The University of Sydney
Centre for Integrated Sustainability Analysis

Assessing the Impacts of a Loaf of Bread

ISA Research Report 04-07
Prepared by Joy Murray and Christopher Dey

ISA, Centre for Integrated Sustainability Analysis at the University of Sydney, Australia

The University of Sydney
Centre for Integrated Sustainability Analysis

Assessing the impacts of a loaf of bread

Joy Murray and Christopher Dey, ISA, A28, The University of Sydney NSW 2006, Australia

This report is freely available at http://www.isa.org.usyd.edu.au/publications/

For further inquiries please contact
Joy Murray
ISA, A28
The University of Sydney
NSW 2006, AUSTRALIA
j.murray@physics.usyd.edu.au
Phone: +61 / 2 / 9351-2627
Fax: +61 / 2 / 9351-7725

Table of Contents

Executive summary

Intended Audiences

This paper will be of interest to those concerned with the integration of the assessment of social, environmental and economic impacts of doing business. While it may be of specific interest to people involved in bread production and the bread production supply chain, the principles espoused and the methodology employed can be applied to any organization. They can also be applied at the individual, project or product levels. The metrics provided for analyzing the true cost of a loaf of bread have broad application.

Full supply chain integrated sustainability analysis (ISA) with shared responsibility for all transactions is the methodology presented below. The ISA approach recognizes the inter-dependencies of social, economic and environmental decisions and the wider inter-dependencies of producers and consumers throughout society. We are all in this together! Change one thing and the world changes. But just in case the change has unforeseen and possibly detrimental consequences the ISA methodology allows for scenario testing. This means that the groups identified below as audiences for the paper will be able to conduct a series of 'what ifs' to test out their ideas. They can, for example, try out a change in supplier (e.g. change to a local producer) or a reduction in one commodity and an increase in a substitute commodity. The TBL account will then reflect changes in any interdependencies in the supply chain, for example what the change might mean for employment or water use. This has strategic importance when organizations are endeavoring to manage risk as well as make ethical changes to their practices.

The methodology also embraces the principle of shared responsibility, and proposes a mechanism for sharing responsibility equitably throughout supply chains. In so doing, it recognizes that we all make contributions to the total impact from the production of bread and that there is a fundamental inter-relationship between consumer and producer (see Lenzen et al. 2006).

As a briefing to the reader we present below some suggested audiences for the methodology contained in this paper. It is suggested that vertical supply chains engaged in the production of a loaf of bread, or a whole sector with input into bread making, may be interested in understanding the broad issues affecting their triple bottom line (TBL). It is also envisaged that single entities, such as a farm or a bakery, will use this to identify the on-site as well as upstream 'low hanging fruit' opportunities for improvement. It may be that changing something upstream is more effective and efficient than making an on-site change, but only a detailed examination of the supply chain can reveal this. It is also suggested that government agencies will be able to make use of this methodology as an additional reliable data set on which to base strategic decision making. Other audiences include: investment and financial institutions where risk assessment is an important capability; individuals who want to examine their personal or family expenditure; and educators with the crucial role of community education as well as primary, secondary and tertiary education.

A strand in the supply chain: taking a vertical slice of the economy, starting anywhere in the supply chain and agreeing with supply chain participants to track a chosen indicator (e.g. employment, water use, energy) upstream and downstream. A conversation can be started based on TBL results that show for example the employment generated in the supply chain or water use in the supply chain. These quantitative results will allow any producer (who is also a consumer) and consumer (who can also be a producer) to identify problems or success stories in the supply chain and initiate conversation with suppliers and consumers to propose remedies or celebrate achievements. The supply chain participants can draw on the work done in equitable sharing of responsibility to quantify their share of responsibility. The shared responsibility metric is just one way to present the results to stakeholders in a transparent manner so that the notion of 'blame' can be removed and a healthy discussion initiated.

A sector in the supply chain: taking a horizontal slice of the economy, say a group of bakeries, or flour mills or farmers agree to examine their TBL and compare themselves with the sector average (and perhaps, by mutual agreement, with each other) and discuss ways to improve practice across the whole sector according to their results. They may agree to share ideas and practices that will benefit the environment and the wider community. The advantage in this could be, for example, more efficient water or energy use across a sector; it can also be an advantage in the market place as consumers become aware of the initiatives that have resulted from intra-sector communication and the identity of those who have participated.

A single entity such as a bakery: TBL accounting at the local level can provide detailed information on which to make onsite changes to business practices as well as changes in suppliers. Or, if you don't want to change your supplier, then the detailed information provided by a TBL report will form the basis for discussions that can lead to a change in practices along the supply chain. Access to information that allocates responsibility for, say, greenhouse gas emissions, along the supply chain can form the basis for informed and non-judgmental discussion. Shared responsibility recognizes that we are all in this together and we all must take responsibility for the world we inhabit.

Government agencies: full supply chain TBL reporting, together with scenario testing capability will allow government agencies to work with industry sectors to make adjustment to practices that will have the most benefit to society. The methodology is transparent and relies on published national data. It will provide benchmarks as well as reliable, quantifiable information. People will always make the decisions however, the more transparent the method and reliable the information, the easier it is for government agencies to discuss with, explain and justify their decisions to the public. Demonstrating that we all take responsibility for our world is a powerful addition to the TBL. It recognizes societal interdependencies, and that we all play a role in achieving a complex social, economic and environmental balance; and hence that we can change things through our rights to free speech and the democratic process.

Investors and financial institutions: along with the *Global Reporting Initiative*'s G3 guidelines and the expansions of the *Carbon Disclosure Project, Integrated Sustainability Analysis* has been recognized[1] as a significant move towards improved reporting and greater disclosure. ISA provides an analytical TBL framework that responds to the need for accessible metrics that will facilitate informed financial decision making. It can

[1] AMP Capital Investors Newsletter 12, April 2006, http://www.ampcapital.com.au/corporatecentre/research/srinewsletter.asp

highlight supply chain issues and identify potential flow of effects of major changes in economies, for example, the imposition of a carbon tax. In general, this detailed supply chain information makes it a useful risk management tool.

Individual consumers: detailed TBL reports will provide consumers with the information necessary to make more informed choices in their selection and use of goods and services. Consumers will also be able to apply the same methodology to their household expenditure with a personal calculator[2].

Educators: at all levels, including community educators will be able to make use of the arguments presented and the methodology described here. An earlier version of this methodology was included in a New South Wales statewide Science program for use by all High School Science teachers (Lenzen & Murray, 2001) and was used by tertiary students (Lenzen, Dey & Murray, 2002). The current methodology and its accompanying support materials will help educators to raise the many philosophical debates inherent in any discussion of how best to protect and restore our world.

Summary - a systems approach to synthesizing the impacts of a loaf of bread

The quantitative methodology presented in this paper provides detailed information about on-site and supply chain ‘costs’ of producing a loaf of bread across the social, economic and environmental bottom lines. Although the methodology is quantitative, the ISA team recognizes that nothing is value free. The team therefore has spent time documenting the methodology and the ideologies that underpin it. The methodology uses nationally available data which facilitates transparency. The philosophical and technical decisions that underpin the methodology as well as the methodology itself are available in numerous articles published in international refereed journals[3].

The TBL software (http://www.bottomline3.com/) that is driven by this methodology was developed over a two-year period in consultation with end-users from business and industry, government and non-government organizations[4]. It represents both a demonstration of our commitment to working with people, rather than doing things for or to them, and a guarantee that the end product meets the needs of TBL practitioners.

ISA can be applied at the individual, project, product, organization or national sector level. It provides depth to the GRI’s breadth. It is a generic methodology able to be applied consistently and comprehensively thereby making comparisons possible between organizations and within organizations over time. Audit approaches provide the richness of local detail on indicators that can be negotiated in consultation with stakeholders year by year. Both viewpoints help to tell a story. Both are necessary components of ‘the true cost of a loaf of bread’. But the real decision about what to do with this information ultimately rests with people. What we can offer is a metric, underpinned by a transparent philosophy, that can lay bare the intricacies of an interdependent and infinite supply chain.

---

[2] http://www.isa.org.usyd.edu.au/education/index.shtml
[3] see http://www.isa.org.usyd.edu.au/publications/paper.shtml#Journal for details
[4] http://www.isa.org.usyd.edu.au/research/TBLEPA.shtm

1. Analytical Framework

1.1 Introduction

The true cost of a loaf of bread can only be accounted for if social, economic and environmental costs of doing business are all taken into account in a systematic and comparable way. Before we describe our method for doing this we need to outline conventional approaches. In current approaches to Triple Bottom Line (TBL)[5] assessment this is frequently based on an audit process. An audit collects local performance information and compares this against a set of principles or policies. An organisation may conduct an audit say, to examine its use of resources, or to scrutinise waste. The audit is usually limited to what happens within the actual organisation and has traditionally referred in some way to the economic bottom line. The TBL audit has developed from this process. As with all audit techniques, a boundary is drawn within which the audit is undertaken. For example economic indicators are usually calculated from existing financial records, compiled using accepted accounting standards. Social indicators are usually determined by a local audit of the organisation's operations, for example, employee conditions, health and safety and support for the local community. Environmental indicators are also usually determined by an on-site audit process.

The major restriction of an audit approach is that in order to make the audit manageable, a *boundary* has to be set. The organisation has to decide, for example, if it will include the employment it generates in the local area; or the effects on the environment of its packaging. This leads to inconsistencies within and between assessments as the boundary is different for different indicators and organisations, and can shift over time. An audit approach cannot, and in fairness, is not designed to, capture effects outside the reporting organisation's immediate sphere of influence. Therefore, whilst being able to deal with the specificities of companies, the audit approach cannot capture full supply chain effects. For this very reason it cannot be called a systems approach, which rests on the premise that everything is inextricably linked to everything else through space and time and that nothing can stand alone or be quarantined from what happens in the rest of the world.

