

ARGOS Working Paper No. 3, February 2005

# Draft: Research Rationale for the Economic Objective, ARGOS

*By Caroline Saunders and Martin Emanuelsson*

## Table of contents

1	INTRODUCTION	4
2	ENVIRONMENTAL RESOURCE ECONOMICS	5
2.1	OPERATION OF MARKETS	6
2.1.1	<i>Market equilibrium</i>	7
2.2	PROPERTY RIGHTS	8
2.2.1	<i>Property Rights and the market</i>	8
2.2.2	<i>Transfer of property rights</i>	8
2.2.3	<i>Enforcement</i>	9
2.2.4	<i>Property rights and market efficiency</i>	9
2.3	DIFFERENT TYPES OF GOODS AND SERVICES	10
2.3.1	<i>Rival Exclusive goods</i>	10
2.3.2	<i>Rival Non exclusive goods</i>	10
2.3.3	<i>Non rival exclusive goods</i>	11
2.3.4	<i>Non rival non exclusive goods</i>	11
2.4	EXTERNALITIES	12
2.5	MARKET FAILURE AND INEFFICIENCY	12
2.5.1	<i>Imperfectly defined property rights</i>	12
2.5.2	<i>Imperfect information</i>	12
2.5.3	<i>Few buyers and sellers and barriers to entry and exit</i>	12
2.5.4	<i>Market failure and time</i>	12
2.6	MARKET FAILURE AND POLICY	12
2.6.1	<i>Private resolution through negotiation</i>	12
2.6.2	<i>Courts</i>	12
2.6.3	<i>Environmental policy</i>	12
2.7	ROLE OF THE GOVERNMENT	12
2.7.1	<i>Government failure</i>	12
	SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT	12
2.8	SUSTAINABILITY	12
2.9	MEASURING SUSTAINABLE DEVELOPMENT	12
2.9.1	<i>Sustainability indices</i>	12
2.9.2	<i>National accounts and the environment</i>	12
2.9.3	<i>Triple bottom line reporting</i>	12
2.9.4	<i>Natural step</i>	12
3	RESEARCH APPROACH	12
3.1	ECONOMIC INDICATORS AND FINANCIAL ANALYSIS	12
	<i>Preliminary data need</i>	12
3.2	ECOLOGICAL ECONOMICS AND SUSTAINABLE DEVELOPMENT OF NEW ZEALAND AGRICULTURE	12
3.2.1	<i>Avenues of research within EE</i>	12
3.3	TRADE AND THE ENVIRONMENT	12

3.3.1 Possible extensions..... 12

3.4 PUBLIC POLICY INTEGRATION AND THE DEVELOPMENT OF A MULTI CRITERIA ANALYSIS (MCA) FRAMEWORK TO ASSESS REGIONAL SUSTAINABLE DEVELOPMENT TARGETS FROM QTL PERSPECTIVES. .... 12

APPENDIX 1: HISTORY OF RESOURCE ECONOMICS 12

*Classical Economists* ..... 12

*Socialism*..... 12

*Marx*..... 12

*Neo classical Economics*..... 12

*Post war economics* ..... 12

# 1 Introduction

The primary interest of an economist is the allocation of scarce resources to satisfy infinite “wants”, and several theories on how this can be done has been developed. The most prominent and well known of these theories are Marxism and the neo-classical approach<sup>1</sup>

The dominating theme in the post war economics has been financial growth and until the 1960’s, environmental concerns were of secondary importance. From then and onwards, a growing awareness of the social and environmental costs of financial growth has fuelled an ongoing debate and contributed to approaches in economics that explicitly recognises social and environmental aspects of the economic context.

Also these “new” theories differ in the way they propose society should go about allocating our scarce resources to different uses. However, in our opinion, they share a common objective, i.e. to *maximize societies welfare*, with welfare very broadly defined, definitely including such things as clean air and nice views as well as financial aspects.

---

<sup>1</sup> See Appendix 1 for a brief outline of the history of economics.

## 2 Environmental resource economics

Environmental economics explicitly recognises that economic theories cannot operate without the support of the ecological system or biosphere. Thus our economy is an *open system* and we have the materials balance approach based upon the first and second theory/law of thermo dynamics, that is:

1. All resource extraction, production and consumption, eventually result in waste products equal in matter/energy terms to the resources flowing into these activities.
2. There is no possibility of 100% recycling.

Therefore we cannot ignore the interactions between the natural environment and our use of resources (the economy). Natural Resource Economics looks at the interaction between production and consumption activities and the wider environment. There is nothing new in this, in fact economics started as a subject to look at natural resource issues.

Although the definition of resources has changed through time due to increased knowledge, technical improvements, and cultural developments, they usually fall into 3 broad types:

- Raw materials and inputs.
- Amenity and living space.
- Ecosystem functions, especially assimilative capacity.

For the purpose of this paper (and the ARGOS project), we use the construct "resource" in its broadest sense. Essentially a resource is anything that that can achieve societies goals (i.e. change welfare) and include fresh air, pretty views, wildlife as well as coal, oil and other marketed goods and services. The general problem of economics is how (or whether) to use these scarce and finite natural resources to maximise social welfare. Thus we have to make choices, in New Zealand and much of the world.

These 'choices' are usually done via the "market mechanisms", the "invisible hand of the market". Market economics illustrates that perfect operation of the market leads to

maximum efficiency in resource allocation. However, markets frequently do not operate perfectly, *especially in the case of natural resources*, but economists often still use this as an ideal and a 'bench mark' against which to evaluate other solutions/outcomes. Consequently not all of our resource allocation choices are done via the market mechanism; in New Zealand and other "market economies" around half of the resource allocation is decided upon by government and similar institutions.

## 2.1 Operation of markets

Markets act as a co-coordinating mechanism that brings buyers and sellers together. Household decisions about consumption, firms' decisions about what and how to produce, and factor (land, labour, capital) owners decisions about how much to work/invest, *can* be "decided" via markets and the price mechanism.

In a market we distinguish between buyers (demand) and sellers (supply). Demand is defined as potential willingness to pay (WTP) for good or service in a period and/or as potential benefit from good or service. The demand is generally influenced by price, price of other goods and services (substitutes and complements), income, tastes and values, population, etc. We demand goods and services because we obtain some benefit (satisfaction or utility) from them. Demand therefore represents the benefit we get from each unit we have. The price or demand curve is the *Marginal Benefit Curve*, the benefit we obtain for an extra unit of this good or service. The benefits can be differentiated into *Marginal Private Benefits (MPB)* and *Marginal Social benefits (MSB)*. It is the later than economists are interested in.

