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Using 'Inclusive Wealth' to Measure and Model Sustainable Development in Australia: A working example *

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Abstract

Australia in 1992 adopted the National Strategy for Ecologically Sustainable Development to ensure all future development occurs in a 'sustainable' manner. Measurement of the nation's sustainable development is currently conducted through the OECD Environmental Performance Review and various other ad-hoc indicators or measures have been proposed, such as greening the national accounts (Green Gross National Product) and the Genuine Progress Indicator. No one has identified a clear and precise way to either measure or model sustainable development in Australia.

By trialing the implementation of inclusive wealth theory in Australia, this paper aims to identify and comment on the issues of measuring and modelling sustainable development as a stock measure in Australia (measuring the change in composition of national assets over time). Conceptual issues of implementation will be discussed with examples provided from two trial regions Goulburn Broken Catchment (VIC) and the Murrumbidgee Valley (NSW).

Key Words: Inclusive Wealth, sustainable development, capital stocks, production systems

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1. Introduction

In the economic literature on sustainability, theoretical developments tend to exceed empirical progression—there are far more theoretical results than comprehensive and plausible estimates of sustainability that adhere to best theoretical practice. Empirical evaluations of sustainable development (SD) are often based on *ad hoc* foundations (Harris and Fraser 2002) and different approaches to measuring sustainable development have been shown to produce considerably different results (Hanley et al). Clearly, both operational difficulties and data deficiencies have meant that evidence has seriously lagged behind theory.

This paper describes an attempt to rectify this imbalance. In particular, it describes a project that attempts to further the empirical evidence on sustainable development within the constraints of a well-defined theoretical framework. Of course, the fact that the imbalance between theory and measurement exists at all indicates that measurement of SD is much more difficult than conceptualising and analysing it theoretically. Recognising this, the project presented here is a preliminary pilot undertaken at a regional scale, designed to investigate whether more ambitious measurement of SD at the national scale is feasible and worthwhile.

We refer to "sustainable development" or SD in preference to "sustainability", as in policy discussions, sustainability can be sometimes assumed to denote some kind of steady-state, and we by no means wish to rule out development paths in which living standards rise. Also, sustainability can be applied to various things—sustainability of a particular industry or regional community, for example—whereas we have a broader concept in mind, in which particular industries, or population numbers, may rise or fall over time.

The framework in which we analyse SD is the "inclusive wealth" (IW) framework, developed particularly by Arrow, Dasgupta and Maler (2003). The emphasis in this approach is on the maintenance of an economy's productive possibilities, as embodied in its total capital stock (comprised of manufactured, human and natural capital), and in this sense it is a staunchly neoclassical approach (or, using other terminology, it fits in the "weak sustainability" tradition), although it moves the emphasis from standard flow measures such as net domestic product, "green GDP" or "genuine savings" to stock measures of total wealth.

The IW framework has several extensions beyond the conventional weak sustainability paradigm. It does not presume that the economy is first-best-optimising, in ways that previous analyses tended to do. Moreover, smooth substitution between all asset classes is not presumed. That is, discontinuities, non-convexities, irreversibilities and ecological thresholds are capable of being incorporated into the analysis, at least in principle. This last extension allows the possibility of strong-sustainability considerations to enter into the analysis.

The purpose of the IW framework is to enable calculations to be made over time as to whether an economy is on a sustainable path. This does not necessarily imply that accurate forecasts will be made of future development paths into the indefinite future—only that, on current calculations, sustainable development criteria are being met.

The project takes an explicitly regional, rather than national focus, such that sustainable development as measured by Inclusive Wealth is measured at a regional scale. This raises several important issues, such as the role of regional SD in national SD (as in, sustainable development "for whom"), and the role and impact of exogenous effects within the nation as distinct from external to the nation.

A further ambition of the project would be to enable "scenario modelling" and counterfactual analysis: this is the modelling aspect of the project. The intention is that in measuring Inclusive Wealth as comprehensively as possible, that a model be constructed to simulate alternative development paths or policy changes in order to assess SD under different scenarios.

The paper proceeds as follows. The next section discusses different concepts of SD; introduces the reasons for using a wealth-based approach to SD; and the details of the IW approach, particularly when applied at a regional scale. Section 3 outlines the three capital stocks that will constitute our wealth measure (human, manufactured and natural) as well as clarifying the role of social capital. Section 4 charts issues of implementation and how they may be overcome, including exogenous changes, assigning shadow prices, etc. The final section deals with an initial application of inclusive wealth to the Goulburn Broken Catchment.

2. Sustainable Development and Inclusive Wealth

In the economics literature, proposed aggregate measures of sustainability tend to begin with national accounting aggregates that are then adjusted in particular ways to make those aggregates more compatible with sustainability criteria, rather than the output criteria on which standard measures are constructed. A typical approach is to include natural capital as part of the total capital stock, with any reduction in the quantity and/or quality of the resource base treated as depreciation of natural capital that is then deducted from GDP to get a net product measure. The rationale for this approach is that the resulting measure distinguishes between true or sustainable income, and capital consumption (where capital consumption includes natural capital). (Discussion and criticism of this claim is presented in Harris and Fraser 2002.)

The important features of this approach are that it is *aggregate*, taking an economy-wide view of sustainability (not sector or industry or resource-specific); that it is *capital-theoretic* in that it focuses on the identification and measurement of natural capital which is then combined with other forms of capital as measured in the accounts; and that it allows for *capital-substitutability*, such that reductions in one form of capital can be compensated for by equivalent increases in other forms of capital. These aspects (in particular, the emphasis on capital) make this an example of what has become known as the *weak sustainability* approach—"weak" in the sense that by this definition sustainability does not impose restrictions on specific natural resources. (In the sense that this criterion is broader than the alternative *strong sustainability* criterion, they might better be referred to as "broad" and "narrow" sustainability respectively.)

However, while much of the applied literature has followed in this tradition, theoretical work has continued to investigate the limitations of this approach, and what restrictions need to apply in order for plausible results to be generated. Much of the growth-theoretic work in this area begins from the seminal work of Weitzman (1976), which established a direct link between the value of net product today, and the capitalised value of future consumption. Theoretical developments of the growth-theoretic approach can be found in, for example, the Aronsson, Johanssen and Lofgren (1997) monograph, and a number of the pieces contained in Perrings and Vincent (2003).

Theoretical Distinctions

One important distinction in the sustainability literature is that between *point* sustainability and *path* sustainability. Point sustainability requires that a sustainability criterion be satisfied at (as the name suggests) a point in time, but it does not require sustainability to be satisfied at all future points of time. Path sustainability requires that the criterion be satisfied along an entire growth path. To make the claim that an outcome or a development path is sustainable (or is consistent with sustainable development) requires identification of whether point sustainability or path sustainability is being satisfied.

What kinds of sustainability criteria appear in the literature? In a growth-theoretic context, key contenders include (a) *non-declining instantaneous utility*; (b) *current instantaneous utility weakly greater than maximum sustainable utility*; and (c) *non-declining social welfare*, where social welfare is the present value of future consumption. The first two are instantaneous flow measures; the latter is a stock measure in that it involves conversion of a whole path of instantaneous utilities into a present magnitude. Criterion (a) could be satisfied in point-sustainability form while the economy's productive base is being eroded. Criterion (b) focuses on path sustainability by using "maximum sustainable utility" as the point of comparison, but it is an instantaneous measure as is (a). Criterion (c) is not an instantaneous flow measure; rather it embodies the value of the future path of utilities in its definition (Dasgupta and Maler 2001).

Hence there is also an important stock/flow distinction between different forms of sustainability criterion (or sustainability constraint). As noted above, stock (or wealth) measures will have a different relationship between point and path sustainability, because a wealth measure embodies future values in it. In practice, this means it will be easier to satisfy point sustainability while violating path sustainability with flow measures, a point in favour of using a wealth approach to assessing sustainability.

A related practical advantage of using a wealth-based approach is that it is more flexible—increasing current savings (by decreasing current consumption, thus lowering instantaneous utility) will violate a non-declining utility constraint, but will not violate a non-declining social welfare constraint *if* the increased savings is channelled into higher productive investment and thus increased future consumption.

Finally here we revisit the weak vs. strong sustainability debates. The weak sustainability paradigm is essentially neoclassical in its orientation, where the importance is placed on maintenance of aggregate consumption flows[1] rather than maintenance of any particular aspects of the natural capital stock. In particular, all forms of capital are assumed to be inherently substitutable, an assumption challenged by strong sustainability advocates. Specifics associated with the latter view vary, but typically it is the case that substitutability of all different types of capital is rejected, and instead restrictions are placed on the diminution of quantity or quality of particular natural assets. Weak sustainability is mostly associated with the neoclassical environmental economics tradition, while strong sustainability is associated with the ecological economics tradition.

The weak sustainability approach has in its favour that it has a "big picture" focus, allowing trade-offs between different goals and different means of achieving them. What matters in this big picture

[1] This is of course, loose language. We are not distinguishing here between maintenance of consumption flows and maintenance of instantaneous utility.

is overall human well-being, and no particular means of attaining this well-being (that is, no particular form of capital) is privileged over any other. The general rhetorical position is that sometimes it is worth chopping down some trees to build a hospital or factory. However, strong sustainability advocates would contend that standard weak sustainability models make overoptimistic assumptions about the smoothness of substitutability between natural and produced capital. The general rhetorical position is that weak sustainability assumptions can lead to, for example, species extinction or irreversible ecosystem change that can have unforseen long run consequences.

