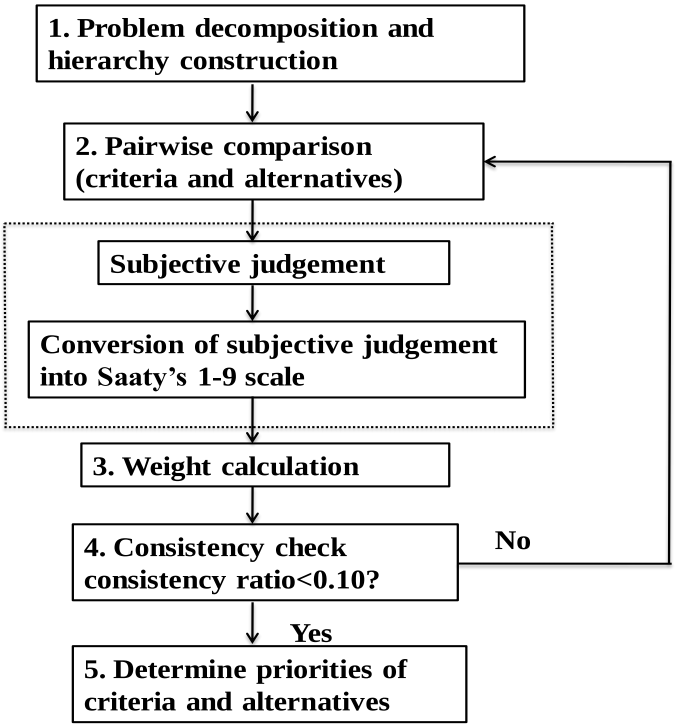
Aussiel & Dymond (2010) have used biophysical models for assessing ES of afforestration on erosion prone land in the Manawatu catchment, New Zealand. We will also use those biophysical models for evaluating ES, but our approach differs in some ways. The authors have categorised conservation values as provisioning ES whereas we classify it as cultural ES as people don't get direct benefit from this service and there is no established market for this service. Second, we will not solely rely on biophysical models for ES assessments; rather we will derive social weights for linking those ES outputs to people by way of cumulative indicator score for each land use type. Finally, we will determine which forestry program is most cost effective in the provision of ES by analysing costs per unit of ES generated.

3.4 Assessing people's preferences for ES

Based on the definition of ES that we adopted in Section 3 which means that without beneficiaries there are no ecosystem services, it is important to elicit preferences of individuals or groups who are likely to be affected by land use changes and flows of ES. For this purpose, we will use the analytical hierarchy process (AHP) which is one of the multi-criteria decision analysis (MCDA) techniques.

The AHP uses theory of ratio scale measurement based on mathematical and psychological foundation **(Kangas, 1993)**. It decomposes the decision problem into decision schema and elements **(Ananda & Herath, 2003)** which are judged qualitatively. Respondents express their relative importance of criteria in the first round and then alternatives in the second round of questions. It decomposes weights of ES by pair-wise comparison within each level with reference to above level in the hierarchy as depicted in Figure 2.

Figure 2: Various steps in AHP



Pair-wise comparison data can be analysed using an eigen-value technique that constructs a matrix using reciprocals of pair-wise comparison. Hence, if A={a_{ij}} then a_{ji}=1/a_{ij} where a_{ij} > 0. As human judgements are not always consistent, the AHP allows for small inconsistency in the judgement. An inconsistency value of lower than 10 percent is acceptable **(Saaty, 1994)**. Saaty (1986) has shown that the largest eigenvalue (λmax) of reciprocal matrix A is equal to n where there are no inconsistencies in pair-wise calculations.

Consistency index (CI) is given by

$$\boldsymbol{CI = (\lambda max - n)/(n - 1)}$$

And consistency ratio (CR) is given by ratio of CI to random index (RI)

CR= CI/RI

Where, RI is the reciprocal matrix of randomly generated CI and the value of RI for 1-15 order matrices can be found in Saaty (1994).