The analytical framework proposed in this paper addresses this need for total integration in two major ways. It recognizes that:

1. there can be no boundaries to the chosen set of indicators, each indicator must be tracked infinitely along the supply chain until there is no further contribution; and that all indicators, social, environmental and economic, need to be analyzed within a consistent framework so that comparisons can be made and trade offs considered; and secondly
2. as producers and consumers at every stage of the supply chain down to the final customer or consumer we too are inextricably entwined; all must claim some responsibility for the transactions that make up the society in which we operate. No one supplier or consumer can be held singly responsible for the production and consumption of goods and services, the symbiotic relationship of which has existed throughout history.

[5] Triple bottom line (TBL) was a termed originally coined by John Elkington (1998) to describe corporations moving beyond reporting only on their financial "bottom line" to assessing and reporting on the three spheres of sustainability: economic, social and environmental.

1.2 Social, economic and environmental interdependencies

Any assessment of social, economic and environmental impact exposes the interdependencies of the total social/economic/environmental system (Oakley & Buckland, 2004). Accounting for the social impact of doing business for example, only makes sense if it is recognized as part of an interdependent system (that eventually spreads out to cover all of existence on this planet and beyond). Any boundaries applied must be recognized as artificial and expedient, and although some partitioning off for the purpose of accounting may serve some purpose to organisations (eg. in order to report to stakeholders on specific, local initiatives) it must be recognized that it is not possible to separate the social from the economic and environmental or to separate any of them from what happens in the rest of the global community. Moreover we operate within a local political and legal context which, in a democracy we can influence through our voting choices which in turn change the social, economic and environmental context. Gallopin (1997:19) recognizes this in his argument for an holistic approach to the development of indicators for sustainability, he suggests that the "systemic nature of many aspects of sustainable development points to the importance of searching for fundamental whole-system attributes for which appropriate indicators could be devised". Everything that we do is ultimately linked to everything else in a seamless web of connections that transverse time and place. Thus an approach that reduces the whole to the sum of its parts will never have the explanatory power of an understanding of what makes a sustainable system (Maturana & Varela, 1987; Richardson, 2004).

1.3 A brief excursion into systems as a way of looking at the world

The shift from a parts/whole perspective to viewing systems in terms of networks of relationships is accredited to theoretical biologist Bertalanffy (1968). Rather than wholes to be dissected into parts he used the distinction between system and environment as an explanatory mechanism [6]. In this way of thinking parts of a living system are understood only in the context of the whole. In reviewing this shift in perspective Capra refers to systems thinking as 'contextual' thinking or 'environmental' thinking (1996:36-37). What we call a part, he says, "is merely a pattern in an inseparable web of relationships" in which "no part is more fundamental than the others" (1996:39). This relational system/environment world is non-hierarchical; system and environment are seen as an interacting whole.

Viewed through Maturana and Varela's biological frame all living systems and their environments (which include other living systems as well as all communication) become coupled so that they grow and change together, each influencing the possibilities of the other. We, they say, are structurally changed in the process of living and communicating over time. This means, as Fell and Russell (1993:35) say, "that everything we have ever done together in this world could be a part of who we are and what we do today" and "[w]e cannot know what the future holds, but we can know that everything we do (or say) contributes significantly to it . . . This awesome responsibility is what we regard as the biological basis of our human ethics" (Fell & Russell, 1993:35; see also von Foerster, 1992 on cybernetics and ethics).

[6] Capra (1996:43) cites the work of a Russian medical researcher, Alexander Bogdanov (1913-1917) who developed a sophisticated systems theory 20-30 years before Bertalanffy published his first paper on his 'general systems theory.' (For the introductory chapter reprinted see Midgely, G. (2003) General Systems Theory, Cybernetics and Complexity. *Systems Thinking Volume 1* Sage Publications).

Thus the social, economic and environmental impacts of doing business are part of the web of interactions that are life on this planet. Sustainable activities, like all of our activities, become part of who we are and what we do. They are activities that, because they become part of who we are and what we do (and the 'we' referred to includes all of humanity including ourselves, carrying with us our histories, and future generations) must, for us if we accept this position, be bound by human ethics. Moreover if human ethics have a biological basis, as suggested by Fell and Russell above, it is probably reasonable to suggest, as Maturana (1988) argues, that they play a role in human survival. Thus approaching the TBL through a systems framework is an ethical endeavour and as such has bearing on human survival. That this project seeks the true cost of a loaf of bread, with all the connotations of the word 'bread', is itself a powerful survival metaphor that in addition requires careful consideration of appropriate indicators.

1.4 Indicators for sustainable systems

Led by the Global Reporting Initiative workplace indicators provide a method for dealing with on-site issues of sustainability in an audit framework. However if we want to reflect the notion of *sustainable system* as an integrated web of connections through time and space ultimately linking everything we do then we need to build on the on-site audit. Starting from a concept of world society can lead us to big picture indicators such as the Ecological Footprint; delving into the complexity points to finer detail and steps along the way, both of which are important.

Taking a world view requires in the first instance big picture, or *endpoint,* indicators. For example, the ecological footprint which rolls up a great deal of complexity into a single world-view indicator, tells you how much of the planet you are taking up through your life-style. The term *endpoint* refers to aggregate measures at the end of one, or several converging impact pathways. An endpoint indicator requires painstaking data collection, and complex modeling and computation. Apart from agreeing on where the endpoint occurs it requires someone to decide what data are relevant and what events contributed to the impact (for discussion of midpoint and endpoint indicators see Lenzen, 2005).

On the other hand retaining the complexity requires a range of what are known as midpoint indicators. Midpoint indicators can be observed somewhere along the chain of impacts, for example, soil fertility reductions caused by intensive agriculture practices. Debate rages around which are more useful, endpoint or midpoint. Many think that endpoint indicators are easier for people to understand (Heijungs et al., 2003). The ecological footprint metaphor, for example, has had a powerful impact. However decision making at midpoints has advantages because it allows for more of the complexity to be examined and involves the immediate players; instead of providing a few aggregated numbers, the more multi-facetted midpoint information reveals the multi-dimensionality of the problem and can suggest a range of areas where action might be taken. Decision making based on indicators is always going to be contentious because endpoints are too uncertain to allow a decision to be made with reasonable confidence, and midpoint information is complex, revealing competing issues that need to be balanced. People will always have to make decisions and decision makers will always belong to some social and political system and make those decisions out of a particular life history. Although this may be self-evident, it is not regularly recognized.

1.5 Making decisions: how do we make use of indicators?

Such decision-making can often rest on quantitative measures which are usually thought to be objective and reliable. Yet such measures come to us embedded in a particular sociopolitical system that itself influences our actions. Not only that, but many believe that our decisions, and hence our actions, are ultimately emotion based (Lutz & White, 1986; Kovecses, 1990; Plutchik, 1994; Wimmer, 1995; Damasio, 1996; Freeman & Núñez, 1999; Hardcastle, 1999). How we feel about the sources of data, how much we trust the people and systems that produce the data, and how they fit with our beliefs, can determine what we do. Metaphors, like *The True Cost of a Loaf of Bread* are important, since acting at an emotional level they can change what and how we communicate (Krippendorff, 1993; Lakoff, 1993). Good numbers and powerful metaphors are part of the mix, their influence may depend on how well they fit with our beliefs and prejudices, how we feel about the source, what story we can tell about them, and how they spark our imagination.

1.6 How ISA addresses some of the issues raised

The Integrated sustainability Analysis (ISA) methodology that is the analytical framework for this paper addresses a number of these issues. It draws on existing, recognised and widely accessible data sources. The methodology itself is open and transparent using Nobel Prize winning input/output analysis which is highly regarded and well recognised (see below). As will be explained further, it can build on the GRI to provide a hybrid analysis that satisfies the need for onsite and supply chain information covering a broad range of indicators. The ISA methodology provides for calculation of the Ecological Footprint as well as a broader TBL. It includes in its range of indicators:

* an indication of economic impact from such items as
  - gross operating surplus (profit)
  - generation of exports
  - dependence on imports
  - stimulus to the domestic economy by purchasing of locally produced goods and services.
* an indication of social impact from, for example:
  - the organisation’s government revenue contribution
  - employment
  - payments for labour (such as wages and salaries).
* an indication of environmental impact from measures like:
  - the ecological footprint
  - emissions to soil, water and air
  - water and energy use.

The ISA framework is based on an assembly of such indicator data for a detailed breakdown of economic sectors. These data are then integrated into a monetary input-output model which describes the interdependencies of the sectors in the economy. By undertaking this integration, the richness of the economic sector interactions reveals the richness of the physical and social interactions between sectors. A sample of typical indicators in the ISA framework is shown in Table 1 together with their sources (for Australia). Similar data are readily available for most countries in the world, since many aspects of the data are covered by standards and conventions.