Given these positions, an "ideal" measure of sustainable development might have something like the following properties.

- It would be highly aggregated, to allow analysis of "trend sustainable development" over time.
- Within the single (aggregate) index, components would be substitutable according to assigned price-weights.
- Irreversibilities and critical thresholds should be identified and accounted for.

These three conditions combine desirable elements of both weak sustainability and strong sustainability. As described below, the Inclusive Wealth measure proposed by Arrow, Dasgupta and Maler [ADM] (2003) enables these three conditions to be met.

Inclusive Wealth

We have defended social welfare as, in principle, our preferred means of assessing sustainable development in an economy and society. Social welfare is defined here as a *stock* magnitude, analogous to the idea of social *wealth* (Dasgupta and Maler 2001). The ADM model reconciles the forward-looking social welfare magnitude with the current value of all capital stocks. This immediately reduces the seemingly intractable problem of the social welfare approach to sustainability—measuring the value of all future consumption—into the still difficult but more manageable problem of measuring the value of all of society's capital stocks. ADM (2003) demonstrate that properly valued, the total value of all society's assets provides a measure of society's total social welfare and that the goal of measuring social welfare is equivalent to the goal of measuring society's total, or inclusive, wealth. Since the price of any capital asset balances out the value of using that asset now ("cashing it in") versus holding it for later use, prices already embody forecasts of future asset values. This is the sense in which future flows of utility are embodied in current asset values, as measured by the Inclusive Wealth approach.

This Inclusive Wealth approach is the stock analogue to the Genuine Savings/Investment approach currently being employed by the World Bank. Where genuine investment measures the change in the total capital stock, inclusive wealth aims to measure the stock in totality. A further extension here, however, is that we attempt to incorporate ecosystem risk, resilience, thresholds and irreversibilities into the measurement of inclusive wealth, thus taking it beyond the standard "weak sustainability" approaches of genuine savings and investment. Changes in inclusive wealth then provide the information necessary to assess whether development has been sustainable or not.

It should also be stressed again that using a wealth-based approach to the assessment of sustainable development means that we are focussing on determinants of well-being rather than the very constituents of well-being themselves. That is, the focus here is on the means rather than the ends of well being. We do not take any particular component—say, a pristine environment—as being an essential constituent of well-being, but instead as some component part of what enables people to achieve well-being. These are philosophical issues with which some will disagree, but we can only be explicit about the approach we are using and the assumptions we invoke.

A Sketch of Some Analytics

The basics of the ADM model of inclusive wealth starts with the conventions of neoclassical growth theory, namely a social objective function that sums and discounts instantaneous social utilities out to infinity into a measure of social welfare, *W(t)*.

$$W(t) = \int_{\tau=t}^{\infty} U\big(C(\tau)\big) e^{-\delta(\tau-t)} d\tau$$

Taking consumption, C, an index of natural resources R, and a measure of produced capital K, we define an economic program as a path of (C,R,K) into the future.

$$[\xi(\tau)]_t^{\infty} = \{C(\tau), R(\tau), K(\tau)\}_t^{\infty}$$

Standard growth theory proposes a production constraint that converts productive capitals and variable inputs into output and hence consumption. This presupposes technical efficiency (the economy is on the production frontier) and economic efficiency (the economy maximises, via benevolent and omniscient social planner or by competitive markets, the objective function subject to being on the frontier). By contrast, ADM presume no such first-best optimisation, instead proposing a general resource allocation mechanism α that produces outputs from inputs given capital, but without any presumption of Pareto optimality.

$$\alpha : \{t, K(t)\} \rightarrow \left\{[\xi(\tau)]_t^{\infty}\right\}$$

This enables us to move from a social welfare function *W(t)* defined explicitly on future utilities, to a value function defined on current capital, *V(t)*.

$$W(t) = V\big(K(t), \alpha\big)$$

Given this value function, shadow prices *p* for capital goods (capital good *i* in this case) can be defined based on hypothetical perturbations to economic forecasts.

$$p_i(t) = \partial V\big(K(t), \alpha\big) / \partial K_i(t) \equiv \partial V\big(t\big) / \partial K_i(t)$$

We can now define our sustainable development criterion, namely that the following must hold for sustainable development to be occurring.

$$dV(t)/dt \geq 0$$

Thus, social welfare must be non-declining for sustainable development to be occurring. The left hand side of this (the change in the value function over time) can be decomposed into the following components.

$$dV(t)/dt = \partial V(t)/\partial t + \sum_i [p_i(t)dK_i(t)/dt]$$

That is, the term after the summation sign is "genuine investment", while the first term on the right hand side is variously referred to as "the value of time" or "the drift term". Genuine investment reflects the choices made over time with regards to converting output back into capital restoration and augmentation, while the drift term reflects any exogenous influences on social welfare through time, whether by external terms of trade changes or exogenous technology shocks.

Applying IW at Regional Scale

Measures of IW are geographical in nature, in the sense that the wealth has to "belong" to *someone*, somewhere. The standard approach is to treat IW as a national measure, and thus treat sustainable development as being measured at the national scale by definition. However, some studies (not using the IW method) have analysed sustainability at sub-national scales (see Harris and Fraser 2002 for examples and critiques). However, particular issues are raised by attempts to assess sustainable development at a regional scale.

Firstly, is it *regional sustainable development* that is being directly assessed, or a region's contribution to national sustainable development? (Some regional studies have taken the first approach, and consequently been criticised for underestimating sustainability prospects by not allowing or accounting for substitutability possibilities across regions.) Second, how easily and sensibly are capitals measured at a regional, rather than national, scale. Third, what analytical and measurement issues are raised by the difference in scale? In particular, what is the role and significance of the "drift term" (measuring the role of external influences) when analysing a region?

These issues are discussed in the context of this project in the rest of the paper.

3. Measuring the Capital Stocks

The Inclusive Wealth approach requires the identification and measurement of all key capital stocks that contribute to economic productivity and hence social welfare. Despite this being a simplification of the task of measuring social welfare (i.e. directly measuring the value of all future utilities), this is still a huge task. Measurement involves understanding what the capital stocks mean at the regional scale and discerning appropriate values for the capital items, where these values are assessed at their shadow prices as defined in the previous section. In this section, the key capitals are described and the relevant spatial scale for investigation is discussed.

The first step in making the task manageable is to divide the capital stock into component categories. The main components are (i) manufactured or produced capital (MC), (ii) human capital (HC), (iii) natural capital (NC), and (iv) social capital (SC). Within each of these capital stocks an understanding of their appropriate scale of measurement is required, as well as what these stocks mean to a measure of inclusive wealth.

Manufactured Capital

MC constitutes the physical or built capital component of the economy: buildings, equipment, technological infrastructure and facilities, communications networks and transport facilities, and the like. Given the regional scale of this project, two aspects of MC stand out. First, MC (or at least, changes in MC) are measured in the standard national accounts and have market prices that can serve as a basis upon which shadow prices estimates can be formed. Second, most components of MC are geographically specific (and largely immobile) so that changes in regional MC can sensibly be assessed.

Human Capital

HC is considerably difficult to measure in practice. Typical approaches used in measuring HC can involve forming estimates based on educational achievements and qualifications themselves, or they can be formed on the basis of estimating the market value placed on educational achievements and qualifications. Both methods present practical difficulties. Moreover, HC is hard to pin down at a regional scale. HC is embodied in people, and people are highly mobile compared to other key forms of capital. Thus, assessing "regional human capital" will be difficult. However, to the extent that we are interested in the productivity of the nation as it is embodied in people, a mobile population is not too big a problem—if people take skills from one region to another, one region's declining HC will be offset by another region's increasing HC.

This, however, is only a first approximation. HC may be less geographically transferable than the people it is embodied in. A skilled farmer may have few skills that would transfer to an urban labour market. One response to this may be that if people are moving for economic reasons, then the value of their HC has declined in one area sufficient to make them move to somewhere it is at least as valuable. On this basis, we could still make the assumption that "one region's loss is another region's gain", and only worry about aggregate (national) calculation of HC. This is, of course, a simplifying assumption, although perhaps a necessary one. Something to be reckoned with during the life of this project is whether HC need only be assessed at the national level, or whether a regional calculation will be required as well.

Natural Capital

NC is where much of the effort of this project will be directed. NC is (i) regionally specific in many cases, (ii) not valued by the market, nor transacted through market processes for the most part, hence is neglected by typical aggregate economic measures (such as the market-based national accounts), and (iii) potentially subject to threshold effects and irreversibilities that mean it is important to evaluate cases where threshold effects might occur and ecological resilience be threatened.

Some of the components of NC we are most interested in lie in the agricultural production sphere: soil and water are obvious examples. Other types of NC (biodiversity, say) lie mostly outside the agricultural production sphere, although there will obviously be interactions. This will have implications for how shadow prices may be calculated for different resources: where resources are utilised in production but there is no market for that resource, values may be inferred through production function estimation where there are both marketed and non-marketed inputs. Where resources are not directly part of the production process the estimation of their shadow values may require some form of non-market valuation, including stated-preference techniques.

