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ABSTRACT

The population in New Zealand is expected to increase to over five million by the mid 2020's from the current level of 4.3 million (Statistics New Zealand, 2009). An increasing demand for primary produce as a result may put pressure on marginal land to be farmed. Understanding the economic value of avoided erosion in New Zealand is therefore an important factor in policy making to optimise the soil related activities in the economy. Establishing a methodology for estimating the economic value of avoided soil erosion is the first step in assessing the problem. This study uses the future forest scenarios developed by Scion to identify potential afforestation areas and thereby compare the current erosion/sedimentation status under current land-use (non woody vegetation) with potential future afforestation. The study aims to quantify the incremental public and private net benefits from the change in scenario. The notion has come under different headings in the literature, such as on-site and off-site erosion effects or sediment and soil erosion effects, all of which recognize the importance of separation of effects to avoid double-counting. The separation into public and private benefits and costs in this case, while avoiding double-counting, will also help identify appropriate policy instruments to avoid soil erosion damage using the private and public net benefit framework (Pannell, 2008).

1. INTRODUCTION

Soil erosion has been identified as one of the major causes of soil deterioration and thus could negatively impact on the main soil services. Over the last 150 years following European settlement, much of the original indigenous forests in New Zealand have been converted to pastoral agriculture increasing the soil erosion and sedimentation in water ways, especially in hill country (Jansson, 1988). Deforestation and agricultural activities were identified as the main contributors to increased flooding and soil erosion throughout New Zealand as far back as the 1930's (Roche, 1997). In the last two decades, however, there has been greater intensification of cropland and dairy farming on better-class land with decreased intensity on hill country by conversion of pastures to plantation forest, reversion to scrub and reestablishment of indigenous vegetation (Sparling & Schipper, 2002). Estimating the economic value of this avoided erosion from plantation forests in New Zealand is important for policy making to optimise the soil related activities in the economy.

Many studies have identified the vulnerability of pasture land to landslide erosion compared to that of forested land or scrub, with forests offering the lest vulnerability (Hicks, 1991; Marden & Rowan, 1993; Pain & Stephens, 1990).. Jones, et al., (2008) suggest that tree (e.g., *Pinus radiata*) planting can be an effective means of controlling erosion. However the "valuable" erosion control service of a forest plot is not seen in market transactions

Many studies have focused on the on-site effects to farmers from erosion (Dominati et al., 2011; Hein, 2007), while some have investigated off-site effects (Clough & Hicks, 1992;

Krausse, Eastwood, & Alexander, 2001). There has been a lack of available data about the impacts of erosion on economic productivity, most data focus on private productivity on-farm and fails to take into account the economic impacts off-farm (Blaschke, Trustrum, & Hicks, 2000). A more encompassing approach to soil erosion valuation has been taken recently in New Zealand, which take greater account of the overall economic impact (Blaschke, Hicks, & Meister, 2008; Hill & Blair, 2005; Page, Trustrum, & Gomez, 2000).

In this study we first analyse the process of reducing soil erosion through the afforestation of marginal land as outlined by the Scion future forest scenarios (Watt, Palmer, & Hock, 2010). Then we propose a novel approach to estimate the overall economic benefits of avoided soil erosion by introducing the concepts of private and public net benefits of avoided soil erosion. Importantly, this approach will enable effective policy discussions around this subject. In section (1) we briefly discuss the issues around valuation of avoided soil erosion. In section (2) we describe the ways to account for these issues. Section (3) outlines a suitable methodology for valuing avoided soil erosion in New Zealand based on previous literature and section (4) discusses the use of such values from a policy perspective.

2. ISSUES FACING THE VALUATION OF AVOIDED SOIL EROSION

If the complex interrelations underlying double counting of economic values from ecosystem services are not disentangled, ecosystem service valuation cannot provide accurate and logical information for policy-making (Fu, et al., 2011). In their study Fu et al. (2011) review much of the relating literature and provide a heuristic outline for dealing with the concepts of double counting. These are:

a) Ambiguity in definition of ecosystem services
b) Complexity of ecosystems
c) Spatio-temporal interdependence of ecosystem services
d) Inconsistency of ecosystem service classification systems
e) Overlap and no cross-referencing of valuation methods