Supply is the willingness to provide/produce a good or service in a particular period. Level of supply planned depend upon; price of good, price of substitutes and complements; price of factors used in production; number of suppliers in the 'industry'; technology; and so on.

Why do producers supply goods or services? Because they want too? They have too? Want to 'make a living'? Whatever the reason they have to cover their costs in doing so otherwise they will be no longer able to provide the good or service. Marginal Cost is defined as

change in total cost per change in output. The Marginal costs curve should include all costs to society not just private costs therefore we can differentiate between:

- Marginal Private Costs (MPC) - costs to private producer.
- Marginal Social Costs (MSC) - all costs to society and it is this which economists are concerned with.

### 2.1.1 Market equilibrium

In a perfectly competitive market, equilibrium will occur where quantity demanded equals quantity supplied, or differently put, when  $MSB = MSC$  (the social and/or economic optimum).

The market equilibrium is the most efficient outcome<sup>2</sup> as it makes sure goods and services are provided at least cost (minimise use of resources), and that the goods and services go to those who value them the most. This means that no one can be made better off without someone else being made worse off or it is not possible to produce more of one good without producing less of something else. This is efficient because it maximises the difference between benefits and costs to society.

Economic/social efficiency only occurs under certain assumptions that meet the conditions of *perfect competition*. Perfect competition exist when:

- Many firms are selling an identical product.
- Many buyers.
- No restrictions to entry or exit.
- Perfect information.
- No external costs/benefits (that is  $MSC=MPC$  and  $MPB=MSB$ ).
- Firms are price takers. As there are many buyers and sellers no one can alter the market price just accept it.

---

<sup>2</sup> NB efficient NOT EQUITABLE.

Of course we can think of many instances or situations where perfect competition is far from the case. Such instances are usually referred to as market failure and needs special attention and careful consideration. Before we get into that however, we need some more instruments; property rights; distinguish between different types of goods and services; and understand externalities.

## **2.2 Property rights**

Property rights define ownership (ownership being the right to use, sometimes legally defined) and are made up of entitlements, privileges, and limitations. How resources are used depends upon the property right structures. By examining such rights and how they affect human behaviour we can better understand outcomes in relation to environmental resource use, and how these are affected by government and market allocations. Some argue many of our environmental problems relate to the property right structure.

Property rights can be vested with individuals as in a capitalist economy or with the state as in a command economy (in fact most societies use a combination of the two).

### **2.2.1 Property Rights and the market**

Property rights are an essential prerequisite for a market; who would pay for something if they couldn't use it? Ownership assigns the right to use, subject to various conditions, where the least restrictive kind is exclusive use rights. Some of these rights are defined in law but many are not and it is basic values and behaviour which constraint or influences our actions.

Individuals exercising their rights to use may come into conflict. Therefore it is necessary to reduce conflict between non-owners and owners of property rights. So rights accompanying ownership have to be specified. How these are specified will vary due to legal, cultural and economic factors. It is these that are the fundamentals behind our society, economy and trade.

### **2.2.2 Transfer of property rights**



The fundamental base of trade is not the physical movement of goods but the transfer of rights, e.g. land buying and selling does not mean movement of land but the actual transfer of rights of ownership. Even purchasing a good is the transfer of right to use that good. Stealing does give physical possession of good but not the right to use it. If trade is to be effective then rights must be transferable so they can go to their highest value use.

This frequently means that goods and services are broken down into a number of rights each of which can be transferred. For example, in land use, there are a complex set of rights which has led to a complex legal structure defining these rights and enabling them to be traded, such as leasing, renting, share cropping, covenants, rights of access, rights to different services off the land (mineral; water; agricultural; conservation), right to pollute, etc. These all allow for more efficient use of land.

### 2.2.3 Enforcement

Property rights must be backed up by a penalty system if these rights are violated. Unenforceable rights are not rights at all. So the penalty for violating rights must be such that it exceeds the benefit from violating rights. For example, pollution control policies; the probability of getting caught and the level of fine if caught often do not outweigh the benefit of polluting.

### 2.2.4 Property rights and market efficiency

Property rights define rules of the game; they are the basis upon which markets operate and economic efficiency occurs as long as they are *non attenuated*, that is:

1. Completely specified - perfect information about rights; their restrictions or use and penalties for violation.
2. All rewards and penalties resulting from use of right accrue to the owner. That is they are *exclusive in use* and *rival*.<sup>3</sup>

---

<sup>3</sup> Exclusive - the owner can exclude others from being affected by the good or service; rival - only the owner can benefit from the good or service (i.e. depleted in consumption). See also 2.4.

3. Transferable - so rights can go to highest value use i.e. free market in transfer of rights.
4. Rights are completely enforceable.
5. Universal - all within a society are affected.

This process is not costless. Specification, transfer and enforcement of rights are costly, e.g. our courts, police force and lawyers, all exist to enforce and specify rights. These costs are called transaction costs (or ICP; information, contracting and policing costs).

There is no unique set of property rights that will achieve Pareto Efficiency, just as there is not in the case of income distribution. So property rights need to be defined first and, to re-emphasise, these *reflect social, cultural, and the institutional basis of society*.

## **2.3 Different types of goods and services**

We mentioned above that a condition for property rights to achieve market efficiency is that the good is rival and exclusive in use. What other types of goods exist? How can we work these goods to achieve market efficiency? In reality goods and services rarely fit into neat categories but they are helpful to our understanding.

The basic distinction is between rival versus non-rival goods, and exclusive versus non-exclusive goods. A rival good is depleted in consumption and a non-rival is not. An exclusive good is a good where all rewards and penalties from its use accrue to the owner.

### **2.3.1 Rival Exclusive goods**

Also referred to as *Private Goods*. These are allocated by the market, and are exclusive in use and rival (depleted) in consumption.

### **2.3.2 Rival Non exclusive goods**

These goods are rival (depleted) in consumption but it is not possible (cost effective) to exclude others from their use. Otherwise known as *Common Property Resources*.

Consequences of market failure in non excludable goods or common property resources are; under-provision of goods; over-exploitation; under-investment in management conservation and productive capacity of a resource.

In excludable goods efficient allocation is assured by the selfish behaviour of individuals. However for Common Property resources allocation usually needs to be provided by the public sector (or by private philanthropy).