An important consideration in evaluating NC within the Inclusive Wealth framework is the issue of ecological resilience—are there thresholds or irreversibilities beyond which ecosystems are at risk of severe damage or are unlikely to regenerate? If the risk of natural capital declining in the future increases, even though natural capital itself may not be exhibiting any changes now, its relative stock value has decreased, and therefore wealth has declined. This is an important and under-estimated aspect of sustainable development. For example, for many decades direct performance measures of the Murray Darling Basin indicated sustainable use of resources. Only in the last couple of decades has the risk of future losses in productivity associated with changes in hydrology and salinity been adequately recognised. The risk of changes in natural capital is reflected by changes in the resilience of the systems concerned. Gradual and sudden changes are both important for sustainable regional development, but this project will have a special focus on the identification and estimation of thresholds in natural systems that demarcate significant changes from one state of natural capital to another (less valuable) state – especially non-reversible changes – and how far the system is from such thresholds. The closer a resource is to a threshold, the lower the resilience and the higher the risk of loss of capital.

Shadow pricing in the presence of "resilience issues" will clearly be more difficult than when it is assumed that all capitals change smoothly, without the nonlinearities implied by ecological thresholds. However, it represents something of a bridge between the weak and strong conceptions of sustainability—inclusive wealth measured in the presence of resilience and thresholds has elements of both.

Social Capital

Social capital sits awkwardly with the other three forms of capital in economic thinking. It is multi-dimensional (see Figure 1), means different things to different people, does not exhibit the same characteristics as the other capitals (Solow 2000) and is 'fiendishly' difficult to measure (Dasgupta 2000).

Its most famous definition, by Putman (1993) states that it is a set of 'horizontal associations' among people who have an effect on the productivity of the community including networks of civic engagement and social norms. However, with the integration of disciplinary works (primarily sociologists, anthropologists, political scientists and economists) a broader meaning and understanding of social capital has emerged (as summarised in Figure 1 and described in Grootaert and Bastelaer (2001).

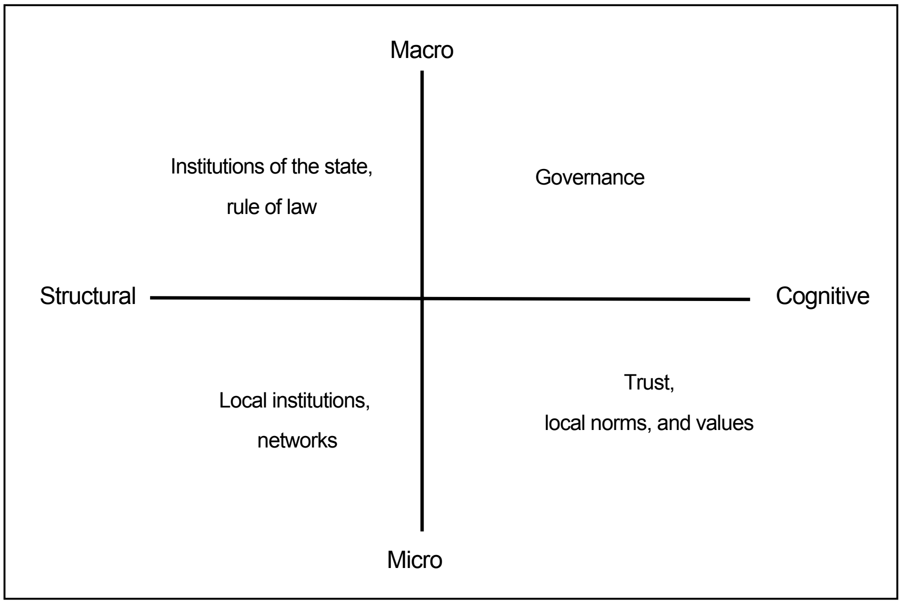

Figure 1. Dimensions of Social Capital (source: Grootaert and Bastelaer (2001))

While part of SC may well directly contribute to social welfare, one of the important roles played by SC is as an "impactor" on productivity—if important elements of SC such as trust, legal institutions and governance are in place and well functioning, then *given a stock of other capitals*, we would expect output to be higher than it otherwise would be. The key role of SC here is to reduce transactions costs and facilitate production and trade. This is not to say that SC cannot play other roles; in particular SC may in certain contexts contribute directly to human well-being, as well as via its role in facilitating production and trade.

For this work we are therefore measuring SC as it improves production the transformative capacity of the capitals into flows. This will be measured in the total factor productivity. However, the aspects of SC that have been identified as intrinsic are not included. This is because:

- current methods for measuring SC are still being developed (Productivity Commission, 2003)
- no study has shown that a change in SC has necessarily a good or a bad impact on resource use (Dasgupta, 2000)
- considering SC as an explicit form of capital is not universally accepted due to the difficulty in defining its stock and the flows (Arrow, 2000)
- lack of understanding of how substitutable and complementry aspects of SC are to the other forms of capital

Noting this, we follow the ADM use of three forms of capital (natural capital, human capital, manufactured capital) as the asset base for inclusive wealth, and do not explicitly measure social capital. SC, as measured in the project, is therefore the institutions and cultural norms that facilitate the transformation of the three capitals into production (or other utility). However, how to account adequately for changes in social capital still needs to be resolved in inclusive wealth.

4. Applying Inclusive Wealth at Regional Scale

The MMSD project aims to pilot a study of measuring and modelling sustainable development in Australia at a regional scale. Questions have already been raised as to what implications a regional rather than national scale will have on implementing inclusive wealth. This section identifies a number of conceptual issues that have arisen in considering the application of IW to a region in Australia. Specifically these issues are:

- the policy significance of a regional assessment
- exogenous influences on a regional measurement
- identification of key capital stocks
- significant regional goods and services and production systems
- assigning values (shadow prices) to capital stocks
- the role of equity in IW

Policy significance of a regional assessment

The focus on regions (eg. spatial units) meets the need in Australia to deal with sustainability issues in current socio-political boundaries. A key requirement for this project to be successful (ie continue to be used and developed) is that it feeds directly into decisions that government agencies (at all levels) have to make. Conducting the assessment at a regional scale is necessary to reflect current funding and management structures for natural resource management in Australia.

The objective of this project is to identify a process of measuring national inclusive wealth, though by using regions we are able to identify a region's contribution to this national measure. Notwithstanding this objective, there is an interest in the sustainable development of individual regions (DoTARS 2001) resulting in a sub-objective to obtain an accurate process to achieve stand-alone measurements of regional sustainability, not only how that region contributes to national SD.

Exogenous influences

Choosing to develop the system on a regional scale brings in added complications that must be acknowledged, chief amongst which are inter-regional transfers of all three capitals. Changes in capital at the regional level must include assessments of inflows from and outflows to other regions.

By adopting a regional scale there are a number of issues that need to be acknowledged, specifically:

- Identification and clarification of inflows and outflows from the region, eg. "foreign" capital and trade
- Trans-boundary externalities, eg. salt or nutrient flows
- Exogenous technical progress, eg. technology change that originates from outside the region
- Exogenous changes in export prices
- Population change

These issues are particularly relevant for small regions in a large nation, such as the case studies we have chosen. Overall, they can be grouped into two themes (i) inter-regional flows of capital (eg. people, water) and (ii) exogenous impacts on the region (eg. changes in export prices or technology changes).

The first theme we are currently proposing to adopt with a 'no change in external flows' approach. This is a common approach to regional modelling which is used extensively for investigating the impact of small projects or perturbations to the present economic system (eg. Shaffer, 1989, Bulmer-Thomas, 1992). With a national measure of SD many of the regional transfers should cancel out, that is they are only transfers between regions within the national system. However at a regional scale these transfers are potentially significant and therefore by assuming a relatively closed system approach (ie. not external movement of capital) is inadequate to a measure of regional SD. This issue will be further investigated as the project evolves.

The second theme of exogenous impacts on the region, or 'drift term', becomes particularly important at regional scales. The proportion of outputs and inputs traded across regional boundaries as compared to national ones, and the degree to which people and financial capital are mobile across such boundaries, means that many of the influences on regional prices and capital values will be externally driven. It is currently proposed to be addressed by identifying a base year and every measure after that year is expressed as a change from the base year, such as the approach adopted for Consumer Price Index (ABS 2003). This would result in marginal change being estimated, however total values of capital would only be calculated for the first year.

Identifying regional key capital stocks

Earlier discussions (Section 3) described the different types of capital to be measured and identified appropriate scales of measurement, such that human capital is more appropriately considered at a national not regional scale. However, it is neither feasible nor necessary to identify and measure all forms of capital within a catchment at the finest level of disaggregation. The need is to identify the key capital stocks, measure their levels and then estimate their shadow prices.

The key capital stocks are a subset of the total capital stocks in a region, as shown in Figure 2.