Efforts have been made in the past to provide a framework for classifying ecosystem services (de Groot, Wilson, & Boumans, 2002; Dominati, Patterson, & Mackay, 2010; Millenium Ecosystem Assessment, 2005). These frameworks have recognised the complex diversity of the various roles that the ecosystem services play. The first such framework separated ecosystem services into regulation, production, habitat and information functions, with carrier functions added in later work (de Groot, 2006; de Groot, 1992). This framework outlined how ecosystem services flow from ecosystem processes. The Millennium Ecosystem Assessment (Millenium Ecosystem Assessment, 2005) picked up on the notion to develop a ‘framework of ecosystem services’. These frameworks avoid double counting by reducing ambiguity in the definition of ecosystem services.

The framework provided by Dominati et al. (2010) follows the Millennium Ecosystem Assessment framework but relates specifically to soil. Their work provides an in-depth literature review of previous frameworks for soil classification and quantification, and developed a more encompassing framework (Figure- 1).

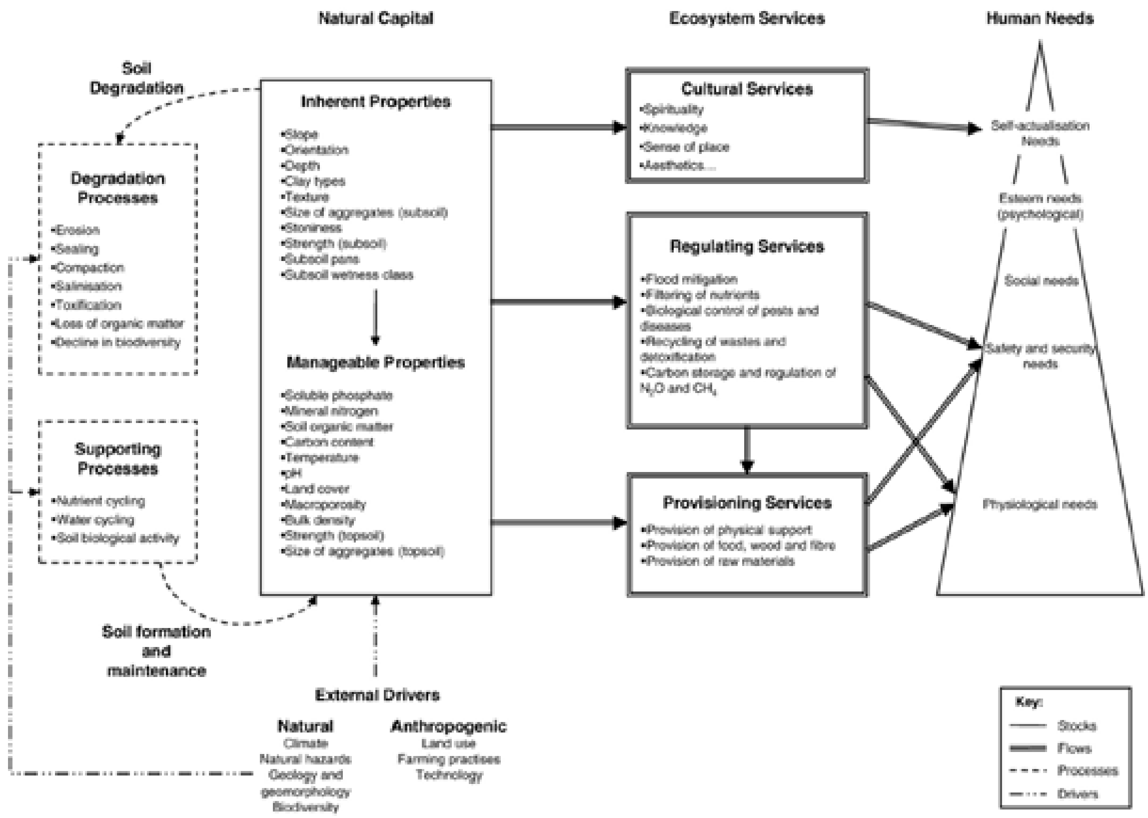

Figure 1: soils framework (adapted from Dominati et al., 2010)

The framework in Dominati et al. (2010) identifies external drivers affecting soil services as natural and anthropogenic, whereby current land management has an important impact on the ecosystem services provided by soil. Many of these services (provisioning, regulating and cultural) are largely impacted as a result of anthropogenic drivers. The valuation of these services along with solutions for maintaining the soil natural capital is key to the maintenance of the value of ecosystem services from the soil.