Table 1: Sample of typical indicators in ISA's TBL framework

Economic Indicators	**Social Indicators**	**Environmental Indicators**
Exports: Exports represent the Australian production of primary commodities that are destined for final demand outside Australia. Units A$million. Data source: Australian input-output tables. Interpretation: The level of export propensity positively reflects the comparative economic advantage and resource availability of Australian industries. This indicator however requires further explanation on a sector-by-sector basis, because there is evidence to suggest that Australia's export profile is generally heavily reliant on primary goods that cause resource depletion and possibly environmental stress.	*Employment:* Employment means full-time-equivalent employment measured as full-time employment plus 50% part-time employment of employees, including employers, own account workers, and contributing family workers. Units: employment-years (e-y) and employment minutes (min) are used. Data source: Australian labour statistics. Interpretation: Employment is a critical TBL factor with its implications for social cohesion, government, transfer payments, international credit ratings and taxation. It is a positive TBL factor and one for which there are demonstrable trade-offs with material and energy use.	*Water use*: Managed water use denotes the consumption of self-extracted and in-stream water (from rivers, lakes and aquifers, mainly extracted by farmers for irrigation) as well as mains water. Collected rainfall such as in livestock dams on grazing properties is not included. Units: litres (L). Data source: ABS Australian Water Accounts. Interpretation: This is a negative indicator. Australia's highly variable climate, including periodic drought, leads to an unpredictable water supply. Net water demand is increasing (e.g. for use of pastures, cotton and rice growing). In the Murray-Darling Basin significant environmental damage has occurred because of water diversion from the Murray and Snowy Rivers, and widespread soil and water salinisation. Irrigation-based industries are likely to face further environmental degradation as well as income losses, unless a number of adaptive initiatives in water management are pursued.
Gross operating surplus: defined as the residual of an industry's total inputs, after subtracting all intermediate inputs, compensation of employees, and net taxes and subsidies. It consists of operating profits, and consumption of fixed capital for capacity growth and replacement (depreciation). Unit: A$. Data source: Australian Bureau of Statistics. Interpretation: This is a positive indicator because it indicates the capacity to invest in innovation and technological progress through turnover of the capital stock as well as the capacity for expansion and investment in other sectors.	*Income*: Income (compensation of employees) involves estimates for each industry wages and salaries, as well as employers' social contributions. Units: A$ million. Data source: Australian input-output tables. Interpretation: Income is related to employment, but in addition can indicate whether parts of the supply chain receive unequal wages and salaries.	*Land disturbance:* The Australian land disturbance approach, Lenzen and Murray (2001). Unit: disturbance-weighted hectares. Data source: CSIRO Landcover disturbance report. Interpretation: this is a negative indicator. The land disturbance factor summarises recent efforts to incorporate land use into life-cycle assessment, not only in area terms, but also in terms of its environmental impact. Few authors have quantified impacts of different types of land use, but most recent approaches consider effects on 'ecosystem quality' or 'condition', expressed for example as the species diversity of vascular plants. ISA uses a measure of land disturbance that reflects the land condition, the degree of alteration from its natural state.ed because of pressure from domestic consumption and exports.
Imports: these represent the value of goods and services purchased from foreign residents. They consist of any commodity needed for the domestic production of commodities. Unit: A$. Data source: Australian Bureau of Statistics. Interpretation: negative TBL indicator. Interpretation: negative indicator; dependence on imports relates to self-sufficiency of a nation and its vulnerability to issues such as international resource depletion and price hikes.	*Government revenue:* this consists of taxes less subsidies on products for intermediate demand, other net taxes on production, and net taxes on products for final demand (incorporated within the sales price). Units: A$ million. Data source: Australian input-output tables. Interpretation: this is regarded as a positive TBL indicator, since taxes contribute to support the national commons, such as health, education, defence, social benefit payments, public transport etc.	*Greenhouse gas emissions* ((CO_2, CH_4, N_2O, CO, NMVOC, PFC, SF_6, HFC, plus further detail by 7 sources): The combined effect of all greenhouse gases in the atmosphere is expressed in terms of the equivalent amount of carbon dioxide which would produce the same effect. Units: In accordance with guidelines set out by the Intergovernmental Panel on Climate Change (IPCC), greenhouse gas emissions are expressed in tonnes of CO_2-equivalents (CO_2-e) and calculated as a weighted sum of nominal emissions of various gas species using gas-specific global warming potentials. Data source: National Greenhouse Gas Inventory, Australian Greenhouse Office. Interpretation: This is a negative indicator. Greenhouse gas emissions cause climate change. Emissions analyses can be used as a guide to the 'carbon risk' (including risk of future constraints on carbon emissions) faced by sectors, including via their supplying sectors.

1.7 Input output analysis

To solve the boundary issue by accounting for impacts of the full upstream supply chain the ISA methodology uses input-output analysis (IOA). This is an internationally accepted accounting procedure that documents all monetary flows to and from discrete economic sectors. It covers all traditional economic activity in an economy. Input-output theory was pioneered by Noble Prize winning economist Wassily Leontief in the 1940's. It is governed by UN standards on IO tables which are published regularly by statistical agencies all over the world. However while sectoral studies using IOA have been a common part of standard economic planning for many years it was always Leontief's intention that IOA be extended from purely financial considerations to a range of social and physical elements. Thus the methods used by ISA integrate the structure and function of the financial economy (as described by the national I/O tables[7]) with other national social and physical accounts such as energy, greenhouse emissions, water, land disturbance, employment and so on to account for, as Leontief intended, the social and environmental, as well as the economic affects of doing business. The fact that IOA works at all scales[8] allows for the assessment of nations, states, regions, cities, suburbs, populations, individuals, industry sectors, companies or products.

The *indicators* in Table 1 can be termed “macro” or whole of economy indicators because they apply (and data are available) for the whole economy. The indicators are therefore additive through the myriad of supply chains in the economy. This means it allows us to calculate cumulative impacts long supply chains, and further to *pass on* or *retain* an agreed amount of impact in a supply chain (see the section on shared responsibility). Such indicators can distil complex information into a form that is accessible to stakeholders. Organisations report on indicators that reflect their objectives and are relevant to stakeholders. One difficulty in identifying and using indicators is to ensure consistency within an organisation, over time, and between organisations. This is important for benchmarking and comparisons.

ISA’s 2005 Australian publication[9] *Balancing Act* uses a set of ten indicators to benchmark 135 sectors of the Australian economy providing a snapshot of the TBL performance of each sector. Using the ISA methodology it makes possible comparisons by solving such dilemmas as ‘what do we count and where do we draw the line?’ For example if employment is an indication of the organisation’s social impact do we count only immediate on-site employment by the organisation, or are we also responsible for creating some of the jobs in the organisations with whom we do business?

The ISA methodology operates in a systems framework, recognising that everything is linked to everything else and everything must be acknowledged and accounted for. The methodology clearly demonstrates that any change in how an organisation does business has social, economic and environmental repercussions. It provides detailed, reliable information on which people can make decisions, recognising that ultimately decisions have to be made and that they entail value judgements.

---

[7] The Australian Input Output Tables are compiled by the Australian Bureau of Statistics (ABS). They represent a comprehensive “snap-shot” of the size and structure of the economy.
[8] IO tables are built from company data
[9] http://www.isa.org.usyd.edu.au/publications/index.shtml

1.8 Shared responsibility

The notion of *shared responsibility* has often been shied away from in the past because of the value-laden nature of the term. However it must be recognised that sustainability indicators are not simply about promoting a particular kind of understanding of our impact on the environment. They are implicitly about promoting someone's notion of 'right action' based on that understanding. Similarly, users of the ecological footprint, or any reporting methodology, are not operating in a value-free zone. They are using the methodology in order to influence people and effect change. Again, presumably they have in mind a notion of 'right action'[10] that they hope will follow. Thus to design a methodology and to use that methodology are already value-laden actions. In using this or any methodology we take responsibility for the choice and all that it implies by way of underlying assumptions: someone produced the methodology, someone else used it. Any actor is part of a web of interactions for which there is no beginning and no end point – nowhere to apportion ultimate responsibility (Lenzen, Murray, Sack, & Wiedmann, 2006).

Currently, responsibility for the impacts of doing business is either allocated to the consumer or to the producer, but not to both (see Lenzen, Murray, Sack, & Wiedmann, 2006 for a full discussion). There are two main differences between the principle of shared responsibility, and that of either full producer responsibility (e.g. national reports on greenhouse gas emissions to the Intergovernmental Panel for Climate Change) or full consumer responsibility (e.g. traditional Life-Cycle Analysis).

1. In contrast to full producer responsibility, shared responsibility, acknowledges that every member of the supply chain is affected by their upstream supplier and affects their downstream recipient, hence it is in all actors' interest to enter into a dialogue about what to do to improve supply chain performance. In shared responsibility, producers are not alone in addressing the impact issue, because their downstream customers play a role too.
2. In contrast to full consumer responsibility, shared responsibility provides an incentive for producers and consumers to enter into a dialogue about what to do to improve the profile of consumer products.

Both of the above positions (i.e. full producer responsibility or full consumer responsibility) are unsustainable when viewed from within a systems framework. It is intuitively clear that responsibility should somehow be shared between the supplier and the recipient of a commodity, because supplier and recipient are part of an interdependent system. The supplier has caused the impacts directly, but the recipient has demanded that the supplier do so, and both parties are embedded in a local and global social, economic and environmental network of interactions. When thinking about environmental, social and economic impacts of a loaf of bread, for example, crucial

[10] We have not attempted to problematise the notion of *ethics* in this paper however our attention has been drawn to Churchman, who advocates what he calls, whole system ethics, regarding the traditional view of ethics (i.e. pertaining to the individual) as inadequate to deal with the complex and irreversible environmental effects of say, greenhouse gas emissions that threaten the survival of the whole global eco-system (see Ulrich, 2002). The general notion of human ethics has also been problematised by Córdoba and Midgley (2003) who argue that in practice there are always implicit or explicit boundaries to the extension of human concern for others, thus creating "insiders" and "outsiders". Therefore in systems practice, they suggest, there is a need to explore the boundaries of concern and justify cut-off points that come to people's attention. The methodology presented here is designed to address the issue of boundaries.

questions arise such as: who is responsible for what, or: how is the responsibility to be shared, if at all? For example: Should a bakery have to improve the eco-friendliness of its products, or is it up to the consumer to buy or not to buy? And further: should the firm be held responsible for only the downstream consequences of the use of its products, or – through its procurement decisions – also for the implications of its inputs from upstream suppliers? And if so, how far should the downstream and upstream spheres of responsibility extend? Similar questions can be phrased for the problem of deciding who takes the credits for successful abatement measures that involved producers and consumers: Who has the best knowledge of, or the most influence over how to reduce adverse impacts associated with the transfer of a product from producer to consumer?