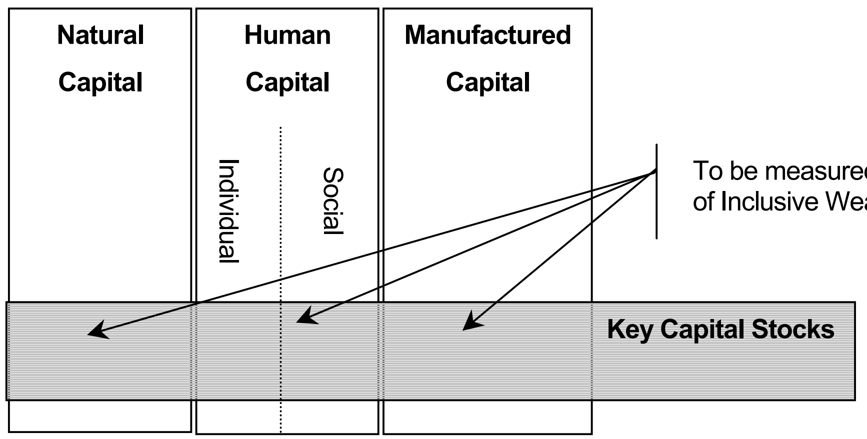

Figure 2: Inclusive Wealth's three capitals and their relationship to Key Capital Stocks

To identify the key capitals some assessment needs to be made of how important these capitals are to social welfare. Earlier discussions have highlighted the various direct relationships between social welfare and capitals, now a systematic process for identifying the key capital stocks is required so that they can be quantified and valued.

Currently there are no known techniques to identify, inventory and then measure key capital stocks in a region. Van der Perk et. al. (2000) have previously recognized a number of issues which need to be addressed for identifying key natural capital. We have modified this list to identify key capital stocks for human, manufactured and natural capital.

- Identify the role and significance of the functions that directly affect human welfare and consider their determining capitals
- Consider the relevant spatial and temporal scale for measurement and understanding of the key capital stocks
- Understand the links between capital stocks that affect the key capitals
- Ascertain the quantitative/ qualitative thresholds that exist for each capital and consider the distance to/ if the threshold will be crossed

These considerations are used to guide a two-step process to identify key capital stocks. Specifically, identify regional goods and services that directly impact human welfare, and then construct production systems (which can be distilled to production functions) for identification of critical capital stocks. These steps are elaborated on later, whilst Section 5 describes how this is undertaken for the case study region, the Goulburn Broken Catchment.

In adopting this approach a significant issue is the identification of how disaggregated capital stocks should be within the identified system. Ekins, et. al. (2003) identify four natural capitals; air, water, land and habitats. However, when this schema is applied in the measurement of capital stocks it is not only the quantity but also the quality and the distribution of these stocks that needs to be measured.

Therefore key capital stocks will have important quality aspects, such that a number of defining criteria or components are required to assist in providing realistic and appropriate values.

For example land is a key capital stock and needs to be valued in our region, but it has many uses. If land is to be measured appropriately for its value to human welfare then an appropriate metric of measurement needs to found. For example land used for productive dairy use has a different value, potentially, to land used in national parks and for recreation uses.

The relationship between significant regional goods and services, key capital stocks and critical capital components is shown in Figure 3. Where critical capital components represent the appropriate metrics required to value each key capital stock, they will include:

- Quantity determinates including spatial considerations, eg. land used in irrigated dairy
- Quality determinates eg. soil salinity

A contribution of this study will be to attempt to systematically, identify and value key capital stocks in a region.

Significant regional goods and services and Production systems

Identification of significant regional goods and services for the purposes of implementing the IW framework has no prior guidelines. For this project the aim is to identify all goods and services that significantly impact on human welfare. The process used here will be twofold. First a literature review of published regional statistics and information will be used to identify a long list of significant regional goods and services. Second, this list will be assessed and shortened by key regional stakeholders.

Production systems of each significant regional or service will be used in this study to help focus the investigation of capitals. Ideally all capitals would be included in an analysis of Inclusive Wealth, however resource limitations and data unavailability ensure that a comprehensive assessment will not be carried out. Therefore this project will attempt to design a structured approach to identifying key capitals using production systems and then (in some cases) estimating shadow values from production functions.

Mapping of production systems has been used extensively in value chain analysis as a first step to identify the ‘critical components’ of production processes and identifying areas for intervention, given an identified objective, such as lean production, total quality management (Porter 1985). This technique has been used extensively in manufacturing and some service related industries.

However, identifying the production system to be investigated is a difficult task. The theory of value chains suggests simplicity and clarity of focus (Hamel and Pralahad, 1994). However, the real world is much more complicated and arbitrary decisions to construct a production system for each significant regional good or service will be required (Brown, Bessant and Lamming 2000).

Due to the difficulty in identifying, measuring and understanding these production systems a consultative approach will be taken. This approach has the following four characteristics and is built around concepts sketched in Kaplinsky and Morris (2001):

- Objectives are set as to why and what you need the system to provide
- Background research is used to ‘construct a general system for the area’
- Participation with the whole system and its constituent ‘players’ to identify relative accuracy of the system, weightings of importance of the system and generally agreed critical parts of the system
- Follow-up with specific system parts is then used to provide robustness for the whole system

Once a system has been identified there is a need to simplify this by producing production functions, which include all (as many as possible) of the identified capital stocks and their key components in the system. These production functions will be used directly or indirectly in assigning shadow prices.

Production functions typically produce a single output derived from a functional relationship with the quantities of the inputs. As stated earlier in Section 2, this project does not require the economy to be on a production frontier or achieve economic efficiency. Instead, it is presumed that some resource allocation mechanism, generally specified, produce outputs from inputs given capital, with no presumption of Pareto optimality. This ensures that the production functions defined do not have to be specified as efficient, optimal, dynamic or otherwise (Chiang, 1992).

Production functions will therefore be a combination of stocks and flows to produce identified significant regional goods and services. Initial estimates will be based on quantities of identified capital components, but latter valuation will occur for each key capital stock.

Assigning values: shadow prices and future scenarios

The inclusive wealth measure requires that all key capital stocks included in the measure require a shadow price.

Shadow prices represent the marginal change in present value terms of the future well being of all peoples, derived from the capital stock, including direct and indirect uses and intrinsic, option and bequest values. Some capital stocks already have established market values (primarily in manufactured capital) that can be used as a first proxy to the shadow price. However, these may need to be modified to reflect significant market failures or externalities. Other capital stocks will not have markets (non-market goods and services such as biodiversity) and their shadow prices will have to be found through other means, such as benefit transfers from past studies, stakeholder surveys (eg. reveal preference and stated preference techniques, not within this project scope currently) or ‘expert’ discussions.

There are two requirements with estimating shadow prices: (i) a future scenario will be developed for the region, such that current and future use and demand (impact on human welfare) of capitals can be estimated, (ii) different stakeholders will have different shadow prices therefore assumptions about aggregate demand curves need to be explicitly detailed and defended (Hanley and Spash, 1993).

The estimation process of shadow prices for each key capital stock will be different. It is proposed that shadow prices for capital stocks can be estimated by a number of processes (see for example, Hanley and Spash, 1993). A number of methods will be investigated during the project.

1. Market prices: derived directly form market exchanges, eg. ABS 2002
2. Adjusted market prices: derived from market prices but adjusting for lack of information, government intervention (eg. taxes, subsidies), time lags, and can be estimated by production functions, hedonic pricing,
3. Benefit transfers: applying non-market valuation results from other studies, within identified criteria as outlined in Desvousges, Naughton and Parsons (1992)
4. Revealed preference and stated preference: survey techniques such as contingent valuation and choice modelling to derive estimates for non-market capitals, eg. Bennett and Blamey (2001)

The following breakdown by capital stock is our initial assessment of how shadow prices will be attributed.

Items of manufactured capital are typically tradable in markets and hence have market prices (or values in the national accounts) from which inferences can be drawn. For each key stock consideration of significant market distortions (eg. taxes, subsidies) and the impact of these on capital value will be considered. If market prices are not considered an appropriate proxy for shadow value then methods proposed to value the other capitals will be considered.

The valuation of human capital will start with initial work undertaken by the Australian Bureau of Statistics and will be investigated for its application to a regional scale (Wei, 2003).

Natural capital is a focus of this project. We distinguish between items of NC that are primarily used in production processes that are highly marketed (eg. irrigation diary) and those involved in non-priced production processes (eg. recreation and biodiversity). In highly marketed processes initially production functions will be used to estimate capital values of non-marketed inputs. In those processes, which are highly non-marketed then benefit transfers will have to be used from previous studies that estimate 'value' of the capitals via past stated preference studies for water used in recreation.

A novel contribution that this study will make is the incorporation of resilience/ threshold effects in Inclusive Wealth. For example, each 'value' identified for key capital stocks must acknowledge characteristics of resilience (outlined in Brock, *et. al.* 2001). This will be further investigated as the project matures.

How does equity fit into inclusive wealth?

Finally, there is the issue of equity. It is possible for the total inclusive wealth of a country to increase while the poor get poorer, or the disparity between rich and poor gets larger. Therefore, a comprehensive measure of sustainable development should accommodate equity. Inclusive wealth at this stage does not appropriately deal with the issue of intragenerational equity (eg. between people currently living). The regional approach adopted will have some spatial implications and hence could conceivably already include some descriptive equity considerations. As this is a pilot for a national program where many regional models will be put together it will enable issues of interregional equity within Australia to be considered.

Inclusive wealth does consider intergenerational equity (eg. between different generations of the population). Further modification to the theory and possible tools are underway to include intragenerational equity and when, if, these become available they will be included in the analysis.

5. IMPLEMENTING IW IN THE GOULBURN BROKEN CATCHMENT

The application of inclusive wealth in this pilot project will be made to the Goulburn Broken Catchment and potentially the Murrumbidgee Valley. This section will use the Goulburn Broken Catchment (GBC) as the sample catchment.

There are three parts to this section providing initial guidance on the application of inclusive wealth to Australia.