The services provided by soil can be broken down into cultural, regulating, provisioning and supporting. Cultural services include; recreation and aesthetics; regulating services are those that enable humans to live in a stable, healthy resilient environment such as flood mitigation or carbon storage; provisioning services refer to products provided by ecosystems such as food and timber; and supporting services drive soil natural capital formation and soil functioning, such as nutrient and water cycling (Dominati et al. 2010).

Within this framework, avoided erosion is valued as a degradation process which impacts on the economic value of different ecosystem services derived from the soil natural capital. The framework also enables economic analysis of different land use practices to mitigate soil erosion, including changes in cultural, regulating and provisioning services under different land uses (Dominati et al. 2010).

The complexity of ecosystems means that the inclusion of supporting services in valuation may lead to double counting because their value is captured in how supporting services impact on the supply of the other three types of services: cultural, regulating and provisioning (Hein et al., 2006). The framework provided by Dominati et al. (2010) highlights the complicated entanglement of the different soil services and outlines how supporting services do not provide direct human welfare. Similarly de Groot et al. (2006) recognised that some functions of ecosystem services provide the necessary preconditions for other services. There is an argument, therefore, to exclude supporting services from valuation of avoided soil erosion because estimation of values could be very complicated and may lead to double counting of ecosystem service values. For example carbon storage, a regulating service, provides a stable environment for humans while nutrient cycling, supporting services, are essential in forming and maintaining the soils ability to provide carbon storage. However, to value these services separately would result in an over estimation of the true value of soil.

Often the scale and stakeholders of ecosystem services are correlated (Vermeulen & Koziell, 2002). Short term erosion may affect the private land owner, where as off-site erosion may occur downstream over a longer time period, affecting the public. The spatial effects of soil erosion pose a challenge in valuation. To avoid double counting, they can be separated into those that occur on-site and those that occur off-site- these distinctions are important in the land and soil degradation literature (Berry, Olson, & Campbell, 2003). Separating these effects has been used under different headings in the literature. Some studies refer to it as off-site and on-site effects (Clough & Hicks, 1992) and some as sediment and soil erosion effects (Krausse, et al., 2001). These terms loosely refer to property rights, although some on-site/soil erosion effects may occur on public land, i.e. recreational facilities on Department of Conservation land.

The term private is broader than financial benefits or costs that occur to the private landowner, it includes factors that influence the relative advantage of the new land use options (as perceived by the landholders), such as riskiness, complexity, social considerations, personal attitudes to the environment, and farming systems impacts of the land use practice (Kabii & Horwitz, 2006; Knowler & Bradshaw, 2007; Pannell, 2008). Separation of effects is necessary because we are considering a conservation action and so there are benefits and costs which do not relate directly to soil erosion, such as the costs associated with converting land to forestry. This is more appropriate for comparing the relative net benefits when outlining a policy mechanism to avoid soil erosion (Pannell, 2008).

3. ASSESSING THE EFFECTS OF AVOIDED SOIL EROSION

Afforestation often comes at a high opportunity cost to farmers in productive land areas. For areas with less productive land, afforestation would be expected to cost less to the landowner while avoiding many of the associated off-site costs of erosion, such as flooding. In this study, we will focus on the Land Cover Data Base classes (LCDB2 Class) (Thompson, Grüner, & Gapare, 2003), which generally has less productive value for agriculture.

Some of the costs of soil erosion are not relevant to afforestation (Blaschke, et al., 2008), Krausse et al (2001) estimated the cost of soil erosion to be in the region of NZ$127million however there is no one solution to offset this cost. When looking at a solution to the problem (afforestation), the perspective from which costs and benefits are assessed is something that requires consideration. For example, a change from pastoral activity to forestry is a cost of the conservation method and not a benefit from avoided soil erosion. Thus, careful consideration must be given to identify the relevant costs and benefits as well as whether or not they are costs or benefits associated with afforestation to avoid soil erosion. Table 1 below shows how the costs and benefits are affected by the perspective of the valuation. Cultural services are benefits through aesthetic enhancement in Hill and Blair (2005) because they look at avoided soil erosion from forestry, while Krausse et al. (2001) look at soil erosion directly and thus cultural services such as visual effects are costs of degradation.