It seems obvious that both the final consumers and their upstream suppliers play some role in the economic, social and environmental impact of doing business. A bakery's suppliers use land and energy in order to produce grain or flour. They in turn make decisions on how much land and energy to use when considering for example the pros and cons of organic farming, while consumers decide to spend their money on upstream suppliers' products. And this role-sharing probably holds for many more situations in business and in life. The concept of shared responsibility recognises that there are always at least two (groups of) people who play a role in commodities produced and impacts caused, and two perspectives involved in every transaction: the supplier's and the recipient's. *Hence, responsibility for impacts can be shared between them.* Naturally, this applies all the way along the supply chain and to both burdens and benefits.

McKerlie, Knight, and Thorpe 2006 (p. 620) report that the concept of product stewardship "suggests that *all* parties with a role in designing, producing, selling or using a product are responsible for minimising the environmental impact of the product over its life". In practice, this "shared responsibility" extends beyond the producers and users of a product to include local governments and general taxpayers who incur the expense of managing products at their end-of-life as part of the residential waste stream. At present, however, most of extended-responsibility initiatives proceed in a more or less qualitative and ad-hoc, rather than quantitative and systematic way in selecting, screening, ranking or influencing other actors in their supply chain.

We agree with Lloyd 1994, who states that "it will be impossible to produce a sufficiently credible ranking of suppliers without quantitative rating". And Spangenberg and Lorek (2002, p. 128) suggest that, "different (groups of) economic agents occupy overlapping spheres of social, economic and political influence […], a quantification of [these] influences […] would be a precondition for an allocation of environmental responsibilities to specific actors". Accordingly, choices of responsibility shares should ideally reflect suppliers' and recipients' financial control, innovation potential and business relations, as well as their influence over production processes and their options to substitute suppliers or buyers.[11]

[11] The Global Reporting Initiative 2005 (p. 2; see also Global Reporting Initiative 2002, p. 26) states that "the organisation's degree of control or influence over the entities involved in these activities and their resulting impacts ranges from little to full. While financial control is a common boundary for disclosure, the risks to the organisation's assets and the broader community and opportunities for improvement are not limited to financial control boundaries. Therefore reporting only on entities within the boundary used for financial reporting may fail to tell a balanced and reasonable story of the organisation's sustainability performance and may fall short of the accountability expectations of users. This is one of the key messages underlying the logic of this protocol".

We therefore suggest *value added* as an indication of influence and control and use this as a basis for a quantification of that influence and control. Value added indicates whether or not a producer has transformed operating inputs in any significant way, and is therefore a good proxy for control and influence over production (for further details see Lenzen et al 2006).

In summary then, ISA's framework is a full production chain approach to assessing macro sustainability indicators for a sector, product, organisation, city, or other entity. Coupled with the shared responsibility concept, we can openly and systematically allocate responsibilities throughout a supply chain. In the following sections we firstly describe operational aspects of the ISA methodology, then make three comparisons of bread production options, then present results of the current Australian bread production system, and finally present some opportunities for action that result from this work.

2. Application of a methodology that is transparent and replicable

The methodology described below was developed initially for the Australian economy. More recently, versions for the German, Japanese, and United Kingdom economies have been established. It is assumed that if the ISA proposal is granted recognition and funding any prize monies will be used to develop a model for the US economy. The US model could be developed in consultation with US partners and software developers.

2.1 How the methodology works

The ISA method works by taking an organisation's expenditure data and converting it into TBL indicators that the organisation can choose from the ISA indicator list[12]. For example, say the organisation chose *SO_2 emissions* as an indicator, and provided a value of, say, *100$* for paper purchased by their organisation. Then ISA calculates how many kilograms of SO_2 are 'embodied' in this 100$ worth of paper. This is added to the other expenditure items and becomes part of the organisation's SO_2 'budget'. And so on for whatever other indicators are chosen (e.g. water, energy, employment, profits). The ISA framework can be applied to quantitative Triple Bottom Line (TBL) Reporting, Ecological Footprint Analysis, Life-Cycle Assessment (LCA), Environmental Impact Assessment, industry and population studies, and supply chain analysis.

ISA's indicators such as the sample given in Table 1, cover environmental, social and economic issues including: energy, water, land disturbance, greenhouse gas emissions, employment, income, taxes, exports, imports, profits, as well as impacts on education, community and cultural services. When using the methodology organisations choose which indicators they wish to address. The chosen indicators can be decomposed to reveal impacts at many different levels, from micro, which could be a company's on-site emissions, to macro or supply-chain emissions.

2.2 A full life-cycle perspective

The *boundary* within which an organisation accounts for its environmental, social and/or economic effects is usually defined as that over which the company has direct influence and can exercise control. In relation to this:

> "[I]t is critical [that] the boundaries adopted for the purposes of reporting are clearly defined and obvious to readers of reports. Careful boundary definition also ensures a report can be verified and meaningful comparisons can be made between information from different reporting periods." [13]

The 'careful boundary definition' quoted above entails a number of challenges. The level of influence and control will vary from organisation to organisation and from year to year, invalidating comparisons within and between organisations. Moreover, extending the boundary beyond the immediate control of the organisation still begs the question of

[12] Information sheet 6 at: http://www.isa.org.usyd.edu.au/research/TBLEPAinfo.shtml.

[13] Environment Australia (2003), *Triple bottom line reporting in Australia: a guide to reporting against environmental indicators*, June 2003, page 8, also contains a wider discussion about the issue of boundaries. http://www.deh.gov.au/settlements/industry/finance/publications/indicators/index.html

exactly where to draw the line. Decisions will differ between organisations and over time. Establishing a clear boundary for an analysis that is consistent across all indicators seems at first sight to be almost impossible. Notwithstanding these challenges, the boundary problem can be solved by taking a full life-cycle perspective.

In a real sense a huge number of upstream suppliers feed into any organisation (see Figure 1 below). Each one of them has Triple Bottom Line impacts to be accounted for. Most audit approaches, such as that taken by the Global Reporting Initiative (GRI), are not designed to extend beyond the first level of suppliers. Whilst important local or on-site effects are captured by the GRI audit, the considerable economy-wide effects that the organisation is part of are not accounted for or reported on. The same is true for downstream impacts, which are only partly accounted for in audit-type approaches (e.g. the energy consumption "footprint" of organisations (GRI Indicator EN18)[14]).

The Global Reporting Initiative (GRI) is aware of the importance of the boundary problem. Its Boundaries Working Group has developed a Boundary Technical Protocol which is based on the key concepts of control and influence[15]. It provides principles and a process for setting boundaries while recognising the complex issues involved, including the problems of comparability and consistency mentioned above. The CSIRO/University of Sydney team was active in the GRI's development of this protocol[16]. The ISA methodology solves the boundary issue by accounting for impacts of the full upstream supply chain[17].

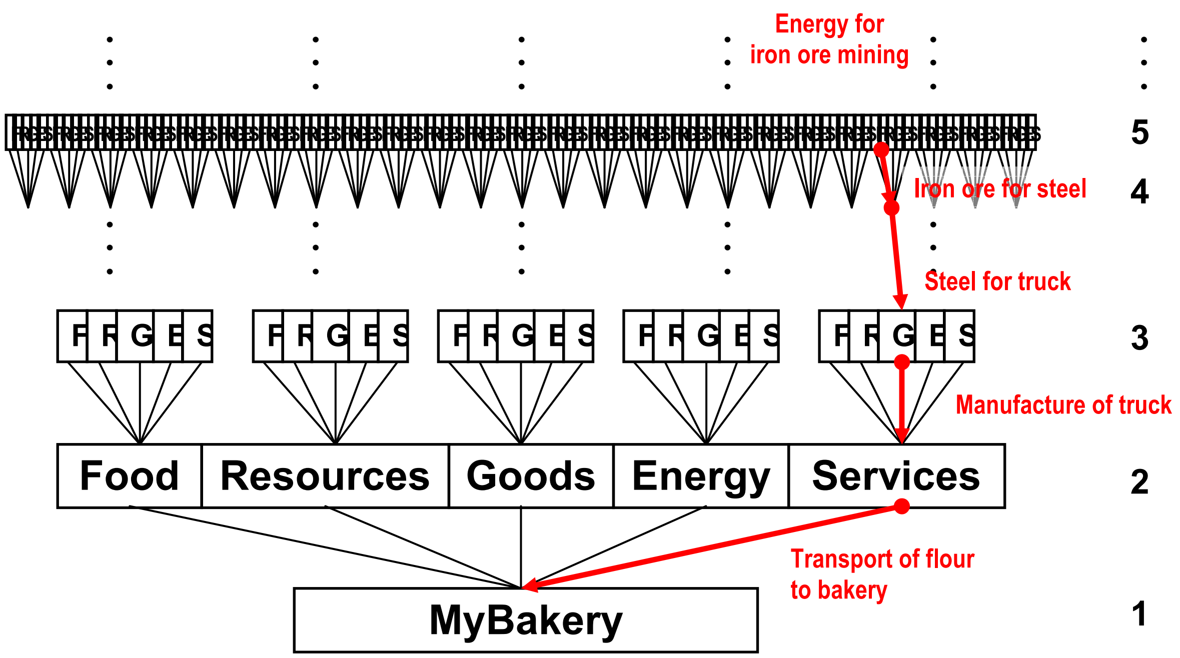


Figure 1: Upstream suppliers and the issue of boundaries

[14] Note this use of the term footprint differs from its meaning in "ecological footprint" where it is used to mean all *upstream* impacts.