- A description of the region (both physical and socio-economic)
- Identification of significant regional flows (goods and services) that contribute to human well being (including future scenario for the catchment)
- Schematic of production systems for key regional goods and services

Description of the Goulburn Broken Catchment

Physical description

The GBC covers 2,431,654 ha in the north of Victoria, some 10.5% of the state. It includes the catchments of the Goulburn and Broken Rivers and part of the Murray Valley (downstream of Bundalong) (GBCMA 2003).

Shepparton Irrigation Region (lower Goulburn Broken in Figure 3): The region is centred on the riverine plains in the north of the catchment, adjacent to the Goulburn and Murray Rivers. Covers an area of 500,000ha with 80% under irrigation. The area is predominantly cleared (less than 10% native vegetation remnants) with the key industries (irrigated area) dairy, cropping and horticulture (fruit). The dairy and horticulture industries account for 90% of the water used.

Mid catchment (dryland agriculture): Typified by expansive riverine plains and low slopes in the middle of the catchment, it is the largest geographic zone covering 1.4 million ha. The area has been 80% cleared of native vegetation with the remnants highly fragmented and confined to roadside and small blocks of public land. Cropping and some intensive industries characterize the plains, whilst the hills are dominated by pastoral industries including sheep and cattle. There are some emerging alternative land uses including- timber, hay and seeds, grapes, olives, berries and other fruit and livestock including horses and goats.

Upper catchment (highland forest): The Upper catchment is primarily steep alpine areas, low foothills and board valley in the southern most part of the catchment, covering 900,000ha. The zone is dominated by national parks and public forestry, with half the zone forested by large blocks of public land (used for forestry, conservation, water harvesting, recreation and tourism) and Lake Eildon. The traditional farming systems and uses are giving way to 'lifestyle' and hobby farming on private land, contributing to the rapid population growth.

Within the GBC identification of natural assets has been undertaken and four have been identified:

- **Soil:** range of different types; lower slopes dominated by poorly drained acidic soils, where salinity can be a problem in the flood plains; lower and mid catchment have moderate to low fertility and erosion potential; upper catchment dominated by good draining, acidic surface and sub-surface making them unsuitable for productive capacity without lime inputs.

- **Water:** region annually uses 803,000ML with 200,000ML extracted from Murray Valley and River, 565,000ML is exported to adjoining catchments for irrigation and stock and domestic and an average 1,760,000Ml flows to the River Murray. The catchment covers Murray and Highlands groundwater basins; 30% of streams are in good condition, wetlands cover 82,181ha

- **Biota:** includes the sum of all living organisms of an ecosystem. The GBC has nine bioregions with the lower catchment mainly grassy and shrubby woodlands and box-ironbark forests, it is the most depleted part with remaining native vegetation scattered on small private land, along rivers/roads and railways. Mid catchment has foothill and valley forests, with grassy woodlands large and small blocks of native vegetation throughout. Upper catchment has continuously vegetated hills and mountains of sub-alpine and treeless vegetation montane moist forests, woodlands and riparian forests, primarily managed by government departments.

- **Atmosphere:** poorly understood, the region contributes to greenhouse gas emission through intensive diary, cattle and sheep farming, whilst carbon sinks are provided in the catchment through vegetation and revegetation efforts. Due to lack of data and current unknown impact on human wellbeing in the catchment and Australia, this aspect of NC will not be further considered for a measure of IW.

Overall the catchment is a main contributor to the Murray Darling Basin, covering only 2% of the Murray Darling Basin land it provides 11% of the Basin's stream flow, but also provides significant salt and nutrient loads to the Murray River. There has been significant change in the landscape of the catchment over time with currently half of river flows diverted for agricultural use and 70% of native vegetation cleared since settlement (1830s). This clearing of native vegetation corresponds to private land ownership (70% of catchment), which is primarily used for agricultural production.

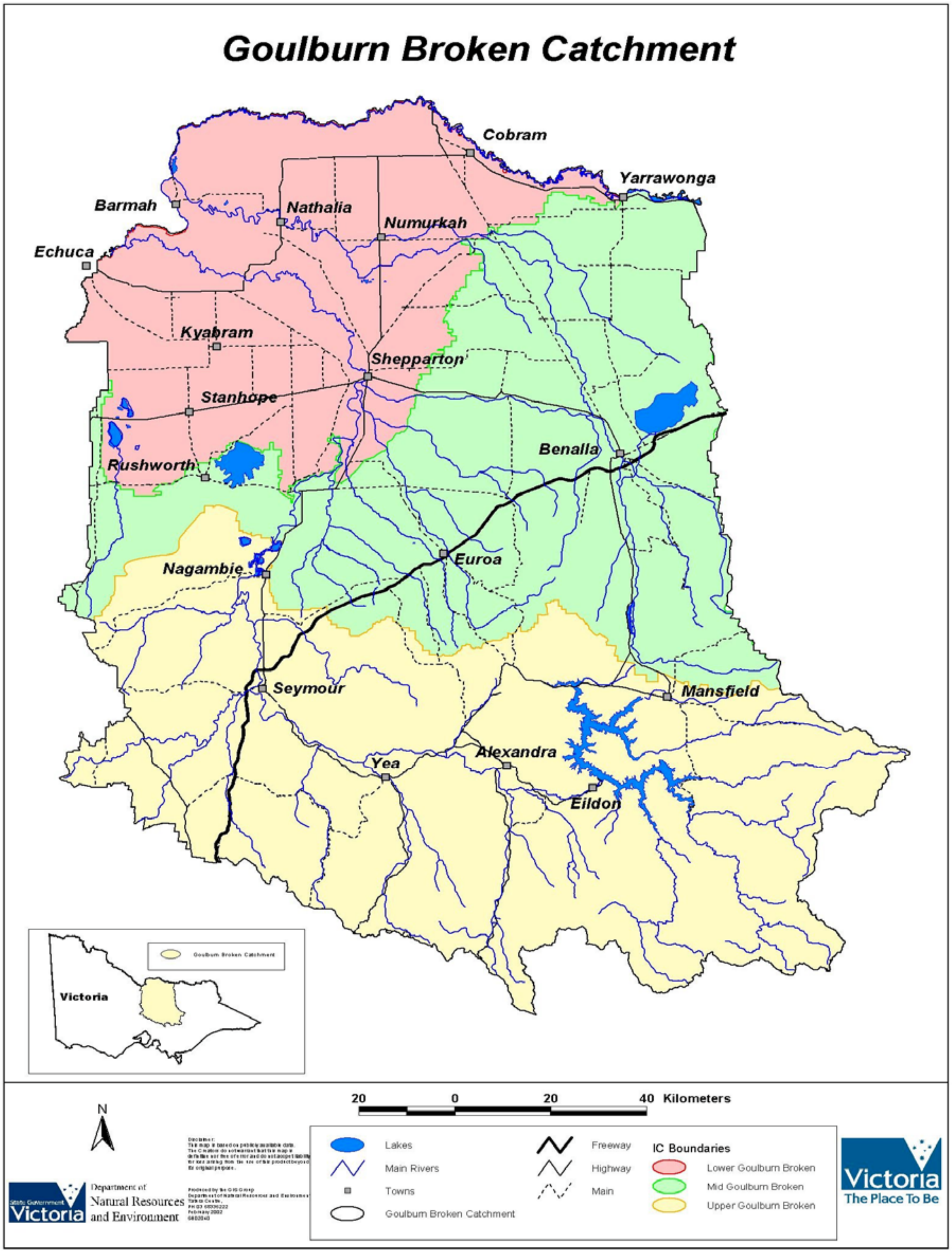

Figure 3. Goulburn Broken Catchment

The catchment has 189,590 people who live in the catchment providing an employment pool of 77,000 (2001 Census). Of this population, 18% are over the age of 60 years and 23% are 14 years and younger, leaving only 59% of the population in the working age. There is an even gender split overall, although females outnumber men 2 to 1 over the age of 80 and men outnumber women under the age of 24. Only 1.5% of the population is indigenous but 8.9% are born overseas and 11% speak another language, apart from English (ABS 2001 Census).

Population numbers fluctuate, throughout the year, like during the fruit harvest season from December to March, about 10,000 itinerant workers from throughout Australia and overseas converge on the Shepparton Irrigation Region (SIR). Rapid population growth is occurring in some parts of the catchment, notably centres within commuting distance of Melbourne, the City of Greater Shepparton and along the Hume Highway (GBCMA 2003).