A recent comprehensive review of valuation approaches to soil erosion looked mainly at farming in the developing world (Adhikari & Nadella, 2011). The results of which found that many previous studies have used the productivity approach, which estimates the effect of soil erosion on farm productivity and the replacement cost approach, which estimates the cost of replacing the value lost from soil erosion, via the purchase of fertilisers for instance.

Certain limitations associated with these approaches were identified, namely;

a) determining the rate of soil erosion; many studies have used the Universal Soil Loss Equation (USLE)
b) the effect of erosion on productivity, as productivity is dependent on multiple factors not just the loss of top soil
c) determining the discount rate and the time horizon - which affects the risk farmers face and the likelihood of a change in behaviour.

Perhaps most interestingly is the lack of attention given to the valuation of the off-site costs of soil erosion. Although difficult to measure, these estimates are crucial in the decisions of policy makers. Without them, the appropriate action may often not be taken or alternatively no action and the issue of soil erosion will continue.

Since the effects of soil erosion occur both on and off-site it is important to distinguish between these effects, this helps identify those that occur to the private landowner and those that occur to the public. The benefit to a land owner from planting forest may not offer a sufficient price signal to change to this land use. By comparing the relative net benefits of avoided soil erosion more appropriate action can be taken by policy makers to encourage afforestation. This distinction is also important to avoid double counting of costs and benefits.

To further deal with the issue of double counting, supporting functions of soil should be excluded from valuation because they do not provide direct human welfare. These are crucial services for soil formation and maintenance, such as water and nutrient cycling, however the benefit of such services is represented in the regulating, provisioning and cultural services. After identifying the ecosystem services from soil natural capital which contribute to human welfare we must establish the specific attributes to be valued from these services.

The studies outlined in table (1) represent attempts to identify and separate the soil service attributes specific to New Zealand on soil erosion from different perspectives. Krausse et al. (2001) recognise two ways in which soil erosion can cause economic impacts- through sedimentation and soil erosion effects. This was the same approach followed by Blaschke, et al. (2008). Dominati et al. (2010) focus on the services provided by soil. Hill and Blair (2005) look at the values associated with a specific action, afforestation, in the middle Waikato catchment. This approach is most similar to ours although we will focus on a wider spatial scale. Hill and Blair (2005) categorise the benefits resulting from soil conservation in the middle Waikato pilot project, including economic benefits, but do not quantify them.

Table 1 - Soil ecosystem services attributes employed by different studies

	Cultural Services/Effects	Regulating Services/Effects	Provisioning Services/Effects
· **(Dominati, et al., 2010)**	· Spirituality · Knowledge · Sense of place · Aesthetics	· Flood mitigation · Filtering of nutrients · Biological control of pests and diseases · Recycling of wastes and detoxification . Carbon storage and regulation of N_2O and CH_4	· Provision of physical support · Provision of food, wood and fibre · Provision of raw materials

Hill and Blair (2005)	· Aesthetic Enhancement	· Water quality protection and enhancement · Flood mitigation · Avoided sedimentation	· Farm infrastructure protection · Public infrastructure protection · Private property protection
Blaschke et al. (2008), Krausse et al. (2001)	· Visual effects · Loss in landowner confidence	· Reduced water quality · Increased flood severity · Water storage loss · Biological degradation	· Recreational facility damage · Direct property damage · Off farm infrastructure damage · On farm infrastructure damage

4. PROPOSED METHODOLOGY

Two steps are involved in estimating the incremental cost and benefits of soil erosion from a given land-use change. First, we should estimate the changes in erosion level due to changes in the land use pattern from current to the new land use practices. We should then estimate the corresponding incremental changes in private and public costs and benefits due to the change in erosion levels. This method has three main advantages over aggregate cost and benefit measures of soil erosion to a country- which is the approach followed by the national level study for New Zealand conditions (Krause et al.,2001):

(i) The method is useful for policy making because it provides insight into marginal costs and benefits of moving from the current activities and thus helpful to identify the economically optimum level of soil erosion control for the economy
(ii) Results of the study could be directly used in policy analysis by using the private and public cost policy analysis framework developed by Pannell (2008)
(iii) The method is normally localised in scope and therefore could draw on site specific parameters to conduct proper valuation of costs and benefits.