[15] GRI Boundary Technical Protocol July, 2005 see http://www.globalreporting.org/guidelines/protocols/boundaries.asp

[16] Dey, Lenzen, Foran and Bilek (2002), Addressing boundary issues in the Global Reporting Initiative: comments on the Draft 2002 Sustainability Reporting Guidelines.

[17] B. Gallego and M. Lenzen (2005), A consistent formulation of shared producer and consumer responsibility, *Economic Systems Research* **17** (4), 365-391.

In the Figure, imagine a company called MyBakery at the foot of a tree that represents MyBakery's supply chain. The first "canopy" up from the foot is MyBakery's suppliers. In this simplified example, the supplier categories are represented by only 5 sectors. The next canopy up is the suppliers of MyBakery's suppliers, and so on. This tree is an infinite tree of suppliers. The foot is called *production layer 1*, the first canopy is labelled '2', the second '3', and so on.

Impacts occur in every production layer. Take the indicator 'energy' for example. MyBakery is connected to town gas and fires ovens. The gas used on-site belongs into production layer 1. My Bakery buys flour. This flour needs to be produced by a flour mill. The energy used in the flour mill belongs into production layer 2, since the flour mill is a direct supplier of MyBakery. The flour also needs to be delivered to MyBakery by a transport firm. The diesel used by the truck also belongs into production layer 2, since the truck company supplies the transport service to MyBakery. The truck that the transport firm uses needs to be assembled by a vehicle manufacturer. The energy used during this assembly process belongs into production layer 3, since the vehicle manufacturer is a supplier of the transport firm which in turn supplies MyBakery.

The chain of red arrows in the supply chain tree is called a *structural path*. There are millions and millions of structural paths in a typical supply chain tree. This is because modern economies are so complex. The complexity of the calculations can be appreciated when you consider that in the ISA model of the Australian economy

- production layer 2 has 344 members, who each have 344 suppliers, so that
- production layer 3 has 118,336 "suppliers of suppliers",
- production layer 4 has over 4 million "suppliers of suppliers of suppliers", etc.

The application of ISA's framework to organisations or products does not require extensive new data to be collected. ISA software requires only expenditure and revenue accounts for the organisation, project or product. This financial data is the input from which the ISA software calculates TBL impacts including full supply chains. This application works because we have developed an integrated method that uses national statistics in combination with established economic theory. This method solves the boundary problem.

As an example of a national-scale study of a particular commodity, the Danish study of transport-related energy embodied in a loaf of bread (Munksgaard, Lenzen, Jensen & Pade, 2005) used: Danish *input-output tables* for 1995 from *Statistics Denmark* (1996); Danish energy flow tables for 1995 from *Statistics Denmark* (1996); definitions of transport energy types from the Danish model for energy supply, demand and related emissions in 24 industries and households; Danish consumer survey (*Statistics Denmark*, 1999); and Danish imports from DataShop Eurostat.

2.3 Hybrid analysis

The ISA approach builds on existing audit approaches, and extends these in order to achieve completeness and consistency. Audit approaches and the ISA method address different aspects of TBL assessment in a complementary way. Building on a TBL audit specific to an organisation, ISA's macro-economic input-output analysis (IOA) covers the entire 'background' economy – *in depth*. The Global Reporting Initiative's

Sustainability Reporting Guidelines provide good reporting scope or *breadth*. These different approaches to TBL assessment and reporting, *breadth* and *depth*, both approaches have merit and work best in combination: a practice known as hybrid analysis. By using micro indicators, which are specific to an organisation or product, coupled with the macro or economy-wide indicators from the ISA framework we can combine the specificities of a bottom-up audit, with the broader and complete top-down view from the macro economy which accounts for the full upstream supply chain (Figure 2).

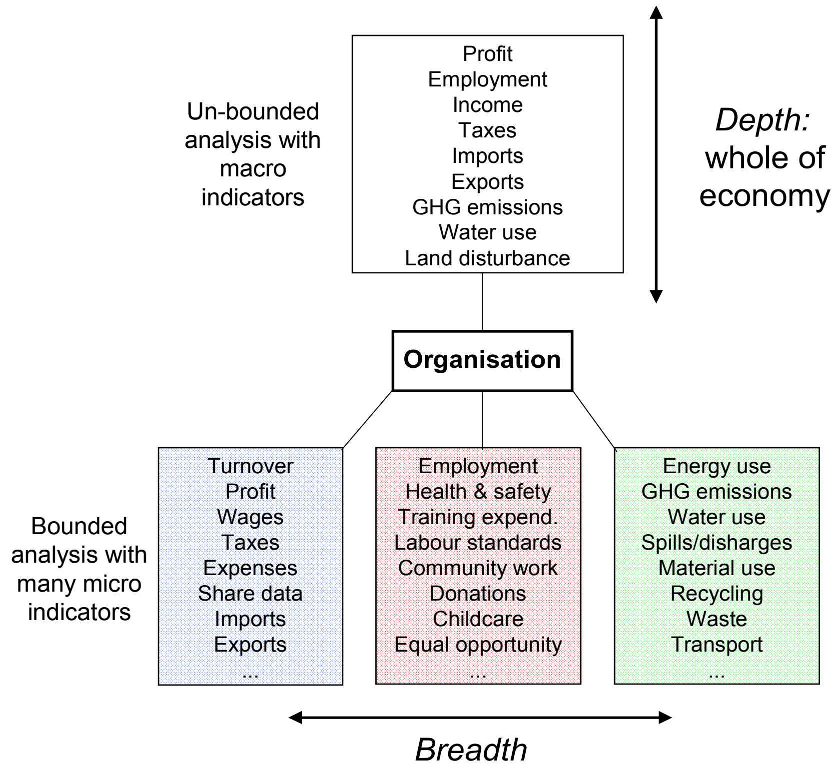


Figure 2: A comparison between bounded audit approaches with large indicator *breadth*, compared with input-output approaches with *depth* from macro indicators extending through the full supply chain (economy). Some indicators in these sets (illustrative only here) are common to both approaches.

Note that the application of the ISA framework outlined above assumes that an organisation or product's suppliers (and their suppliers …) have characteristics which are the same as those of the sectors to which they belong (that they are similar to the national averages). Where a supplier is known to be very atypical (such as a supplier using an extremely high quantity of recycled material), their characteristics can be adjusted to reflect the departure from the national average. In can however, be shown rigorously that the combined uncertainty from random departures in actual suppliers from the sector averages is quite low, certainly much lower than the additional value that the inclusion of the upstream effects provides.

2.4 Indicators for assessing the impact of bread production

By taking a hybrid approach, micro or on-site indicators can be sued together with macro or economy-wide indicators. For some indicators, such as energy, the quantities and issues are the same between micro and macro indicators, and hence can be summed. For other indicators there can be no correspondence between micro and macro indicators and therefore no summation is possible, nor meaningful. This is not a poor reflection on either approaches, but rather, it demonstrates that the complexities of real-world problems can only be addressed with a range of indicators across different scales. A sample of possible indicators, their relationships and typical data sources is given in Table 2 for the case of bread production. The list is by no means exhaustive.

Table 2: Sample micro indicators and their relationships with macro indicators relevant to assessing impacts from bread production.

Issue	Micro indicator	Corresponding macro ind.	Macro source comment
Labour	Wages	Yes	I-O tables
	Safety	Yes	National safety data
	Education	Somewhat	National data
	Health	Poor	Not by industry sector
	Equal Opportunity	Poor	Data not readily available
	Age structure	Somewhat	National data
Pollution	Greenhouse emission	Yes	National data
	Discharges to air	Somewhat	National pollutant inventory
	Discharges to water	Somewhat	National pollutant inventory
Soil health	Nutrient levels	Not really	Non-existent
	Pesticide residue	Not really	Non-existent
Water	Quantity	Yes	National data
	Quality	Not really	Non-existent
Land health	Salinity	Somewhat	Data limited
	Erosion	Somewhat	Data limited
Power	Ownership	Not really	Non-existent
	Business size	Yes	National data
Economics	Farm profitability	Yes	National data
	Debt levels	Not really	Non-existent

It is likely that those organisations with an interest in the TBL and who feel they have nothing to hide will access the methodology first. However it only needs one or two larger organisations to build critical mass so that anyone not reporting on the 'true cost' will be viewed with suspicion. A good place to begin may be with those organisations already applying GRI standards to their accounting practices.

3. Three scenarios

Below are three examples of where the ISA methodology and ways of thinking might be usefully applied to reveal hidden aspects of the costs of doing business. We look at ancient grain bread and organic farming against modern wheat bread. The issue of feeding a growing population is briefly examined. Our next example, monocropping vs. polycropping farming practices, looks at climate change, water use, health impacts and intellectual property rights. Our final example, mass production vs home production examines energy use and briefly discusses community vitality. In each example we indicate where the ISA approach may be useful for addressing some of the issues raised.

3.1 Ancient grain bread vs. wheat bread

The Middle East's Fertile Crescent is known as the birthplace of cultivated wheat (Gill & Friebe, 2002) although bread wheat arose about 2000 years later further to the north-west in the Caspian Plains. According to Curtis (2002) wheat was one of the first domesticated crops. It has evolved over the last ten thousand years through repeated hybridization. Emmer, an ancestor of wheat, is a low yielding small grain wheat that dates from about 7000BC and has been found in the Pyramids, as well as throughout Europe. Einkorn was cultivated in Neolithic times, and was widely used throughout the Iron Age, it was more resistant to temperature variations though of lower yield. Spelt was probably sown and harvested in the Bronze Age, and was certainly used in Britain during the Roman period. Its yield was extremely low by today's standards. Modern wheat, which has evolved through selection with human, including technological, assistance such as irradiation to speed mutation, and more recently by Genetic Modification, is now grown on more land area than any other commercial crop and is the most important food grain source for humans providing more nourishment for humans than any other food source (Curtis, 2002). It is not surprising that the word 'bread' is synonymous with 'food' in some cultures and that Christianity, with its Middle Eastern birthplace, reserves a special significance for 'bread'.