If exclusive or non-attenuating property rights are specified and enforced, economic optimum is possible. To this end society has continued to put exclusive property rights on previously non-exclusive goods i.e. enclosures. Some goods remain non exclusive for:

- a) Cultural and Political reasons - goods vary according to different societies.
- b) Basic characteristics of the good; ocean fisheries - mobile species of fish; ozone layer - it is impossible to establish property rights as it is too costly.

The totally non-excludable resource is rare; often choices are available. Rules can be specified to restrict access to a resource e.g. restrictions on fishing fleets.

### 2.3.3 Non rival exclusive goods

These are such goods as un-congested roads and recreational areas where it is possible to exclude consumers but there is no rivalry in consumption. In the absence of perfect discriminatory pricing it is not possible to allocate Pareto efficiently.

### 2.3.4 Non rival non exclusive goods

*Public goods*, where use is non-exclusive and consumption non-rival (not depleted when used (or indivisible)). With public goods more than one consumer can benefit from them at the same time and they cannot be excluded from having the good. Therefore the problem exists as how to:

- a) Get consumers to reveal their WTP for the good or service.

- b) Get them to pay for it.

This alludes to the problem of *free-riders*; those who understate their WTP as they assume good will be provided anyhow. It is usually because of this that public goods are provided out of taxation.

#### *Allocation of Public Goods*

The provision of Public goods or service is not any different from a private good, i.e. an upwardly sloping MSC curve (sometimes public goods are also shown as fixed supply, so a vertical MSC). However the benefits of consumption occur to all beneficiaries so  $MSC = \text{sum of MB's}$ . Assume two consumers a and b with marginal benefits represented by  $MB_a$  and  $MB_b$ . In the case of a private good the MSB would be calculated by summing the quantities of the two marginal benefits at each and every value (summed horizontally). However with a public good the marginal social benefit is calculated by adding the marginal benefits at each and every quantity as they can both benefit at the same time (summed vertically). For the market to allocate public goods efficiently each beneficiary has to reveal their WTP for the good but few will do this due to the free rider problem. There is less incentive to do this the smaller the number of beneficiaries and in this case the good may be provided by a club.

#### *Congestible goods*

There are goods that may be non-rival up to a point and then when usage goes beyond this point congestion occurs and the good becomes rival (goods of this type include roads; parks; recreation areas). Therefore the MSC is 'low' until congestion occurs when it rises rapidly.

The definition of the goods above does depend upon their physical characteristics and secondly the socio- cultural factors. For example a National Park is a non-rival exclusive good by its physical nature but for socio-cultural reasons it is effectively a public good.

## **2.4 Externalities**

Externalities are a form of public good but differ in that they are a *by-product* of a consumption or production activity that is not valued by the market. The most common of these is pollution that is a negative externality, but not all externalities are bad.

A negative externality is when the Marginal Social Cost (MSC) is greater than the Marginal Private Cost (MPC), and thus the level of production and/or consumption activity should be reduced.

A positive externality is when the Marginal Social Benefit (MSB) is greater than the Marginal Private Benefit (MPB) in production and/or consumption. In this case the level of production and/or consumption activity should be increased.

It must be remembered that there are few, if any, activities that do not have some form of externality attached. Thus the problem becomes one of finding a modified alternative that accounts for the externality. Different types of externality cause different problems, for example:

- Point pollution is relatively easily dealt with as the source can be identified and negotiation can take place between the agencies involved.
- Non-point pollution is more difficult in that it may come from a number of sources and problems arise as to how to allocate costs to the polluters.

## **2.5 Market failure and inefficiency**

In the “real” world the market mechanism is subject to frequent failure and thus creates inefficiencies, especially in the case of environmental goods and services. Market failures can be contributed to the following causes:

- Imperfectly defined property rights.
- Imperfect information.
- Few buyers and sellers.
- Barriers to entry and exit.
- Positive discount rates on future benefits

### 2.5.1 Imperfectly defined property rights

Market failure due to imperfectly defined property rights occur where there are non-exclusive property rights or where property rights are not specified. Frequently rights are not perfectly specified and cause market failure due to:

- a) *Incompletely specified property rights* occur where there is imperfect information about rights, their restrictions or use, and penalties for violation.
- b) *All rewards and penalties resulting from the use of right do not accrue to a defined owner.* It is this which we will spend the most time on as this is often related to the physical nature of the good and especially prevalent in the case of the natural environment (see 2.X).
- c) *Non transferable - rights do not go to the highest value use.* Frequently for cultural and social reasons transfer of rights is not acceptable. That is not market failure but the rules of the game (e.g. sale of endangered species, sale of children) Also society may decide not to let resources go to the highest value use for reasons of equity.
- d) *Rights are not enforceable.* This again is often related to the cost of enforcement and frequently this is greater than the benefit from enforcement. There are also many cases where enforcement is sub optimal e.g. pollution law.

### 2.5.2 Imperfect information

In reality all markets suffer from imperfect information but there are special reasons why this might lead to market failure in the case of natural resources and/or environmental goods and services. Much of this is related to uncertainty:

- Incomplete knowledge on the preferences of future generations. If we knew this then our allocation over time could allow for future generations and future markets could allocate goods between time periods.
- Scientific uncertainty. Our knowledge of environmental goods and services is incomplete. We do not know the impact of our actions on the environment.
- Technological uncertainty. We do not know what is possible.

- Political uncertainty. This is often the cause behind changes in resource use.

### 2.5.3 Few buyers and sellers and barriers to entry and exit

When these are the conditions we have an imperfect market structure such as monopoly or imperfect competition. Environmental goods and services, because they are often geographically concentrated, tend to lead to this form of market failure.

The implication of this is that less will be traded at a higher price than under a perfect market structure. This might be desirable as it allows for conservation of a resource. However that also may lead to supernormal profits, which may be socially undesirable. This often leads to the demand for natural resources to be nationalised so that the government can take these profits and use for society's benefit.

However the trend is to denationalise at the moment with change in property right structure to reduce supernormal profits. The reason for this is that nationalised industries do not produce on their costs curves and therefore are not efficient.

### 2.5.4 Market failure and time

Another cause of market failure is the time effect on benefits; positive discount rates reduce the value/weight of future benefits compared to present ones. Private discount rates are seen as necessary to encourage savings and investment now. However, especially in the case of environmental goods, there are strong arguments that the private discount rate is too high and that a lower social discount rate should be used (even a zero rate in some cases). The arguments for this include:

- Risk for society is less than for individuals so lower reasons for a risk premium on the discount rate.
- Environmental goods are a special case. They frequently require long-term investment decisions, which are costly in the short-term but provide long-term paybacks.