In this analysis, private benefits-costs refers to the costs or benefits accruing to the private land manager as the results of the proposed changes in land management. In principle, private benefits-costs are broader than financial benefits-costs. They include the broad range of factors that influence the relative advantage of the new land use options (as perceived by the landholders) such as riskiness, complexity, social considerations, personal attitude to the environment, and farming systems impacts of the land use practice (Kabil and Horwits, 2006; Knowler and Bradshaw, 2006; Pannell et al.,2006). Public benefit-costs- means the benefits or costs accruing to every one other than the private land manager.

4.1 Evaluating Erosion and Sedimentation for Land-Use Scenarios

To conduct this study we need data to evaluate erosion and sedimentation for different land-use scenarios. We will use the results from the New Zealand Empirical Erosion model-NZeem (Dymond, Betts, & Schierlitz, 2010) to provide sedimentation and erosion) estimates. The model can be used to predict mean sediment discharge in response to land-cover/land-use scenarios. The model uses input data readily available in GIS layers in New Zealand. NZeem is suitable for national management applications, in contrast to physically based models that are presently only suitable for specific research catchments (Dymond, et al., 2010). NZeem allows us to estimate the incremental soil erosion levels for different land types given in the Land Cover Data Base (LCDB2 Class) developed by Thompson et al. (2003).

4.2 Evaluating Net Private and Public Benefit of Avoided Soil Erosion

We will evaluate the benefits of avoided soil erosion impacts by utilising NZeem overlaid with positioning future forest scenarios developed by Scion (Watt, et al., 2010). In using the future forest scenarios, (3 afforestation areas ranging from land affected by severe to extreme erosion to include land affected by slight to extreme erosion~0.7, 1.1, and 2.9 million ha) we can identify potential afforestation areas and compare the current erosion/sedimentation status under current land-use (non woody vegetation) with potential future afforestation using *Pinus radiata*, which accounts for 89% of New Zealand plantation forestry. Radiata pine is highly effective in controlling erosion and provides the greatest returns under carbon forestry among New Zealand's plantation species (Turner, et al., 2008).

As forestry and livestock are perennial activities, a 30 year lifespan for this analysis would usually be appropriate. However during the harvesting period the suspended sediment yield reduction from forestry compared to pasture land is often reversed. This suspended sediment yield is the key contributor to water levels and hence flood damage (Blaschke, et al., 2008). In Hawke's Bay, for instance, a 3-4 fold reduction in suspended sediment yield was measured in catchments with mature pine plantations in the pre-harvesting phase compared to pasture land. While in the first year of harvesting there was a 2-3 fold increase in suspended sediment compared to pasture (Fahey & Marden, 2006). Thus a 60 year lifespan will be investigated to account for this issue.

Highlighting the added cost from harvesting will also impact on the decision of whether the afforestation should be carbon forestry or timber production. Watt et al. (unpublished) noted a number of issues under their scenarios where forests, in which no harvesting is planned, should be used solely for carbon sequestration and environmental protection. This also impacts on the mix of provisioning ecosystem services from afforestation; carbon sequestration and/or timber production.

Furthermore, the estimation for net private and public benefits is a discounted measure. A low discount rate is suitable for discounting for long-term projects. We will conduct a sensitivity analysis using different possible discount rates to reflect both private (normally greater than the cost of capital) and public interest of the long-term benefits.

More recent data sources that compile nationwide erosion valuation include Blaschke, et al., 2008; Jones et al., 2008. These studies will be used as the main sources of data for estimates in this study. For our analysis a further breakdown of the value of avoided soil erosion involves classifying the identified attributes from the literature into the public and private benefits and costs. Table 2 provides an outline of these classifications.

Table 2 - Public and private benefits and costs from avoided soil erosion due to afforestation

Private Costs	Private Benefits	Public Costs	Public Benefits
Establishment and harvesting of forest	Avoided farm infrastructure damage	Construction to reduce soil erosion damage	Avoided public infrastructure damage
Opportunity cost of land use change	Avoided private property damage	Policy mechanism costs	Avoided flood damage
			Avoided damage to consumptive water quality
			Avoided damage to soil regulating facilities

4.3 Estimating Private Costs

Establishment and harvesting cost of forest

Direct market prices of material and labour should account for this estimation using any available forestry financial analysis models.