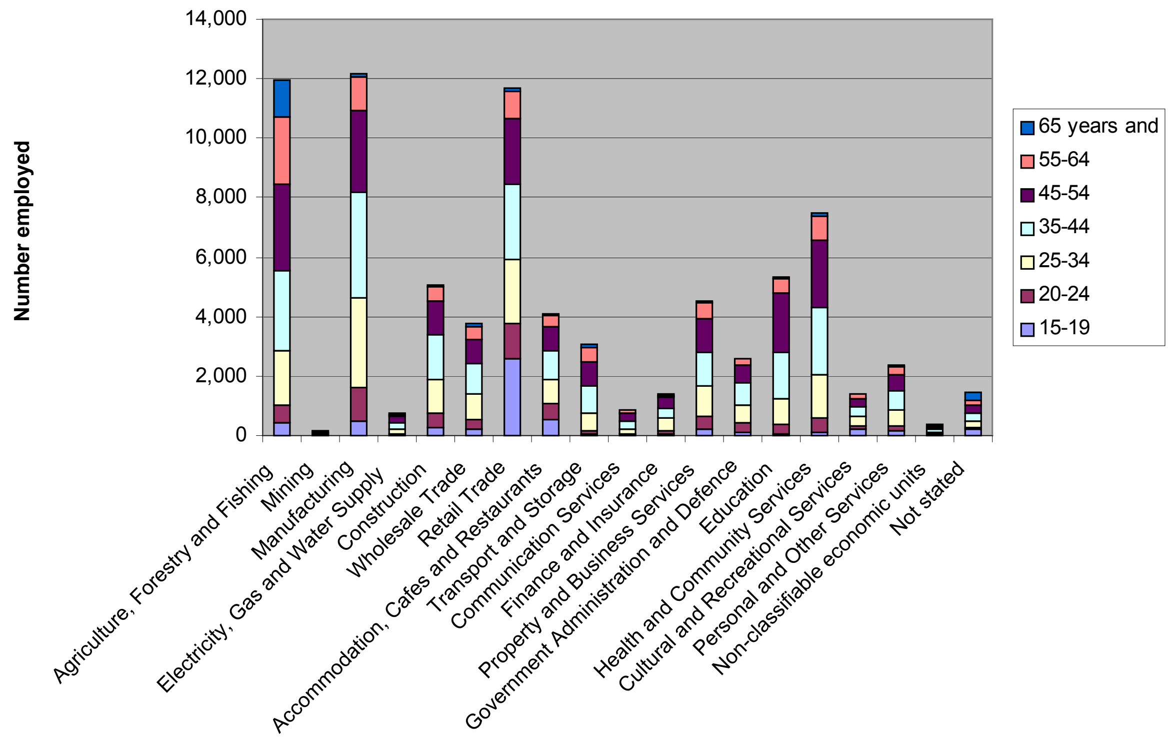

Figure 4 Employment in Goulburn Broken industries by age (ABS, 2001 Census)

The majority of the population is centered around the irrigation region (63% of population) due to the dominance of employment opportunities for example 75% of farm jobs (Figure 4). SIR is more densely settled farming activity with associated larger service towns and value adding industries that have established. The major rural towns and cities in the catchment include Shepparton, Mooroopna, Benalla, Seymour, Kyabram, Cobram, Yarrawonga, Numurkah, Nathalia, Mansfield, and Yea (Figure 3) (Young, 2001).

The Goulburn Broken catchment is widely regarded as the "food bowl" of Australia. The region supports a primary production sector of dairy, fruit, vegetables, forestry with a large fruit and vegetable food processing industry centered on Shepparton and value adding in other commodities such as milk products, wineries and meats (CSIRO, 2003). The catchment's gross value of production from agriculture, horticulture, forestry and aquaculture production and processing is nearly $3.0 billion (estimated for 2000), with the catchment, as a whole, producing approximately $7.8 billion (estimated for 2000) across all sectors of its economy (see Table 1 for breakdown by industry and zone). Of that total, the irrigation region contributes approximately $5.9 billion and the dryland area contributes $1.9 billion (GBCMA 2003).

Table 1. Industry Gross Value of Production[2] for the Goulburn Broken Catchment, 1996

Industry	SIR	Dryland	Total
Dairying – milk	$440.85m	$ 12.50m	$ 453,348,107
Livestock slaughter	$145.94m	$ 64.96m	$ 210,898,408
Fruit(exclude grapes)	$167.66m	$ 1.58m	$ 169,239,297
Timber		$ 85.60m	$ 85,600,000
Hay production	$ 49.56m	$ 12.31m	$ 61,869,172
Wool	$ 15.71m	$ 33.71m	$ 49,424,727
Cereal Grain	$ 41.08m	$ 10.78m	$ 51,857,549
Vegetables	$ 24.19m	$ 3.69m	$ 27,869,372
Pastures for seed	$ 2.22m	$ 8.60m	$ 10,821,915
Aquaculture		$ 10.70m	$ 10,700,000
Egg production	$ 1.00m	$ 6.91m	$ 7,907,664
Potatoes	$ 3.50m	$ 1.68m	$ 5,185,258
Grapes	$ 1.30m	$ 3.01m	$ 4,313,806
Beekeeping	$ 0.94m	$ 0.24m	$ 1,180,472
Non-cereal grains	$ 0.78m	$ 0.17m	$ 953,489
Total GVP (1996)	**$894.73m**	**$256.44m**	**$ 1.151 Billion**
Estimated in 2000	$1.048 Billion	$301.00m	$1.349 Billion
% of Total	**78%**	**22%**	

[2] Gross Value of Production (GVP) is the gross market value of the total number of units of output from an industry, without any deductions for inputs.

Source: Young 2001

Identification of significant regional goods and services

The significant regional goods and services for the Catchment are based on workshop outputs (conducted 2002 see CSIRO 2003 for details). The results identified that human well being for the region was made up of production, community and amenity. CSIRO (2003) further defined these flows in terms of ecosystem services and this work has been widely accepted by the community. Therefore for our purposes (measuring IW) further clarification of production needs to occur. This section endeavours to refine what production refers to currently (refer to Table 1) and its future requirements.

Key regional products and industries

The identified goods and services in the GBC are outlined below. The way the industries are defined and the types of measurement used, for example contribution to Gross Regional Product determine actual significance of the industries, employment or water use are also common measures. Overall, the dairy industry (production and processing) always comes out as the most significant industry followed in varying orders by community services, transport and communication, horticulture, manufacturing, wholesale/retail trade (Young, 2001; CSIRO 2003).

- Primary production, employs about 12,000 in 1996 (Young 2001) and includes the following:
  - Dairy in the GBC contains 24% of nation's dairy farms and producers 26% of national milk, it is nationally and internationally competitive because of the low cost of production, ready access to markets and value adding capacity, highly dependent on water and still has a range of herd sizes (80-1000 cows).
  - Horticulture's main vegetable crop is tomatoes others important crops are potatoes, carrots, sweet corn, capsicum, eggplant, zucchini, broccoli, peas, snow peas, beans, pumpkins and squashes. The principal orchard crops are pears, apples, peaches, nectarines, apricots, plums, nashi, kiwi fruit and cherries grown for both the fresh market and for processing through the major canneries in the region.
  - Hay, pasture seeds and grains is mixed farming that supports other regional industries with direct hay and silage and is a national drought fodder reserve. The industry is responding as an alternative for decreasing meat and wool prices.
  - Timber production, overall 26,718 ha of the catchment are under commercial plantation, the majority are with Hancocks Victorian Plantations (58%) and a further 18% are with private landholders. Additionally 2,396 ha are under private landholders for natural resource management (Robb 2003).
  - Livestock includes slaughtering of cattle (beef and diary), sheep meat, pigs, poultry that accounts for 18% of Gross Value of Production (1996) and wool production for a further 4% of GVP, primarily occurring in the dryland areas.
  - Other industries include *wine grapes* that occupy 2,600ha (September 2000) with significant increase in winemaking capacity, including; crushing, winemaking, bottling and storage and processing. A*quaculture* is located adjacent to the Goulburn River (and

tributaries) between Eildon and Nagambie and has grown 10-18% per annum since 1998-2000 with additional value adding opportunities (fish smoking) also starting to appear. H*orse breeding*, in the catchment is recognised as the second largest breeding area in Australia, with 11 current facilities and employing about 1,500 people in 2000 (Young, 2001).

- Processing/ value adding of primary products, estimated to employ 5,200 in 1996, with more than $630 million spent on capital investment from 1997 to 2003 with the existing assets being added to at an annual investment rate of $100 million (GBCMA 2003). The key processing/ value adding that occurs in the region is primarily:
    - Dairy processing occurs through co-operatives such as Bonlac Foods (Stanhope) and Murray Goulburn (Cobram and Rochester), Tatura Milk Industries (Tatura). Multinationals include Nestle (Tongala and Echuca), Kraft (Strathmerton) and Parmalait (Albury), with Diary Farmers Cooperative and Ducats as milk product packagers and distributors.
    - Fruit and vegetable processing occurs primarily in the irrigation region. There are a number of operators including: Campbell's Soups (Lemnos), Cedenco Australia (Echuca), Girgarre Country Foods-Heinz (Girgarre), Simplot (Echuca), Unifoods (Tatura), Ardmona Foods and SPC Ltd (Mooroopna / Shepparton), Heinz Wattie (Echuca) and Henry Jones (Kyabram), most are Australian owned.
    - Timber processing occurs in five softwood sawmills; three panel mills, two pulp/paper mills; one log exporter, one sawmill residue processor and several smaller processors obtaining wood from within the catchment. There are around 14 mills using native forest logs, with annual intakes from 45,000 m^3 to less than 5,000 m^3 (NorthEast 1999).
- Service and tertiary industries [no blurb?]
    - Wholesale and retail trade sectors are experiencing significant growth and are nominated as ‘indicators’ by the North East Victoria Sustainability Indicator Report (Victorian Department of Premier and Cabinet, 2002) of contained regional business growth and discretionary household expenditure. This sector is also considered a key part of the tourism and recreation sector, which employs about 1,200 workers.
    - Health and community services and education are centred in the main cities through the region with high quality education facilities available Melbourne University’s Dookie College, LaTrobe University in Shepparton and Mt Buller, Goulburn Ovens TAFE.
    - Transport and communications are key infrastructure assets in the region and include: the Hume freeway, Goulburn Valley Highway, Midland Highway, Seymour (rail hub) and container handling facility at Mooroopna. The road bridges over the River Murray are being upgraded to facilitate southern NSW using value adding processing in the region, and timber is exported from Geelong port using rail and road to get there

Regional industry is highly dependent on the natural assets that underpin its success. CSIRO (2003) has estimated the amount of water required and nitrogen and phosphorus produced for industry sectors in the region. The industries that used the most water (directly and indirectly) per dollar of demand were: other horticulture; hay/seed, grapes, cereal crop and fruit. The industries that polluted the most nitrogen and phosphorous per dollar of demand were fruit, intensive animals, grazing and cereal crops (CSIRO, 2003).