## 2.6 Market failure and policy

The economic literature tends to focus on market failure and externalities as special cases but this is not the case. This is especially true when externalities are combined with imperfect markets and risk and uncertainty in conjunction with public goods. So we need some form of market modification, usually achieved through:

- private resolution
- courts
- changing legislation
- government intervention
- government provision

### 2.6.1 Private resolution through negotiation

The simplest means to restore efficiency when there are imperfectly delineated property rights is through private negotiation. This does occur frequently especially where relatively few members are involved/affected. However in many cases this is not sufficient and we have:

### 2.6.2 Courts

Courts can respond by imposing property or liability rules. Property rules state the initial allocation of the entitlement e.g. who has the right to clean air or the right to pollute? Liability laws are where courts enforce liability of a party and make them pay compensation. However, the courts may not be able to solve this so we have legislative or executive decisions where policy needs to be changed or new laws developed.

### 2.6.3 Environmental policy

Environmental policy is aimed at changing the rules of the game so we consider environmental impacts more explicitly. The values we place upon the environment change over the long-term and are uncertain. So environmental policy must assume values and focus



upon the context humans operate within, i.e. the economic and social system. What laws are passed, and just as importantly enforced effectively, does depend on public attitudes, sympathy with the law change, and the enforcement of that law. Thus environmental policy tends to be pragmatic and policy responds on a piece meal basis.

*Government intervention* can be either indirect, providing information or aiding operation of the market, or direct through taxes and subsidies or quotas.

*Government provision* is when the market failure is deemed to be either complete or the political will is for the good or service to be provided by the government. The government has a central role in the provision of pure public goods but also provides many good and service for efficiency or political reasons. In reviewing or determining provision we therefore need to assess:

- a) What is the 'nature' or class of good or service in theory and thus what types of provision are feasible?
- b) Are these types of provision feasible in practice?
- c) Are these types of provision politically feasible?

Thus we can assess why we are doing something and what it is possible to change and what is not. However government intervention must not make matters worse, *government failure*.

## **2.7 Role of the government**

In general terms the government provides four economic services:

- a) Sets the framework of economic activity; establishes property rights (rules of the game).
- b) Stabilises macro economic policy.
- c) Allocates resources where there is market failure (provides public goods).
- d) Redistributes welfare/income.

### 2.7.1 Government failure

Is easy to think of instances very government fails to improve economic efficiency, i.e. reduce social welfare. The reasons for failure is:

- *Bureaucratic imperative.* Bureaucrats do not have the incentive to improve efficiency instead they have an incentive to survive through increasing the size of their agency. They have vested interest in projects even if they are not optimal. There is inertia to government policy as bureaucrats favour the status quo.
- *Short time horizons* due to electoral system
- *Knowledge of politicians.* Politicians often rely upon the advice of bureaucrats who are the only ones with information.
- *Power of lobby groups.* Often interest groups exert disproportionate influence. This is because they have a vested interest and the knowledge to do so (of both the issue and lobbying procedures). The general population is often ignorant as the cost of obtaining information is greater than the benefit.

## Sustainability and sustainable development

Sustainability and sustainable development really came to prominence in 1987 with the Brundtland report of the WCED (World Commission on Environment and Development., 1987). The report defines sustainability development as an approach that:

*“...seeks to meet the needs and aspirations of the present without compromising ability to meet those of the future.”*

This was not seen as incompatible with growth; in fact the report recognised that growth was essential especially if redistribution of income was to occur. Growth rates of 3-4 % in the MDC's were considered necessary and not necessarily unsustainable so long as those countries could continue developing towards less intensive resource using industries.

The research questions originating from the Brundtland report revolved around how these concepts/ideas could be incorporated into our decision-making and policy setting. This led to attempts to define what could be used in the “political” arena and we had sustainability as a dominating construct.

### 2.8 Sustainability

Sustainability has many definitions but in economics generally as: *“non-declining per-capita human well being over time”*. This emphasises equity rather than efficiency, which is not covered in market analysis. To 'convert' this definition into a policy relevant form it was proved that it was equivalent to: *“non-declining resource stock over time”*. This definition implies:

- Always use renewable resources so that the harvest rate is less than or equal to the renewal rate.
- Always keep waste flows below or equal to the assimilative capacity of the environment.

However, the definition is not easy to implement for a number of reasons; what about stock resources? What about management that may increase the productivity of resources? The main challenge was thus *how to include stock resources in decision-making*. Ideas on how to achieve this include:

- As resources are depleted ensure the reduced stock is compensated by increased investment in renewable resources, i.e. *substitutability*.
- Allow for a (constant or growing?) standard of living from a reduced set of resources, i.e. *efficiency*.

There are a number of issues to consider when using/defining natural capital stock

- technology (increased efficiency)
- uncertainty and irreversibility
- resilience of the ecological system
- resilience of the economic system
- intergenerational equity
- rights in nature
- multi-functionality of natural capital

## 2.9 Measuring Sustainable Development

Measuring sustainable development is fraught with question marks. How do we measure, and what is a constant capital stock? Do we calculate the physical quantity? Is 3 bags of coal equal to 3 ingots of gold? Do we use the value of the stock? If so, should we value it in current prices (so the stock may go down as value rises), or real prices that ignore inflation? How do we value non-market benefits? Should we increase capital stock? Is the existing capital stock optimum?

However, attempts are being made to try and overcome these problems and have some consensus, incorporating sustainability in decision-making. Examples of such approaches are sustainability indices and green accounts. On a more micro level, triple bottom line accounting and Natural Step has had some limited success.

### 2.9.1 Sustainability indices

#### *Weak Sustainability Index*

This calculates an index of the sustainability of countries by deducting from savings (a proxy for investment) the depreciation in capital over a time period.

Therefore

$$Z = s / Y - m / Y - n / Y$$

where,

s = savings (= investment)

Y = GDP or national income

m = depreciation of man made capital

n = depreciation of natural capital

If  $Z \geq 0$ , then the economy is sustainable.