Opportunity cost of livestock

Benefit forgone by ceasing livestock activities could be estimated by employing direct market prices. Farmax farm modelling software is capable of this estimation. It is important to account for lost productivity due to soil erosion in sheep and beef farming. The higher erosion levels of sheep and beef farming activity compared to forestry plantations could be estimated by NZEEM (Dymond, et al., 2010). The value of the productivity loss due to corresponding incremental erosion levels could be estimated using two methods:

(a) De Rose et al. (1995) cited by Krausse et al. (2001) estimated expected pasture production recovery curves for areas lost to slipping. We could then use Farmax to transform expected pasture production curves into associated financial indicators of sheep and beef farming.

(b) The value of the provision of support for farm animals using a proxy- for the amount of days that the soil would not support the animals. The annualised cost of the construction and maintenance of a stand-off pad would provide an estimate of the cost of the lost soil service. This was estimated at an average of NZ$90/ha/yr (35yrs) (Dominati, et al., 2011).

4.4 Estimating Private Benefits

Benefits from forest end products and ETS schemes could be estimated by direct market values. It would be useful to simulate benefits from different life spans, as the ETS scheme offers the flexibility of different length life spans while reducing the erosion incurred during harvesting.

Value of avoided farm infrastructure damage

For this estimation we employ Korte's (unpublished, cited by Krausse et al. 2001) relationship between scar and debris area and infrastructural damage (fences, tracks). Blaschke et al. (2008) used a summary of reliable data, under-pinned by real costs and returns collected for an area where an investigation was carried out (Hicks, 1995).

Value of avoided private property damage

As reported in Krausse et al. (2001), this damage estimation of erosion can be derived from the Earthquake Commission payments for damage costs to residential properties.

4.5 Estimating Public Costs

This will include the costs of constructions designed to reduce damage caused by soil erosion. As per Krausse et al. (2001) relevant data for this estimation is available at Transit NZ. In addition, data available at relevant regional councils on soil conservation programs could be useful for this estimation.

4.6 Estimating Public Benefits

Value of avoided road/rail infrastructure damage

Estimation of avoided road/rail infrastructure damage could be gathered from the data available at Transit NZ which is responsible for maintaining the state highway network in New Zealand.

Value of avoided damage to utility network

As indicated by Krausse et al. (2001), Telecom management supplied data based on the average fault repair costs as outline in utility network damage. It is possible to get an average estimate on damage to utility network form soil erosion from this data base.

Value of avoided damage to recreational facility

Costs of erosion related repair and maintenance for recreational facilities are available at the Department of Conservation. Erosion related estimation could be calculated from this database.

Value of avoided damage due to increased flood damage
Whole catchment afforestation would result in reducing the frequency, duration and magnitude of flood waves passing down a channel. These changes would be too small to affect over bank flooding. Valuation should instead be focused on reduced sediment yield causing improved channel flood capacity (Blaschke, et al., 2008). Establishment of pine plantations was a mitigation option common to most sub-catchments in Tauranga, and was expected to be effective in reducing sediment loads (Hume, Green, & Elliott, 2010). With effective sediment control the costs associated with the frequency or overall necessity of sediment removal from waterways can be avoided (Hudson, 2005).

It was estimated that nine major floods in New Zealand in a 16-year analysis period (1968-84) costs $1.3 billion, and that when additional losses from smaller flood events are added, the total annual loss equates to around $80 million (1984-value) (Ericksen, 1986). Around 15% of flood damage costs could be attribtued to soil erosion and sedimentation (Clark, Haverkamp, & Chapman, 1985).

Value of avoided damage to consumptive water quality
The drainage network in New Zealand becomes a source, a sink and a conduit of sediment and contaminants. As reported in Krausse et al. (2001) approximately 10% of total water treatment costs can be due to sediment filtration. It would be possible to gather estimates on water treatment costs in the proposed afforestation areas perhaps through city council data bases.

Value of soil regulating services
The value of soil regulating services could be estimated using the defensive expenditure method. For example, the value of the amount of nitrogen (N) lost by the soil can be estimated by using the amount of money farmers spend to deal with the lack of provision of the service as a proxy (Dominati, et al., 2011). In this case the amount of nitrogen lost by leaching was modelled using SPASMO, from Plant and Food Research (Green, et al., 2003), to quantify the filtering of nitrogen. In Dominati et al. (2011) filtering of N (regulating service) was estimated, as an average over the 35 years modelled, at 36.8kg N/ha/yr of N lost. This was estimated at an average of NZ$554/ha/yr.