Respondents are asked to prioritise between two elements at a time and then asked to quantify the relative degree of importance using the nine point scale developed by **Saaty (1986)**. The value '1'indicates the two elements are of equal value and the value '9' indicates absolute importance of one element over the other (Table 3). Thus, using AHP we can find out stakeholders' preferences for different ES.

Table 3: Measurement scale of AHP

Degree of relative importance	Definition
1	Equal importance
3	Weak importance of one over the other
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6 and 8	Intermediate values between two adjacent judgements
Reciprocals of above non zero	If factor *i* has one of the above non zero number assigned to it when compared with factor *j*, then *j* has the reciprocal value when compared with *i*

Source: (Ananda & Herath, 2003)

3.5 Effectiveness of forestry programs

For finding out which forestry program is most cost effective in the provision of ES, we need to measure expenditure by government and landowners (Table 4). The chosen forestry programs will be compared by the ratio of total aggregated flow of ES in a given area to total costs.

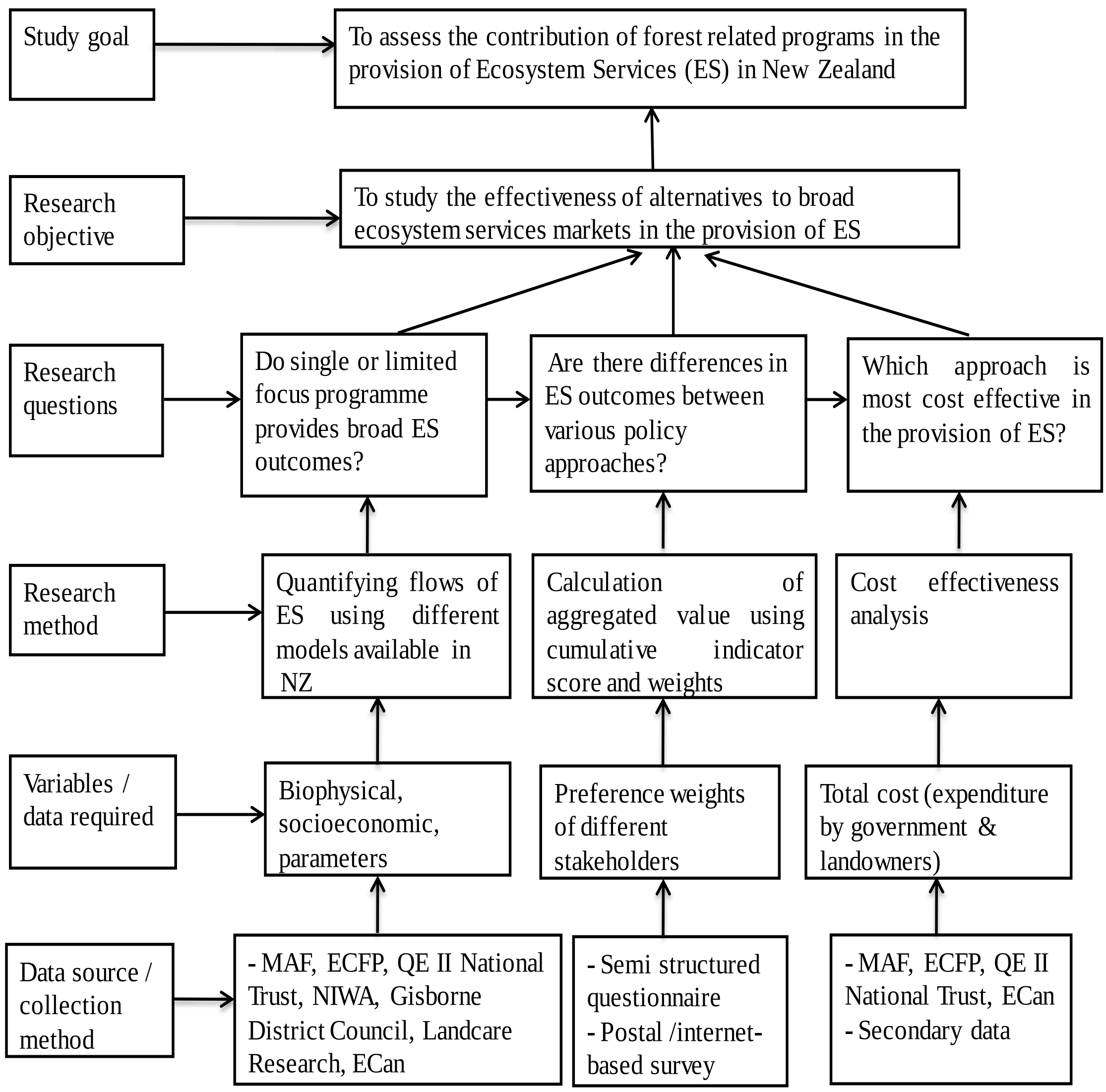
Table 4: Costs for implementing a forestry program