Future regional scenario

The Catchment Management Authority has already identified the future of the GBC and it is reiterated below:

> Our regional community is growing. By 2020, we expect the population to be 220,000 and the cultural mix will be diverse. The world demand for food will continue to increase, driving an expansion of our agriculture sector. This growth in production and population will place increased pressure on the region's natural assets. Over the past 20 years we have seen a trend in the intensification of agriculture production. We are using less land for agriculture but have managed a significant increase in agricultural production. This trend is expected to continue. Land is moving from agricultural use to rural living uses, particularly in the areas with easy access to Melbourne.
>
> Within this context, the GBCMA, in consultation with partner agencies, local government and the community, is proposing the following vision for the Catchment:
> "*A catchments recognized locally, nationally and internationally for quality agricultural produce and where community values contribute to the benefits of abundant and well-maintained environmental assets used for tourism and recreational activities.*
> *The environmental footprint of irrigation and dryland farming will be significantly reduced, with farmers occupying less land and using less water whilst managing their resources more sustainably. New opportunities will arise for increasing the ecosystem services provided by the land retired from agriculture and by improved environmental flows.*
> *The region's economy will be robust, with much of the agricultural produce processed within the region, generating employment and wealth creation opportunities for a regional community actively engaging in natural resource management programs.*"
>
> GBCMA 2003:9

This future vision is being implemented through a number of expected landuse changes. These have been identified and the key ones are listed below:

- An intensive agricultural zone with a smaller ecological footprint, colloquially called 'doubling production from half the land'.
- An increased conservation zone where the land previously used for traditional agriculture is managed for nature conservation and ecosystem services.
- Rural living areas where land, particularly near urban centers, is converted to hobby farms and smaller farms where the main household income is from activities other than agriculture and which may offer additional conservation benefits.

What are the significant regional flows?

The following long list of significant regional flows that contribute to human wellbeing in the catchment has been identified and will be further refined and tested with stakeholder groups in the catchment.

Production consists of:

- Dairy and processing
- Cropping and grazing
- Nature conservation
- Fruit and value added processing
- Forestry

Community consists of:

- Houses, etc
- Recreation

Amenity consists of:

- Nature conservation
- Areas of future opportunities and cultural significance

Schematic production systems for significant regional flows

Once the significant regional flows of goods and services have been identified then production systems are used to identify the key capital stocks and to further reduce the processes to a production function. This section only provides three conceptual production systems, diary, nature conservation and forestry.

These production systems are only conceptual in nature and need to be further tested and trialled in a workshop situation with stakeholders that represent some or all of the production process. Following this, discussions with technical experts on components of the chain will be used to elicit information on critical components to determine the value of each stock.

Each production system combines all three capital stocks to be measured, as well as flows which originate from stocks outside the catchment. At this conceptual phase they are only to illustrate the whole production process in the catchment and will be later refine to production function equations.

The first identified significant regional output was dairy production. Figure 5 shows the initial dairy production system constructed for the GBC. This system identifies a number of capitals and flows that combine to form the regional dairy output.

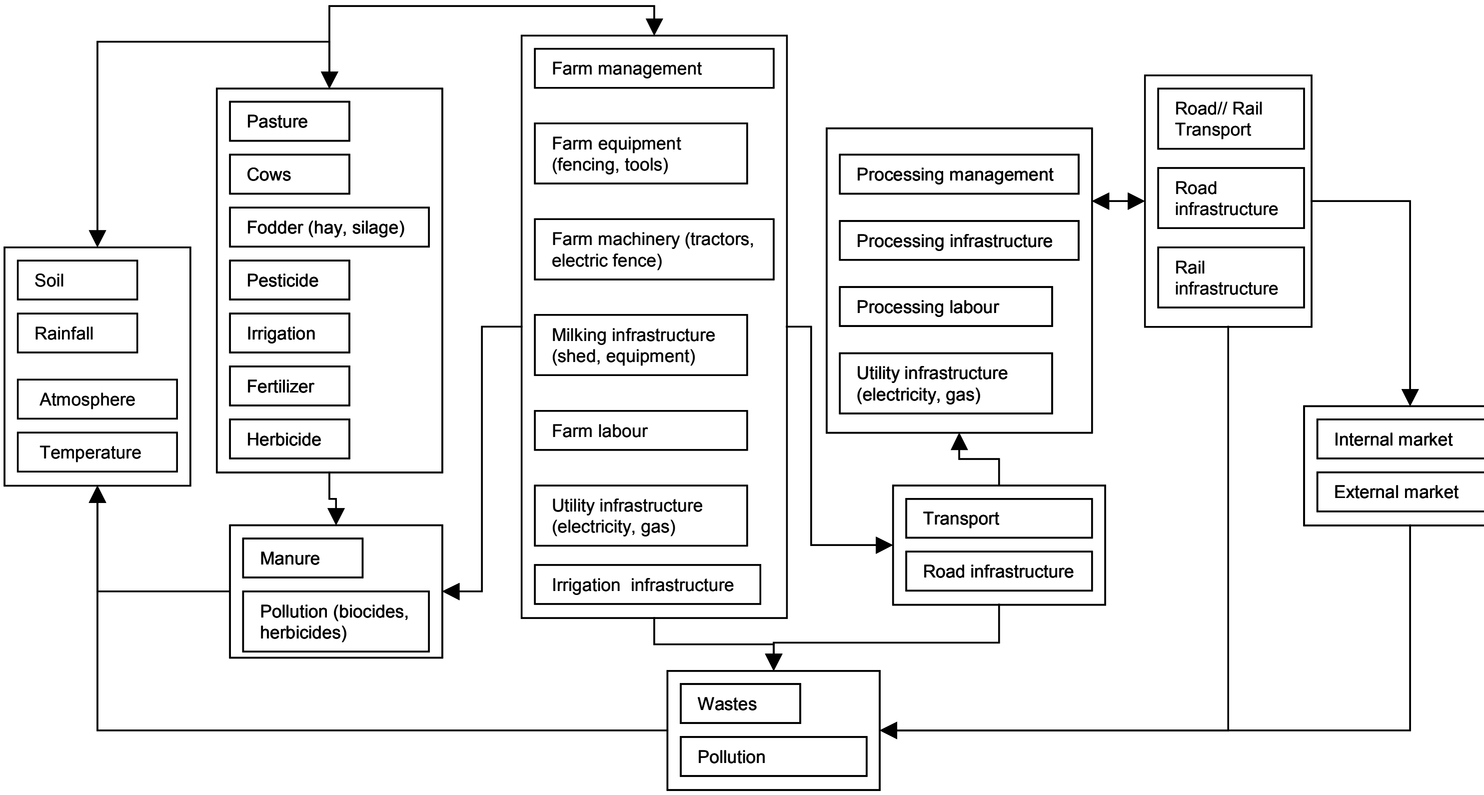

Figure 5. Diary Production System for the Goulburn Broken Catchment

The next production function is nature conservation or biodiversity (Figure 6). It is a significant user of land in the lower catchment and has growing important to the aesthetics of the region and its future as a peri-urban development.