5. POLICY PERSPECTIVE

Among the factors affecting soil erosion and conservation, the most direct impact on land managers is the external land use policies in place (Boardman, Poesen, & Evans, 2003). These policies provide price signals, explicitly as constraints or implicitly as subsidies, which encourage land managers to make decisions which provide the best economic return and not to take into account of the impacts of their actions on the environment, a cost faced by society.

Following the estimation of the net public and private benefits of avoided soil erosion due to afforestation projects we will use the net private and public benefit policy framework (Pannell, 2008) to assess the relative magnitude of net private and public benefits of avoided soil erosion from the afforestation scenarios from a policy perspective. The framework given in figure (2) does not include the direct cost of the policy action but is more useful for outlining the method for comparing the public and private net benefits. Pannell goes onto include the cost of policy action along with the cost of a lag to adoption in the framework and how it affects the policy choice but for an outline for the framework this diagram is more appropriate.

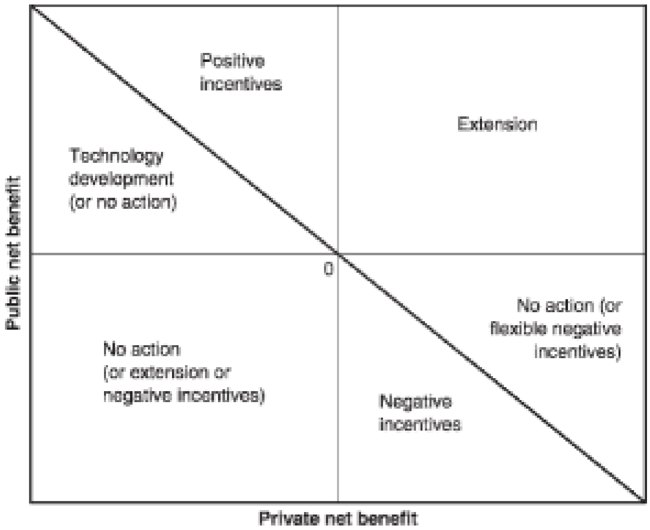

Figure 2: Selection of policy instruments based on public and private net benefits of land use changes (Pannell -2008)

The choice of appropriate policy mechanism is very important in avoiding the cost of soil erosion efficiently and effectively. To ensure that land use is more sustainable and does not incur external costs on the public, such as reduced water quality or flooding different policy options should be carefully assessed considering the relative magnitude of net private and public benefits. This study would therefore contribute to providing a more realistic economic value of the full range of services provided by forests and the externalised costs of erosion from pastoral land. We envision that this would contribute to future policy decision making.

The separation of public and private is one method for avoiding double counting of benefits and costs. It is also important for outlining practical steps for selection of a cost effective policy mechanism to deal with the issue of soil erosion by comparing the relative net benefits to the land owner and society at large.

A recent afforestation initiative by national government has been the Sustainable Land Management (Hill Country Erosion) programme (HCEP), this scheme seeks to, 'increase the protection of New Zealand hill country pasture with a severe or extreme erosion risk' (Ministry of Agriculture and Forestry, 2010). Funding from the scheme has been allocated to some regional councils (Greater Wellington, Taranaki, Hawke's Bay and Manawatu-Wanganui)-three of which have just completed their first year of an 8 year programme. The success of these projects cannot be accurately assessed as initial costs are expected to outweigh benefits in the early stages. However the Whole Farm Plans tool used by the Horizons regional council in the Manawatu-Wanganui region encourages farmers to include forestry into farm planning to reduce erosion risks to themselves and the public and, in the first four years of the programme, have covered 40,000ha of highly erodible land. The government emphasise the importance of quantifying the problems of sustainable land management environmentally as well as economically, stating that, 'the costs and benefits of the proposal (HCEP) need to be clearly described to enable a balanced judgment of whether the proposal is rational to fund from an economic perspective' (Ministry of Agriculture and Forestry, 2011). The framework proposed by this study will enable for policy makers to make better judgments around policy approaches in their effort to mitigate damages from soil erosion to the New Zealand economy.

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