There are some problems associated with this approach:

- Ignores trade; the index puts onus on the producer and therefore exporter, so it is possible for a country to 'buy in' sustainability. Whereas many would argue it is the consuming country (the importer) that should invest in alternative forms of capital to maintain consumption.
- Assumes that it is possible to substitute man-made capital for natural capital

Therefore it ignores:

- Multi-function of natural capital
- Ignores irreversible nature of some natural capital
- Ignores uncertainty

Thus economists developed the idea of *Strong Sustainability*. This assumes that the level of natural capital remains the same. However this is subject to many of the criticisms above.

- Ignores the multi function of natural capital.
- Assumes it is possible to substitute between natural capitals.

To meet some of these criticisms the idea of *critical natural capital* were developed. That is natural capital that is of such importance we use it very cautiously, if at all.

## 2.9.2 National accounts and the environment

Another way of incorporating sustainable criteria in decision-making is by including environmental variables in the national income accounts. The national income and product accounts may constitute the greatest advance of the century in economic science (Eisner,1994:8). In 1940s the UN System of National Accounts (SNA) were introduced, and since then they have been used as a major tool in assessing performance of economy's both over time and across countries. However it is recognised that National Accounts provide a fairly poor indicator of human well-being as they fail to consider several factors:

- income distribution
- non-market activity
- quality of life
- income at the expense of wealth
- environmental degradation
- depreciation of mineral stocks
- assimilative capacity of the environment
- expenses associated with ameliorating the effects of environmental degradation (defensive expenditure) are also classified as income

With rising awareness of environmental issues over the last three decades a number of initiatives have been undertaken to address this and green accounts are one. 3 ways of including environmental factors have been put forward:

1. Natural Resource Accounts, which measure physical stocks and flows between the environment and the economy.
2. Satellite accounts, which enhance the existing accounts with what are effectively, bolt on additions.
3. Complete reform of existing Accounts.

International organisations have favoured Satellite Accounts over more radical reform (UN, 1993; OECD, 1994). Satellite Accounts are still in their infancy and no precise framework has yet been established by international organisations. A general outline of compatible approaches has however been provided by the UN in their System to integrate Environmental and Economic Accounts (SEEA) (UN,1993). Early applications of Satellite accounts include:

- Indonesia (Repetto et al, 1989)
- Costa Rica (Solorano et al., 1991)

### 2.9.3 Triple bottom line reporting

Triple Bottom Line (TBL) reporting is an approach for organisations to demonstrate they have strategies for sustainable growth. It focuses on decision-making and reporting which explicitly considers an organisation's economic, environmental and social performance.

The approach has gained some acceptance, but have been criticised on the basis that it is often, in practise, 'just' an add-on to the standard set of accounts and thus focused on external reporting.

### 2.9.4 Natural step

The Natural Step is a methodology for managing and improving sustainability within organizations. The methodology build on four core principles and is implemented in four phases:

1. Phase one involves building awareness and understanding, aligning key decision-makers and stakeholders around a common understanding of sustainability and the 'whole-systems' context for their organization.

2. Phase two consists of conducting a sustainability analysis of the major flows and impacts of a business or organizational system. This analysis includes the impacts of an organization's entire supply chain.
3. Phase three revolves around the creation of a vision, a strategic plan, and an action plan for moving towards sustainability.
4. Phase four is the implementation phase and consist of advising and supporting the execution of specific initiatives by providing appropriate training, techniques, and tools for implementation, followed by measuring progress towards goals.

The Natural Step methodology has.....



## 3 Research approach

In this section we outline some possible research themes.

### 3.1 Economic indicators and financial analysis

The most obvious theme for analysis within the economic objective is the economic/financial aspects of farming in general and, in particular, the economic/financial issues related to the 0-hypothesis of the ARGOS project.

#### Preliminary data need

Generic data needed re size type of farm ect etc. Ideally data should be broken down into where possible output type eg: milk. The standard farm management/financial indicators could include:

#### **Sales revenue**

#### **Inputs – Variable**

Fertiliser

Pesticides

Feed

Vet bills

Fuel

Electricity ect

Vehicle costs, insurance registration

Contractors

#### **Inputs – Fixed**

Machinery

Labour by type

- casual

- seasonal

- part-time

- fulltime
- family
- (maybe by age and sex)

Rent/Rates

Buildings

---



---

### **Up and down stream impacts**

---

% of sales

- local
- national
- overseas

% on inputs from

- local
  - national
  - overseas
- 

---

### **Indicators relating to farm practice**

---

- farm diary
  - labour use by full-time, part-time and casual
  - machinery use by operation eg cultivation, harvest
- 

---

### **Farm income**

---

- agricultural ( also break down type of sales such as processed ; to cooperative; etc)
  - non agricultural income relating to farm e.g. on farm tourism
  - non-agricultural income not relating to the farm
- 

Choices regarding farming practise frequently depend upon what inputs are available such as 'labour' and thus a few questions relating to constraints on farming practice such as labour shortages would also be helpful.

## 3.2 Market access

New Zealand is unique as a developing country relying on agricultural production and trade for most of its foreign exchange earnings. This, of course has had its problems, not least, difficulties of access into the main high value markets around the world. However, given the latest agreement at the WTO<sup>4</sup>, this may begin to change with the gradual removal of trade distorting support from the main markets. This won't happen overnight but nonetheless bodes well for a reduction in trade restrictions and duties against NZ products. A word of caution is that while direct trade barriers will be removed, other restrictions on trade may start to be applied more stringently such as the method by which the food is produced.

The challenge for the NZ agricultural sector to accessing high value markets is the change in consumer demand, away from price<sup>5</sup>, to a greater focus on food safety, concern over the environment and the way food is produced. Whilst NZ has some real advantages in these areas, it also has to be able to meet these new market demands and consider its' production methods as well as marketing. This is seen clearly with the rise in European schemes that require farmers to comply with various standards of food production. EUREPGAP<sup>6</sup> is one such scheme that has developed widely accepted standards and procedures for the global certification of Good Agricultural Practices (GAP).

The specific objectives of this research theme are to:

1. Contrast relevant schemes that require farmers to comply with various standards of food production.
2. Assess implications for NZ agricultural sector of different scenarios relating to schemes and standards for food production.
3. Detailed assessment of the on farm consequences of adopting the schemes.

---

<sup>4</sup> The WTO General Council decision on 31 July 2004, states that direct payments (Blue Box support) is to be limited to 5% of members average total value of agricultural production. This puts pressure on many member countries, particularly the EU, to move from trade distorting Blue Box payments to Green Box payments and measures.