Of course "Culture is not static; it preserves traditions but also builds in mechanisms for change. Food habits are part of this dynamic process" (Fieldhouse, 1996, p2). With the cultivation of wheat came the ability to eke out a living in adverse times. With this came population growth; and with population growth came the search for new lands to inhabit, displacing other peoples in the process[18]. Thus a simple proposition of ancient grain bread versus wheat bread is loaded with political, cultural, social and economic significance not to mention a changing landscape, that could be referred to as 'degraded'. However, Tainter (2006) argues that 'degradation' is a construct with no absolute reference in biophysical processes. For example when soil is eroded from one place it can be deposited somewhere else, thus 'in the world of sustainability and degradation there are winners and losers.' (p93). Sustainability becomes a matter of problem solving. Historically we have solved problems with increases in the complexity of our efforts. Over the centuries human societies have increased in size and complexity thus increasing problem solving capacity through such as technical ability, specialization

[18] http://www.economist.com/science/displaystory.cfm?story_id=5323362&no_na_tran=1 accessed 9/08/06.

in social roles, average life span, better health. Although it depends on whether your group is currently a winner or a loser as to how much power you have to use this increase in human complexity. As Tainter (2006:100) points out the "evolution of complexity, and its consequences for sustainability, presents a continuously varying spectrum of opportunities and costs."

Nonetheless people are still being displaced and alienated from indigenous food technologies; and politics is still cited as the central issue concerning the retention of ancient food knowledge (Kuhnlein & Receveur, 1996). In Australia, for example wheat was introduced by the British about 200 years ago. It was first grown in a small plot of land near Sydney Harbour. It yielded about the same amount of grain as had been sown. Today it is Australia's largest crop (O'Brien, Morrell, Wrigley & Appels, 2001), and may be part of the complex mix of reasons for why few Aboriginal people practice traditional food technologies. In what Fieldhouse refers to as the New World, "there are thousands of acres occupied by wheat, barley and rye that were previously grazed by native animals" (1996 p52). Again this is likely to be a part of the reason for dietary and health problems in indigenous communities along with "[M]ission schools, boarding schools, public health programs, and nutrition education programs emphasizing the food known to the dominant culture" (Kuhnlein & Receveur, 1996, p.422).

The Copenhagen Consensus 2006[19] which asks the question: "How would you spend $50b to improve the world?" ranks Malnutrition and Hunger in fourth and fifth place (4th improving infant and child nutrition; 5th investing in agricultural technology in developing countries). They say that it is possible to breed wheat plants that are more dense in iron, zinc and Vitamin A. The evolution of wheat has always taken place alongside the evolution of technology. In parts of the developing world wheat flour is already supplemented with other grain flour (e.g. Amaranth) to improve the protein quality, which is particularly important for infants and new mothers (Ayo, 2001). Ancient grain bread, were it to be widely available, would not solve the nutritional needs of a world in which "every year the world's farmers must try to feed an additional 70 million people" (Brown, 2006, p. 2). The yield of ancient grains would be too low, the fertilizer and water needs of the crops unknown.

Population

As the global population grows, the challenge to feed the increasing numbers becomes more difficult. Already, there are more than 800 million people, mostly in Asia or Africa, who remain chronically undernourished[20]. Current agricultural productivity is dependant on the realities of soil degradation, insufficient fresh water, biological competition, and limited quantities of arable land. It has been predicted that if ways aren't found to grow more per acre, over the next 50 years a third of all remaining natural tropical and temperate ecosystems could be lost to clearing for farming purposes. Such forest loss and fragmentation of natural habitat would severely affect global biodiversity.

Wheat in the form of bread provides more nutrients for world population than any other single source of food (Pena, 2002, p484). The increase in world population has called

---

[19] http://www.copenhagenconsensus.com/Default.aspx?ID=728 accessed from the web 9/08/06
[20] http://www.monsanto.com/monsanto/layout/our_pledge/global_challenges/default.asp accessed from the web 9/08/06

for an increase in food production and particularly of wheat. However in the interest of preserving the environment increased wheat production must come from higher yield rather than expanding the production area. However it is difficult to increase yield and maintain the protein content.

The developed countries consume more bread than any others. Grain imports into Iran and Egypt have both eclipsed those of Japan with both importing over 40% of their grain needs. Both have growing populations but they do not have increasing water supplies so will continue to import grain. Most of the 80 million people added to the world population each year live in countries with water shortages (Brown, 2002)[21].

Again the population/food issue is far from simple. Although millions of people continue to be undernourished the number of health problems related to overeating and unhealthy diets has increased to epidemic proportions (Pretty, J. 2003). Moreover, Pretty (2003) reports, environmental degradation related to the current system of agriculture is thought to be strongly linked to both issues. He asks: "can a new way of agriculture - one that takes advantage of complex interrelationships among humans, our culture, and the ecosystems to which we all belong - help to bring us closer to equilibrium?" (Pretty, 2003, p.8).

Organic farming practices

A return to organic farming practices[22], which in some instances can incorporate the use of ancient grains[23], could be seen as a practical step towards recognition of something lost in the course of our technological advances. Even so this is fraught with difficulties for the commercial farmer. For example, between 1990 and 1997 an Australian company *Uncle Toby's* produced a breakfast cereal product using organically grown wheat. This was discontinued in 1997 because of lack of consumer interest in the environment (revealed by market research) (p319). It was also considered no longer economically viable to produce it because the price of organic wheat had risen dramatically since 1990, and by 1997 cost more than 30 percent more than conventional wheat. When Uncle Toby's stopped producing organic breakfast cereal many growers were forced to sell on conventional markets, foregoing their organic premium. In other instances growers committed to organic production methods lost their organic markets where, due to changing circumstances, it no longer suited the food processing company to deal with them. Clearly the optimization of economic efficiencies for the companies remained a higher priority than the development of the entire organic production sector (Dept of Agriculture, Fisheries and Forestry, Australia, 2001, p320). The *Uncle Toby's* debacle may have had something to do with the establishment in 1998 of the Organic Federation of Australia (OFA). The Federation's role is to work in co-operation with all sectors of industry and government to develop Australian organic farming from a vulnerable niche industry into a viable component of farm production capable of delivering benefits to consumers, producers and the environment[24]. With such organized support organic farming has developed to tap into local markets and help regenerate "rural communities who have been 'done over' by large insensitive

[21] http://www.earth-policy.org/Indicators/indicators6_print.htm accessed from the web 9/08/06
[22] What constitutes 'organic' is open for debate.
[23] See for example the ancient grains and seed bread organic Healthybake, containing Spelt flour http://www.organicfeast.com.au/custom/products/html/detail/index.cfm?productid=1924 (accessed from the web 21/08/06)
[24] http://www.ofa.org.au/ (accessed from the web 21/08/06)

companies, whose only concern is profit[25]". However the produce remains expensive and therefore confined to a small section of any community. It is certainly not available to Australia's remote Aboriginal communities which have notoriously poor access to fresh food of any kind.

Markets are not the only issue for farmers considering organic practices. Rigby and Caceres (2001, p.23) suggest that the "complex nature of the interrelationships between agricultural production and the natural environment means that we are far from knowing which methods and systems in different locations will lead to sustainability". They acknowledge that some farming systems such as that employed by the Amish are sustainable 'at the farm level' however question whether such farming practices would have a sufficiently high productivity rate to support a growing population. They also point out the added complexity of a population that is increasingly urbanized and so becoming divorced from agricultural production. This is particularly apparent in the current development occurring in China which is experiencing a drastic loss of arable land to urbanization (Chen, Chen, Shi & Tamura, 2003) which not only is destroying a whole way of life but is also impacting on the global food market. Once again political, social, environmental and economic decisions and consequences cannot be disentangled and all are constituted within a particular time/space trajectory. The best we can do is to provide sound and transparent information so that people have the opportunity to make informed decisions about changing the trajectory.

Providing some grunt to increase the power of the consumer

The ISA methodology can be used to compare the production of ancient grain bread (albeit produced by modern methods with a range of ingredients) with modern wheat bread production on a number of indicators. Ideally the indicators will be identified in consultation with the communities involved. They are likely to include onsite audit-type indicators and others that can be tracked along the whole supply chain using the ISA methodology. Such a combination will make for a comprehensive account of the true cost of doing business. A similar comparison can be conducted for organically produced wheat bread and conventionally produced wheat bread. As the discussion above has hopefully outlined, the validity of such comparisons (and the real world shifts which they represent) must be placed firmly in the context of the immediate problem of feeding all citizens of the world with a sufficient quantity, and indeed quality, of food. For developed countries it may well make some sense to consider traditional grains even if their yield is comparatively lower and they cost more, because quality and not quantity of food is required. However, for developing countries, the conclusion may well be the opposite.

[25] http://www.organicfeast.com.au/index.cfm?menukey=12 (accessed from the web 21/08/06)

3.2 Monocropping vs. polycropping farming practices

The evolution of wheat and its role in feeding the world's increasing population described above, has had major consequences for how it is grown. Investment in the technology to enhance yield, nourishment qualities, pest resistance and temperature fluctuation has placed market control in fewer and more powerful hands. Economies of scale have been an inevitable consequence and monocropping practices have become dominant. Large scale monocropping practices, including for example forest clearing, are likely to have contributed towards loss of biodiversity. They are driven not only by the direct need for wheat but also the indirect need for protein through cattle farming. Beef-cattle-driven global monocultures are destroying local agricultural diversity to feed the increasing dependence on animal protein. Rather than the use of cereal crops for flour and other grain products they are being fed to cattle to produce animal protein (McMichael, 2001). McMichael says that "[T]he global cattle complex binds the world into an animal protein dependency that imposes feed grain and livestock monocultures on local ecologies and competes with the direct consumption of cereals." (McMichael, 2001, p216).