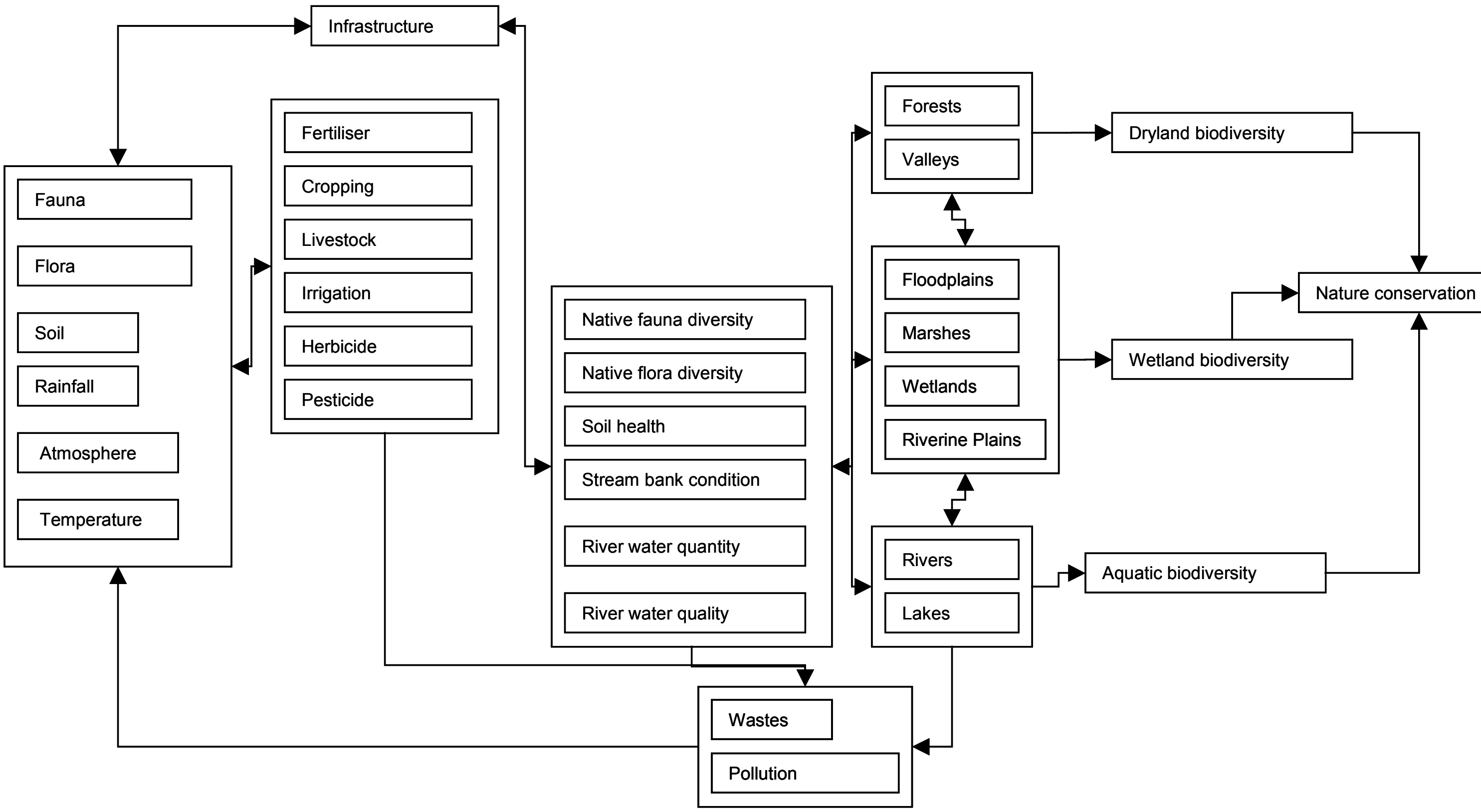

Figure 6 Nature Conservation Production System for the Goulburn Broken Catchment

The final production system outlined in this paper is the forestry production system (Figure 7). This system producers two outputs nature conservation and forestry for market. It is also linked directly to the nature conservation production system highlighting the interdependence within a region of not only the capital stocks but also the outputs.

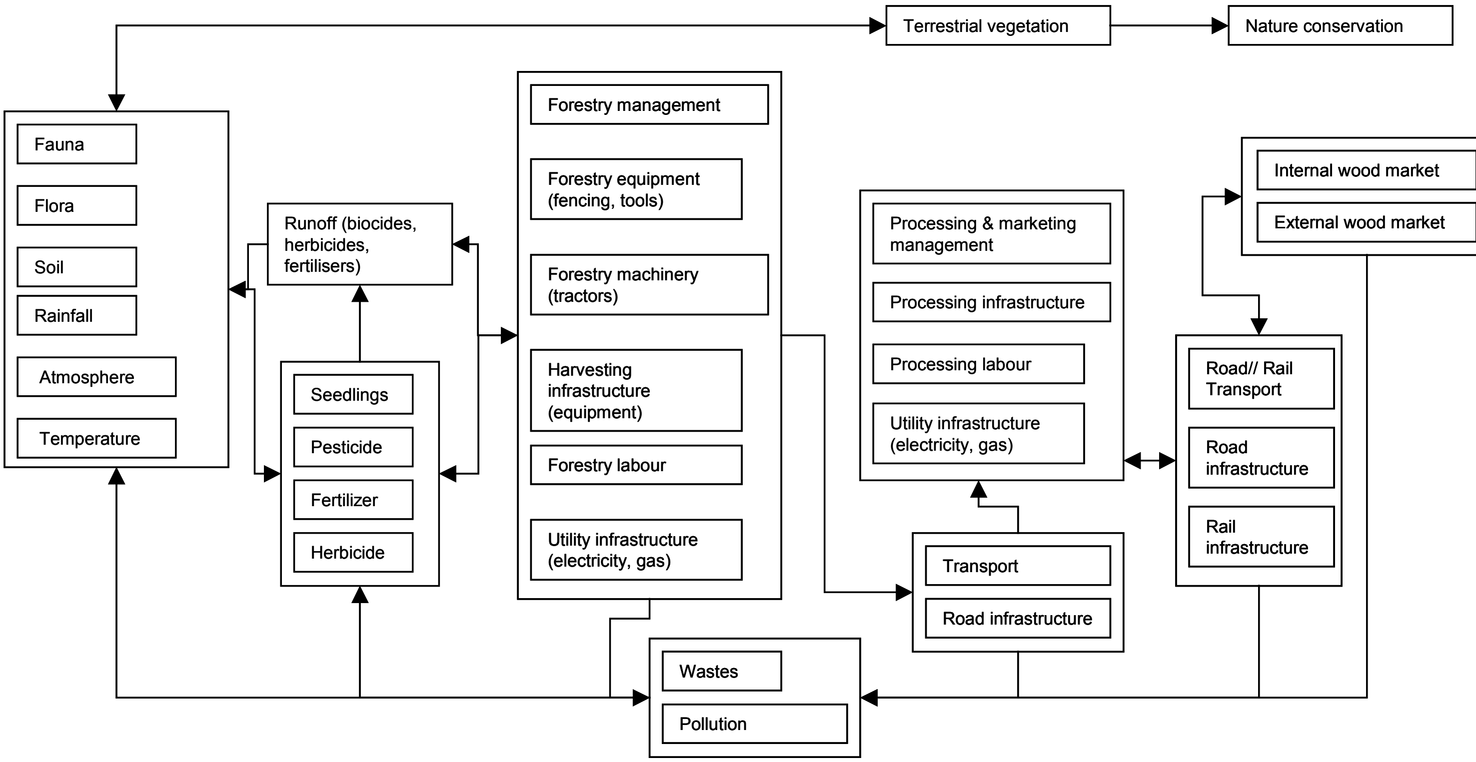

Figure 7 Forestry Production System for the Goulburn Broken Catchment

All of these conceptual production systems require some of the same capital stocks for production, eg. land, water. However, some of them are complementary uses like dairy and forestry, while others are substitutable uses, eg. nature conservation and forestry. The value of capital stocks will be impacted by the rivalry nature or otherwise of the goods, obviously land in the forestry and nature conservation systems needs to be valued the same, otherwise there would be a use shift. However, as diary occurs on irrigated floodplain- where forests cannot be grown, it is conceivable that different values can occur for the same key capital stock, land.

The initial aim of measuring IW in the GBC is to inventory all flows to human well being and their constituent critical capital stocks. Initially it may resemble a presence/ absence indication such as in Figure 8, however over time this will be further refined to include quantity and price estimates.

		Production				Community		Amenity	
		Dairy & processing	Horticulture & processing	Grazing/ cropping	Forestry	Housing, etc	Recreation	Areas of culture/ future options	Nature Conservation
Natural	Agricultural land	✓	✓	✓		✓	✓		
	Forests				✓		✓	✓	✓
	Native vegetation				✓		✓	✓	✓
	Livestock	✓							
	Water	✓	✓	✓	✓	✓	✓	✓	✓
Manufactured	Transport Infr.	✓	✓	✓	✓	✓	✓		
	Buildings	✓	✓	✓	✓	✓	✓		
	Machinery & equipment	✓	✓	✓	✓	✓			
	Utility Infra.	✓	✓	✓	✓	✓			
	Dams, canals	✓	✓	✓					
Human	Skills/ Health	✓	✓	✓	✓	✓	✓	✓	✓
	Age	✓	✓	✓	✓	✓	✓	✓	✓

Figure 8. Example inventory of for an estimate of inclusive wealth in the Goulburn Broken Catchment

6. CONCLUSIONS

The project described herein represents one of the most ambitious attempts to assess sustainable development carried out in Australia thus far, and it is at the "leading edge" of world attempts. It is based on a rigorous framework—the Inclusive Wealth framework developed by Kenneth Arrow, Partha Dasgupta and Karl-Goran Maler—which provides a clear rationale for using changes in aggregated capital values as a measure of sustainable development, without requiring any assumptions of "first best" behaviour or market structure. Moreover, the approach extends beyond conventional assumptions-of-convenience whereby smooth substitutability is presumed between various different types of capital.

The project will proceed at the regional scale, with the Goulburn Broken Catchment in Victoria being the first area in which IW will be measured. This region is highly agricultural, but also contains processing industries and several large urban regional centres, as well as areas of environmental interest. Initial investigations have identified the significant flows to human well being for the region and for some of these conceptual production systems and derived production functions have been constructed.

In this project, the CSIRO is interacting with a variety of other policy and analytical agencies, and we hope that such interactions provide a model for future productive exercises in the measurement of sustainable development.

Additionally, as this project is a proof of concept for implementing inclusive wealth, it is proposed that the refinement of theory will be an outcome of the project as well as the testing of empirical application of the theory.

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