<sup>5</sup> The proportion of consumer expenditure spent on food in EU has fallen over the last two decades, and from 1995 to 1999 it went from 14.2% to 12.9%, with UK down to 9.1% in 2003<sup>5</sup> (Statistics UK; Household final consumption expenditure in the European Union, 2002).

<sup>6</sup> For further information: [http://www.eurep.org/Languages/English/index\\_html](http://www.eurep.org/Languages/English/index_html)

The first stage will involve a thorough review of existing certification schemes relevant to New Zealand, for example EUREPGAP. This will draw upon results of the SAMsn initiative. The review will include an evaluation of the scheme requirements, why these requirements have been included, how relevant they are to NZ trade access and their relevance in the NZ production environment.

The second stage involves an extensive literature review. This will involve contrasting what is and what is not required in the different schemes with relevant and related literature on the economic, social and environmental outcomes of different farm management practises. This will draw upon systems approaches to management, in particular Ecological Economics.

Third stage involves a detailed analysis of the ARGOS data to empirically base the outcomes for the New Zealand farmers from adoption of management practises required by the EUREPGAP type schemes. The ARGOS farms will provide robust financial and environmental data that will allow us to understand the economic and environmental effects to NZ of adopting farm management practises stipulated by the food production schemes.

The specific outcomes will include:

1. Improved understanding of NZ access to high value markets.
2. Evidence to offset demands from overseas markets for production systems and environmental compliance which is not appropriate in NZ.
3. Detailed insight into economic and environmental consequences of farm management practises that are related to market access issue and production schemes.

### **3.3 Ecological economics and sustainable development of New Zealand Agriculture**

The point of reference for the ecological economist is a lovely article titled “The Economics of the Coming Spaceship Earth” by Kenneth E. Boulding (1966). In the “spaceman”

economy the essential measure of success is not production or consumption, but the nature and quality of the total capital stock.

Ecological Economics (EE) is the study of relationships between ecosystems and economic systems in its broadest sense. EE places the economic (human) system as subsystem of the ecological system, thus implying interdependencies between the two systems as well as the subsystems dependency on the larger ecological system. The focus is not on tools and techniques but on the problems at hand and in relation to these problems known or new tools and techniques could be applied; EE is characterised by a plurality of approaches (Duchin & Lange, 1994; Stern, 1997). The ecological economist uses tools of conventional economics and ecology as appropriate.

The concept of evolution is a guiding notion, i.e. a process of change in a complex system that does not imply a particular direction. Sustainability does not imply a static state or a stagnant economy but there is an important distinction between growth and development/evolution. Economic growth is usually referred to as a growth in quantity, which cannot be sustained on a finite planet, not even with technological progress. A development/evolution with a growth in quality of life (welfare) that does not necessarily imply an increased demand on resources way well be sustainable. There is a clear limit to economic growth but not necessarily to development (Costanza & Daly, 1992; Georgescu-Roegen, 1975). Arrow et al (1995) put it eloquently:

“Economic growth is not a panacea for environmental quality; indeed, it is not even the main issue. What matters is the content of the growth – the composition of inputs (including environmental resources) and outputs (including waste products).”

Historically, there has been a tendency to marginalize the environment when designing national and international economic policy. Economic growth and economic liberalization has been encouraged with the assumption that environmental problems will take care of them self or can be dealt with separately (Arrow et al., 1995). Indeed, the issue that most tend to separate the economists and the ecologist is the discussion about linkages between economic growth, human carrying capacity, and the environment (Costanza, Daly, Folke,

Hawken, & al, 2000). The discussion tends to be polarised by economists who are technology optimists (technology will increase efficiencies in resource usage that more than offset population and consumption growth), and ecologist who believe that the earth would be better off were there no humans at all.

A more fruitful approach would be to focus on the common ground, which very well could be sustainability, the overarching macro-goal of EE. The common challenge is to manage the environment, a huge asset/resource, in the face of uncertainties about technology and the capacity of our ecosystems, so that it will support the human system well into the future (Costanza et al., 2000). Whilst this may seem simple enough, there remains considerable disagreement on the conceptual level as well as the operational, not to mention philosophical and ethical dimensions of intra- and intergenerational equity (Common & Perrings, 1992).

Sustainability has many definitions but in economics generally as: “*non-declining per-capita human well being over time*”. This is the equivalent to a “*non-declining resource stock over time*”(.....). This definition implies that a minimum condition for sustainability is the maintenance of the total natural capital stock at or above the current level. Although a lower stock of resources may be sustainable the uncertainty and the consequences of wrong assumptions warrants a conservative level. This constancy of natural capital also satisfies the technology optimists by raising the price of natural capital and thus faster induces the technological innovations they hope for, as well as the technology pessimists by conserving natural capital for the future.

### 3.3.1 Avenues of research within EE

(Costanza, 1991) identified some broad areas of interest within EE. Some of these are:

- a) Investigation into the basic assumptions underlying current thinking.
- b) Technology
- c) What do we mean by sustainability in economic and ecological systems?
- d) Substitutability
- e) Valuation of ecosystem services-discount rate-threshold for irreversible degradation
- f) What kind of actions can benefit the present without harming the future?
- g) Ecological economic modelling

## h) Instruments

TO BE DEVELOPED.....

### 3.4 Trade and the Environment

Trade is fundamental to NZ economic and social well being with a third of NZ income coming from trade. Seventy per cent of this trade is in exports of primary products, much of which are basic commodities. As the relative prices for basic commodities have fallen over last few decades this explains part of the reason why NZ has not experienced the growth rate of other developed countries. It is therefore vital that NZ reverses this trend and targets high value markets for its land based exports. This requires analysis of the effects of both policy issues and market developments on NZ trade and producer returns.

The World Trade and Environment programme evaluates the link between trade and the environment to enable NZ producers, environmentalists, traders, and policy analysts to assess implications of changes in production, policy and trade on the environment and producer returns. The risks and benefits to NZ of both internal and external changes in market and policy preferences can be assessed.

The LTEM is a multi-country, multi-commodity PE framework that focuses on the agricultural sector. The linkages of the agricultural sector with the rest of the economy are not considered. The commodities included in the model are treated as homogenous with respect to country of origin and destination and to physical characteristics of the product. Therefore commodities are perfect substitutes in consumption in international markets. Importers and exporters are assumed to be indifferent about their trade partners. Based on this, the model is built as a non-spatial type, which emphasizes the net trade of commodities in each region instead of the bilateral trade, flows between the countries. However, the supply and demand shares of countries in trade can be traced down.