The destruction of local ecologies contributes to climate change. The general increased need for food production, whether of animal protein or grain products, to feed our growing population means that more water is being drawn from the earth. However climate change is changing global weather patterns which in turn effects water availability and hence, what can be grown where and how well.

Climate Change

Average Australian land under wheat growing in 1993 – 1995 was 8.7 million hectares (Curtis, 2002). Average production was 14 million tonnes 73% of which was for export. Between 1995 and 1999 average production was about 20.5 million tonnes (O'Brien, Morrell, Wrigley & Appels, 2001) with about 10 million hectares under production. Yields, which vary between 1.14 and 2.10 t/ha depending on the local climate, have gradually increased but are comparatively low because of the extreme fluctuations in rainfall both across the country and from year to year (Curtis, 2002). According to Karoly, Risbey and Reynolds (2003) in 2002 "Australia experienced its worst drought since reliable records began in 1910" the drought was concentrated in "the nation's agricultural heartland". They attribute this severe weather pattern to "human-induced global warming".

Warrilow (2006) says that in India the marked increases in rainfall and temperature projected over 21st Century will substantially affect crop yields and irrigation demands. For example a 2 deg C rise in temperature decreases Indian wheat yield by up to 6% in sub tropical areas and by up to 17-18% in tropical areas.

Water use

While it is obvious that large scale monocropping requires large amounts of water it is perhaps not so obvious that large scale exporters of wheat are also large exporters of water embodied in that wheat. In countries like Australia, that has experienced widespread drought for several years this is a highly contentious political issue.

The agriculture sector uses ten times more water than the industrial and municipal sectors combined. Apparently it “takes 1,000 cubic metres of water to grow a ton of grain. Therefore importing a ton of wheat is equivalent to importing a 1,000 cubic metres of water” (Dept for Economic and Social Affairs, 2000, p.2). Countries that are arid and wealthy can surmount their water shortage by importing grain. The US and European Union subsidize the international wheat trade which leaves some countries vulnerable to political pressure – food could be used as a weapon. Some commentators predict that the next war in the Middle East will be over water not oil (Dept for Economic and Social Affairs, 2000). The ISA methodology can fully account for water use in wheat production chains.

Brown (2002, p.1)[26] says that “water tables are now falling in key food-producing regions – the North China Plain, the Punjab in India, and the southern Great Plains of the United States. The North China Plain accounts for a quarter of China’s grain harvest. The Punjab, a highly productive piece of agricultural real estate, is India’s breadbasket. And the southern Great Plains helps make the United States the world’s leading wheat exporter.”

Canada is one of the leading exporters of water in the form of grain – its export of 18 million tons of grain represents 18 billion tons of water. Likewise the US annual grain exports of 90 million tons of grain represents 90 billion tons of water. 60% of the world’s grain harvest is produced on irrigated land. World grain demand grew at the rate of 16 million tons per year over the last decade. Thus if the world is facing water shortages it is also facing food shortages. A cynic might say the most efficient way to import water is to buy grain from elsewhere.

Health impacts

In Australia there are approximately 6000 workers compensation claims each year for on farm injury/illness. This is amongst the highest rates of any industry. There are several health concerns associated with farming. For example the Rural Industries Research and Development Corporation and Australian Centre for Agricultural Health and Safety say that male farmers in Australia face about a 40 percent increase in age standardised death rates compared to the male population of Australia. This includes increased death rates from cardiovascular disease and some cancers (Fragar & Franklin, 2000). Although Fragar & Franklin say that more work is required for a full analysis of available information regarding respiratory disease in the grain industries in Australia, they can say that between 1889 and 1992 cereal grain farming directly accounted for about 4% of farm-related fatalities, mixed farming including cereal grains accounted for 17.4%; and 8.3% of fatalities occurred during activities related to working with crops (p23). Although the research was not aimed at comparing monocropping to polycropping the above would suggest that farming cereal grain is somewhat safer than mixed farming. The report also indicated that 22.3% of traumatic deaths on farms were associated with tractors and other plant.

Indicators for Occupational Health and Safety and more general health indicators are not currently available in the ISA indicator suite but are possible since the basic national data does exist. However several social performance indicators are available in the GRI

[26] http://www.earth-policy.org/Indicators/indicators6_print.htm accessed 9/08/06

guidelines. These can be used in conjunction with ISA indicators. Further health indicators can be developed within the ISA methodology if national data are available.

Intellectual property rights

The company Monsanto, which sells genetically modified agricultural inputs, believes that low-tech agriculture will not produce the yield necessary to feed the growing world population without requiring huge tracts of additional farmlands. The company pledges to use “sound and innovative science and thoughtful and effective stewardship to deliver high-quality products that are beneficial to our customers and to the environment”. According to the Monsanto website they aim to “apply innovation and technology to help farmers around the world be successful, produce healthier foods, better animal feeds and more fiber, while also reducing agriculture's impact on our environment”[27]. However the supplying of modified grain has a price. It is the intellectual property (IP) of Monsanto and is subject to IP laws and regulations. According to Jordan (2000, p. 805) in North America “public sector wheat breeders find themselves at a disadvantage because their ability to use the latest technology or process is limited though Intellectual Property Rights. Public sector scientists may have the knowledge and the technology to improve wheat but do not have the legal freedom”.

Providing sound metrics to examine true costs

A comparison of the impacts of producing a loaf of bread using monocropping or polycropping farming practices is possible using the ISA methodology given sufficient information about the costs and characteristics of the suppliers to these activities. Existing indicators (see sample in Table 1) can be used and others can be developed Such as local content, reliance of proprietary inputs, diversity of suppliers, local biodiversity counts, although indicators such as this last one are at present problematic. For example, some completely pristine natural ecosystems have quite low biodiversity ranges. If they are replaced by non-native plants and animals this could be regarded as an improvement under a simple species number measure.

Whilst desirable, strict **valuation** is always problematic since there is great subjectivity and uncertainty in putting a value on something not routinely with a value in the marketplace. In our work, ISA prefers to avoid this subjectivity by presenting indicators in their “natural” units. It is for policy makers and informed consumers to bring valuation into their own decisions …

Metrics such as intensities (per dollar of comparable items), material efficiencies (per mass of comparable items), product efficiencies (per sale value of comparable items) are more useful for the comparison of a range of options across a range of indicators/issues.

[27] http://www.monsanto.com/monsanto/layout/ accessed 8/08/06

3.3 Mass production vs home production

Home production of bread conjures images of organic farming practices with judicial and economic uses of soil, water, fertilizer and pesticides. It also has connotations of stone grinding by hand and hand kneading, not to mention baking in a wood-fired oven or on an open hearth. It does not usually conjure an image of the ill effects of open fires on health or the destruction of landscapes for firewood[28]. Neither do we think about increased use of energy through for example electric home grinders for the grains, or more modern all-in-one breadmakers and ovens used in baking. Such increases in home bread making, which goes against the general trend about food preparation in developed countries, involve diseconomies of scale, and significantly lower energy efficiencies. In some endeavours such as bread making, bigger and centralized systems can indeed be better.

Energy use

The energy used in production of a loaf of bread will vary according to agricultural conditions and practices, bread production scale and methods, and communication and transport between the two. In 2005 Munksgaard, Lenzen, Jensen & Pade, published a Danish study of the transport-related energy embodied in a loaf of bread. In order to calculate this they used a hybrid methodology that included the ISA input-output analysis described below. To focus on international transport energy use the authors divided total energy embodied in the consumption of bread into production and transport energy use. They further divided transport into national transport (domestic and foreign) and international transport. They conclude that compared to energy use in the whole production chain for bread, transport energy is of minor importance, accounting for only 10% of total energy use. The study shows that the “total transport energy requirement for one DKK of bread and bakery products converges towards a total of cumulative value of about 0.25MJ” (p294). Such studies are important because they provide information about the environmental impact of production and consumption in physical terms. This particular study also provided information about the sensitivity of consumer prices to energy prices, in this case transport energy prices. At the most detailed level of analysis, considering the whole production chain, the findings from this study showed that “producing bread is more energy consuming than transporting bread. Of total energy embodied in bread 90% is used for production whereas 10% is used for transport” (p297).

Community vitality

Home bread making has different connotations in different parts of the world. In first world economic structures where the majority of people live in cities home breadmaking has something of privilege about it. It implies time at home to make bread, access to ingredients and the means to make it. To advocate home bread making on a large scale as a way of life in such communities is to contemplate obvious as well as subtle changes. It implies changes to family income and social structures so that someone has time at home, as well as to the economy through jobs lost in the bread industry and

[28] Environmental degradation is commonly thought to explain collapse of ancient societies (Tainter, 2006).

associated industries including transport and child care. Once again the interdependency of our decisions quickly becomes apparent.