Particulars	Costs NZ$
A. Costs for local & central government	
Program costs	
Administrative costs	
Other costs	
B. Costs for landowners	
Application costs	
Maintenance costs	
Labour contribution (hrs)	
Other costs	
C. Total costs (A+B)	

4. Study site and data

The Canterbury region was selected for the study as this region has witnessed a major land use change in the last two decades. Forests and shelterbelts that once used to dominate Canterbury planes have been cleared for establishing dairy farms which produce higher economic returns compared to other land uses **(Evison, 2008).** However, increased dairy cattle population (more than seven fold increase between 1996 to 2009) and water usage (260 percent from 1985 to 2005) **(Sage, 2008)** has lead to degradation of soil, water and biodiversity. As a result management of water has become the most important environmental issue in the Canterbury region in recent years **(Dark *et al.*, 2009; Hearnshaw *et al.*, 2011).**

The study will use both primary and secondary data. Primary data collection involves eliciting stakeholders' preferences using AHP questionnaire. The main stakeholders in Canterbury are farmers, water resource managers, and the wider community. The data on rainfall, evaporation, slope, soil type, cover factor will be collected from ECan office in Christchurch. The data on cost of implementing forestry programs will be collected from MAF and QE II National trust offices. The details of variables and data collection methods are shown in Figure 3.



The management of many natural resources is governed by the Resource Management Act (RMA), 1991 **(PCO, 2011)**. Within the spirit of the RMA, regional, district, and city councils are responsible for managing natural resources. However, the effort of many landowners have mainly focused on the provision of food or fibre (provisioning services) and other ecosystem services (regulating and cultural) have received less attention **(Rutledgea *et al.*, 2010)**. As a result land uses are selected that provide greater returns in the short run and downstream costs tend to be overlooked. Thus, there is an urgent need to integrate not just provisioning ES, but regulating and cultural ES in the management of natural resources to achieve improved land management.

5. Significance of the study

This study is important in the New Zealand context where current land use practices have severely degraded many ES **(Baskaran *et al.*, 2009; Clark *et al.*, 2007; Cook, 2008; Hughey *et al.*, 2008; MfE, 2009; Moller *et al.*, 2008)**. Degradation of ES will not only impair biophysical aspects of ecosystems, but also it will impair the ES base which is essential for sustaining several major industries in New Zealand - hydropower, tourism, agriculture, and forestry. New Zealand exported food and forestry products worth NZ$26.5 billion or 64% of total merchandised exports in the year ended March 2009 **(MAF, 2011b).** Tourism sector contributed to NZ$21.7 billion in the year ended on March 2009 **(Statistics New Zealand, 2009).** Hence, safeguarding New Zealand's economy will require sustaining or enhancing not just provisioning services, but also regulating and cultural services that are valued by locals and the international community. By assessing the contribution of different forestry programs in the provision of multiple ES, the study will identify the most cost effective forestry program for enhancing ES on private lands in New Zealand.

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