The LTEM is a synthetic model since the parameters are adopted from the literature. The symmetry condition holds for the supply and demand elasticities, therefore own- and cross-price elasticities are consistent. The model is used to quantify the price, supply, demand, and

net trade effects of various policy changes. The policy parameters and/or variables and non-agricultural exogenous variables are listed in Table 2. The economic welfare implications of policy changes are also calculated in the LTEM, using the producer and consumer surplus measures. The model is used to derive the medium- to long-term policy impact in a comparative static fashion basing the beginning date to either 1997 or 2000. The model also provides short-run solutions as it applies a sequential simulation procedure year by year in which the stock change is used to link two consecutive years.

**Table 2: Policy Variables/Parameters and Non-Agricultural Exogenous Variables**

<i>Policy Variables- Domestic Market</i>	<i>Policy Variables- Border</i>	<i>Non-Agricultural Exogenous Variables</i>
Land set-aside	Import tariff	Gross domestic product
Production quota	Export subsidy	Country price index
Support/minimum price	Trade quota	Population
Producer market subsidy	In-quota tariff	Exchange rate
Producer input subsidies	Out-quota tariff	
Producer direct payments	Export tax	
Producer general services		
Consumer market subsidy		

The LTEM includes 19 commodities and 17 countries. These are presented in Tables 3 and 4. The dairy sector is modelled as five commodities, raw milk is defined as the farm gate product and is then allocated to the liquid milk, butter, cheese, whole milk powder or skim milk powder markets depending upon their relative prices, subject to physical constraints. The meat sector is disaggregated into sheepmeat, beef and pig meat, and the poultry sector (poultry meat and eggs) and wool are also modelled explicitly. There are seven crop products (wheat, sugar, coarse grains, rice, oilseeds, oil meals, oil) in the LTEM.

**Table 3: Country Coverage of the LTEM**

Argentina	Japan	Slovakia
Australia	Mexico	Switzerland
Canada	New Independent States	Turkey



Czech Republic	Norway	United States
European Union (15)	New Zealand	Rest of World
Hungary	Poland	

**Table 4: Commodity Coverage of the LTEM**

Wheat	Beef and Veal	Raw milk
Coarse grains	Pig meat	Liquid milk
Sugar (refined)	Sheep meat	Butter
Rice	Wool	Cheese
Oilseeds	Poultry meat	Whole milk powder
Oilseed meals	Eggs	Skim milk powder
Oils		

Basically, the model works by simulating the commodity based world market clearing price on the domestic quantities and prices, which may or may not be under the effect of policy changes, in each country. Excess domestic supply or demand in each country spills over onto the world market to determine world prices. The world market-clearing price is determined at the level that equilibrates the total excess demand and supply of each commodity in the world market. The LTEM is built using a spreadsheet-based framework for the Excel software.

#### 3.4.1 Possible extensions

- Add environmental and production variables as and when they become available, including biodiversity and energy.
- Add the social science.

### **3.5 Public policy integration and the development of a Multi Criteria Analysis (MCA) Framework to assess regional sustainable development targets from QTL perspectives.**

MCA enables the critical factors needed to facilitate sustainable development at the sub national level that is either sectoral or regional to be assessed. The MCA framework

integrates the social, economic, environmental and cultural factors in sustainable development and has the strength in that it allows qualitative and quantitative data to be included in the analysis. Thus, the use of MCA will enable all of the factors to be included in evaluating best sustainable development choices. MCA is in use by number of overseas analysts and agencies, including Department of the Environment UK (Pearce et al. 1999); for waste and waste water management (Buchart et al. 2002); sustainable strategies in Italy (Mauro et al. 2002).

An MCA analysis has a number of stages however the main ones are firstly to determine the set of goals and/or objectives and then to identify the trade-offs between these against different methods of achieving desired policy outcomes. The second stage of analysis is to identify best policy by attaching weights to various objectives. (Clearly this second stage is developed with close reference to those involved in policy formation and implementation). Moreover the technique does allow sensitivity analysis against different weights and thus the policy makers can assess their priorities alongside their potential effect.

The Multi Criteria framework will enables researchers not only to integrate the components of sustainable development (socio, economic, environmental and cultural) but also incorporate the impacts of interregional spatial links, and trade offs, different types of criteria and models (e.g. cost benefit analysis, input/output analysis and qualitative data) under uncertainty. The framework therefore has the capability to assess the socio-cultural influences and existing organisational structures and their interaction in how they influence outcomes and therefore affect the success of different policy/project options to achieve sustainable development.

The AERU aims to evaluate the best practices from both national and international literature on Multi Criteria frameworks and their applicability to the NZ context. This will include both the methodologies and also the relevant software used to assess the criteria. Alongside this the research will review the international implementation and development of policies to facilitate regional development as well as the institutional and socio-cultural structure within which this occurs. This will concentrate upon 'whole management systems' of policy development that emphasise the integration of government at the central and local levels.

In conducting the research, information and input from three sources are required for each example, both to establish the Multi Criteria analytical framework but also so that key

factors from international literature relating to policy and its context can be applied. First is through an analysis of the institutional and policy environment. This will involve studying the impact of central government decisions and policies in the case study context, local government policy and implementation, as well as community initiatives towards sustainable development. Secondly, information from the community is of vital importance on their attitudes and aspirations regarding sustainable development. Secondary data sources are important in establishing the socio economic and environmental status of the case study. From this the most appropriate policy and recommendations can be determined.

## Appendix 1: History of Resource Economics

The modern market economy is a relatively recent development; from the 15<sup>th</sup> century and onwards in Europe, later elsewhere. Up to then the economy, including the allocation of natural resources was based upon a social system of rights and obligations. The transformation came with colonisation, which opened up vast potential for trade. This meant more resources were allocated through the market.

### Classical Economists

The classical economists concentrated upon the optimum use of resources and the subsequent economic development. They saw growth as a period between two static states, the final position being a barren subsistence existence. This approach led to economics being called *the dismal science*.

Adam Smith, the prominent thinker on economics at the time, believed that markets, based upon selfish behaviour of individuals, could serve society as a whole. The basic motivation to buy cheap and sell dear, encouraged goods and services to be produced by the most efficient means and sold to those who valued them the most (he did recognise the problems of income distribution). His theories resolved earlier dilemmas of governments who were concerned about the morals relating to the development of individualism associated with markets, as it meant that individual and society goals were not necessarily in conflict under a market mechanism.

There were three other economists (Malthus; Ricardo and Mill) in the classical school who were mainly concerned about long run development. They concluded that through the law of diminishing returns there would be limits to growth. So as we use more of a resource (land), its productivity falls and therefore output as will the population. Malthus argued we have a fixed amount of land, and therefore, as population grows, the law of diminishing returns means we get less food from the land and the food supply falls. The standard of living then falls to the subsistence level until there is no growth,

leading to starvation, disease etc. As a result the population falls and we then start the whole process over again! This “cycle of feast and famine” is still advocated by many.

Ricardo, using a more complex model, reached the same conclusion as above. As population grows society is forced to use more of less productive land, thus productivity falls, until we reach the carrying capacity of the environment. At this point population will fall. He did recognise that technology would increase the production possibilities (carrying capacity of the environment) but this would only prolong the time till we reached the carrying capacity. We would still reach it, and population would fall. Again this theory is still advocated today.

Mill argued that economic progress was a race between technical change and diminishing returns. He was more optimistic than Ricardo and Malthus in that he argued technical progress would help to supply wants and allow some other non-subsistence goods and services even in the long run.

Not surprising Economics was called the DISMAL science!<sup>7</sup>

## Socialism

Socialism, in its various forms, was developed as a critique of the classical economists. Socialism unlike the classical economists stressed society rather than the individual.

The social fabric is an “organic whole” comprising of “classes” rather than “independent individuals”. It stresses cooperation in human nature rather than competition as classical economics did. It argues for an egalitarian society with an equal distribution of income and this is only way society can go in the long run.

---

<sup>7</sup> Interesting switch from current thinking where some economists are called market optimists, when analysing economic development, whereas historically they were exactly the opposite.

## Marx

Marx argued that the classical economists ignored the social relationships and that history as a process of conflicts between economic forces. Marx predicted that conflict for the control of economic resources would occur.

The capitalist economic system would be faced with falling profits (due to competition), increased destitution for the working classes, and increased control of resources in the hands of a few (monopoly ownership). Ultimately the majority would overthrow the capitalist class and create a socialist society.

Marx believed “technical progress” and “financial growth” was natural in society due to the exploitation of nature via technological advance (this was inevitable because of human nature within the capitalist system). Nature was there to be “humanised” and turned into financial value. So Marx argued that neither the current social and political system is sustainable nor is the natural system.

The Marxist model has competitive capitalists seeking 'labour saving' innovations to increase the short run returns to labour. In fact they have to do this to survive. These new technologies have a high environmental burden both extractive and absorptive. These external costs become class costs (borne more by the poor). Capitalism - capital accumulation and growth - is therefore doomed. It leads to cycles of prosperity and depression. Moreover it has a poor moral basis is unjust and therefore will end in class conflict. He concluded that economy of abundance is only possible in classless society with distribution of income:

*“From each according to his abilities to each according to his needs”*

Marx is still popular, but was he correct? Marxists argue that exploitation is still alive and well through developed versus developing countries and within countries with divisions between rich and poor. However social conflict has not been seen nor has any indication that we can live in a ‘classless society’. However, Marxism holds some profane statements in that it do express outrage at condition of humanity, holds a grand

vision of what could be, and provides an analytical structure in which much of modern society is and can be assessed.

### Neo classical Economics

Neo classical economics, whilst recognizing supply and costs as the classical economists did, recognised demand was important too in the allocation of resources. Price was seen to reflect the interaction of supply *and* demand. They were less interested in environmental questions or natural resource use but explaining the current situation Neo classical economics is often called '*market economics*'.

Neoclassical theory of the market is supposed to be neutral and value free. The aim was to establish a set of laws that govern economic activity:

- Rational individuals who seek to satisfy substitutable wants.
- The rational consumer/individual who makes a trade off, at the margin, to maximise welfare.
- *Pareto optimum* (economic optimum; economic efficiency) - impossible to make anyone worse off without making someone better off.

Thus operation of the market leads to maximum benefit from limited resources. (given we do not have *market failure*)

### Post war economics

Neo classical economics had built in assumption that the economy would operate at the full employment level. But experience during the inter war period showed that this is not necessarily true. Keynes writing in the 1930's illustrated why and Keynesian economics or macroeconomics became the norm, from the 1950's through to the early 1980's.

The Keynesian economists is not really concerned with the environment as it is/was more concerned about the pattern of overall financial/economic activity. As a

consequence *financial growth* became the main focus of governments and the Keynesian economics seemed to offer limitless possibilities for this, given confidence in science to solve any problems.

Environmental concerns became of secondary importance, but by the 1960', awareness relating to social costs of financial growth grew. This resulted in the inclusion of social costs *and* environmental cost into economics, which led to debate, which has continued since.



## References

- Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., et al. (1995). Economic growth, carrying capacity, and the environment. *Ecological Economics*, 15(2), 91-95.
- Boulding, K. E. (1966). The Economics of the Coming Spaceship Earth. in Costanza, R., C. Perrings, et al. (1997). *The development of ecological economics*. Brookfield, VT, E. Elgar Pub. Co.
- Common, M., & Perrings, C. (1992). Towards an ecological economics of sustainability. *Ecological Economics*, 6(1), 7-34.
- Costanza, R. (1991). *Ecological economics : the science and management of sustainability*. New York: Columbia University Press.
- Costanza, R., Daly, H., Folke, C., Hawken, P., & al, e. (2000). Managing our environmental portfolio. *Bioscience*, 50(2), 149.
- Costanza, R., & Daly, H. E. (1992). Natural Capital and Sustainable Development. *Conservation Biology*, 6(1), 37-46.
- Costanza, R., Perrings, C., & Cleveland, C. J. (1997). The development of ecological economics. Brookfield, VT: E. Elgar Pub. Co.
- Duchin, F., & Lange, G.-M. (1994). Strategies for environmentally sound economic development. In A.-M. Jansson (Ed.), *Investing in natural capital : the ecological economics approach to sustainability* (pp. 250-265). Washington, D.C.: Island Press.
- Georgescu-Roegen, N. (1975). Energy and economic myths. *Southern Economic Journal*, 41(3), 347-381.
- Stern, D. I. (1997). Limits to substitution and irreversibility in production and consumption: A neoclassical interpretation of ecological economics. *Ecological Economics*, 21(3), 197-215.
- World Commission on Environment and Development. (1987). *Our common future*. Oxford ; New York: Oxford University Press.

(Costanza, Perrings, & Cleveland, 1997)