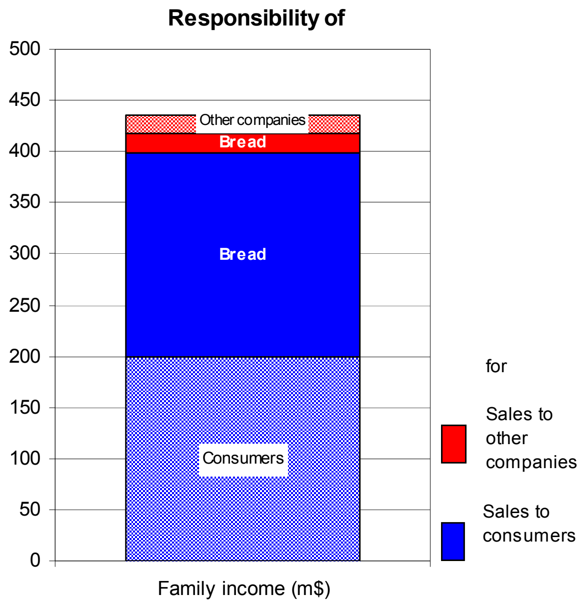
The notion of sustainable bread making practices is complex, not least because sustainability itself is ill-defined (Murray, Dey, Lenzen, 2006). Tainter (2006, p. 92) points out that since “sustainability depends ultimately on the population at large, common conceptions of sustainability must be acknowledged. People sustain what they value, which can only derive from what they know. Ask people what they wish to sustain, and the answer will always involve positive or valued parts of their current way of life. For example, conflict between environmental advocates and rural people who live by natural resource production is not just about ecology versus economics. The conflict is also about sustaining a way of life”. And sustainability may require more not less resource consumption and may not be affordable in terms of energy. People resort to resiliency (i.e. they adapt to change) as a continuity strategy when sustainability is not an option.

4. Sample results for general bread production in Australia

In this section we present typical ISA outputs and descriptions of their meanings purely to illustrate the methodologies. The results are for the entire Australian "bread" sector. The sector has an annual total output of approximately 1.5 billion AU$, corresponding to about 1.6 million tonnes of bread, or about 2 billion loaves. The table below shows the total impact of the bread sector under the assumption of 50% shared responsibility between the sector and its suppliers, and the sector and final consumers. This is the highest aggregation of results (and does include the full supply chain). For example, 436 m$ of family income (wages and salaries) in **total** are paid by the agents involved in the production and consumption of bread (half this amount is attributable to the sector itself). Similarly, about 290 thousand tonnes of greenhouse gas emissions are involved in the provision of bread in Australia.

Indicator	Total Impact	Units
Family income	218	m$
Gross operating surplus	137	m$
Government revenue	21	m$
Imports	54	m$
Exports	46	m$
Employment	6,324	emp-y
Energy consumption	1,746,364	GJ
Water use	12,580	ML
Land disturbance	10,868	ha
Greenhouse gas emissions	145,155	t CO2-e

The shared responsibility concept can be better shown in a graphical breakdown of the 436 m$ of family income (given below). Sales to consumers (final demand) represents about 90% of the total output of the bread sector (the blue sections). The other 10% (in red) represents sales to other companies (such as restaurants). Under 50:50 responsibility, each of these fractions is shared equally between the bread sector and the other player. Note that a different shared responsibility breakdown (such as one based on value added could have been used).



The above table and graph are useful in giving the basic magnitudes that will allow a comparison on this basis with other sectors. A breakdown by intensity (per $) however provides a much better way of comparing very different sectors. Such a listing of intensities for the bread sector is shown in the table below. The denominator ($) is total economic output of the sector. These results show, for example, that approximately 1 employment-minute is involved in total in this sector and all its suppliers per $ output of this sector. Or for example nearly 18 litres of water are required per dollar of output.

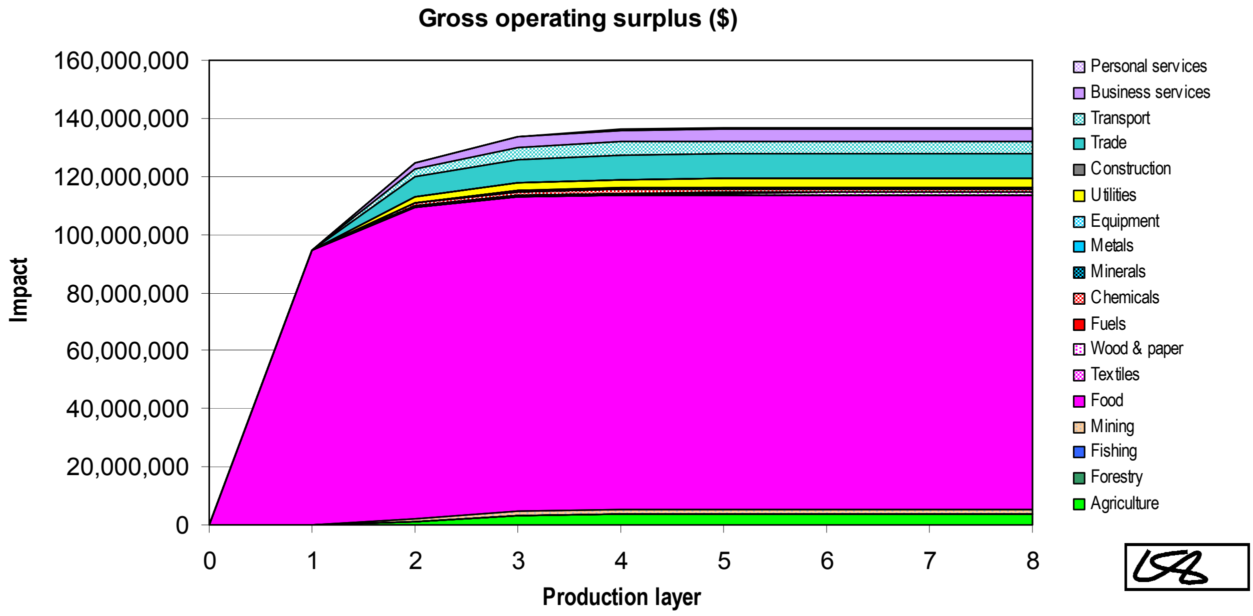
Indicator	Intensity
Family income	30.9 ¢/$
Gross operating surplus	19.4 ¢/$
Government revenue	2.93 ¢/$
Imports	7.70 ¢/$
Exports	6.53 ¢/$
Employment	1.03 emp-min/$
Energy consumption	2,473 kJ/$
Water use	17.8 L/$
Land disturbance	0.15 m2/$
Greenhouse gas emissions	206 g CO2-e/$

The impacts presented above can be broken down into various levels of detail. The first increase in detail is obtained by undertaking a commodity breakdown. We show below a table of the top 10 items from such a breakdown of the 12 580 ML of water involved in the bread sector's 50% responsibility of total water use. The highest ranking component is water used in rice farming that is embodied in rice products that the bread sector buys (4502 ML). The bread sector's direct use of water is the next highest ranking. This could be for example, water as an ingredient, for washing, cleaning etc, directly in bakeries. In this case, these two items dominate the water impact, but they still comprise only 60% of the total water use.

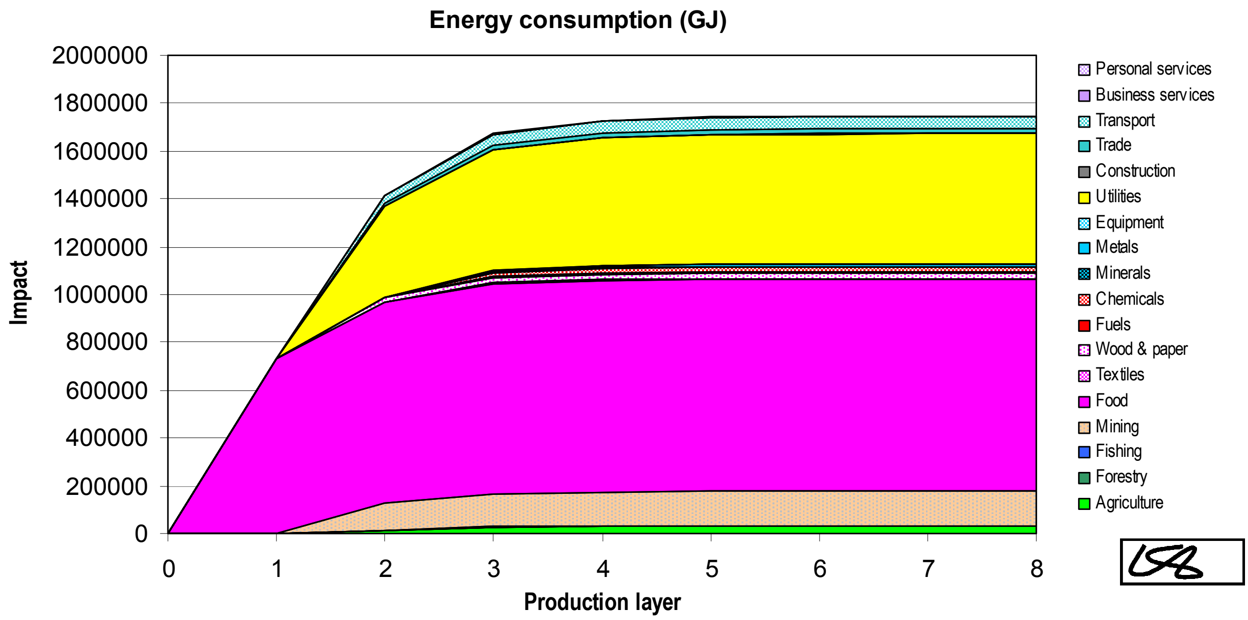
Water use Rank	Commodity	Impact
1	Rice products	4,502 ML
2	Bread	3,090 ML
3	Treated milk	816 ML
4	Plain flour	529 ML
5	Dairy products	519 ML
6	Vegetables	348 ML
7	Electricity supply	342 ML
8	Food products	333 ML
9	Fruit	277 ML
10	Flour mill products	228 ML

The commodity breakdowns can also be presented graphically. In addition, we break them down into production layers (the horizontal layers shown schematically in Figure 1). Such a graph then reveals what broad commodity sector the impact occurred in, and how far up the supply chain it was.

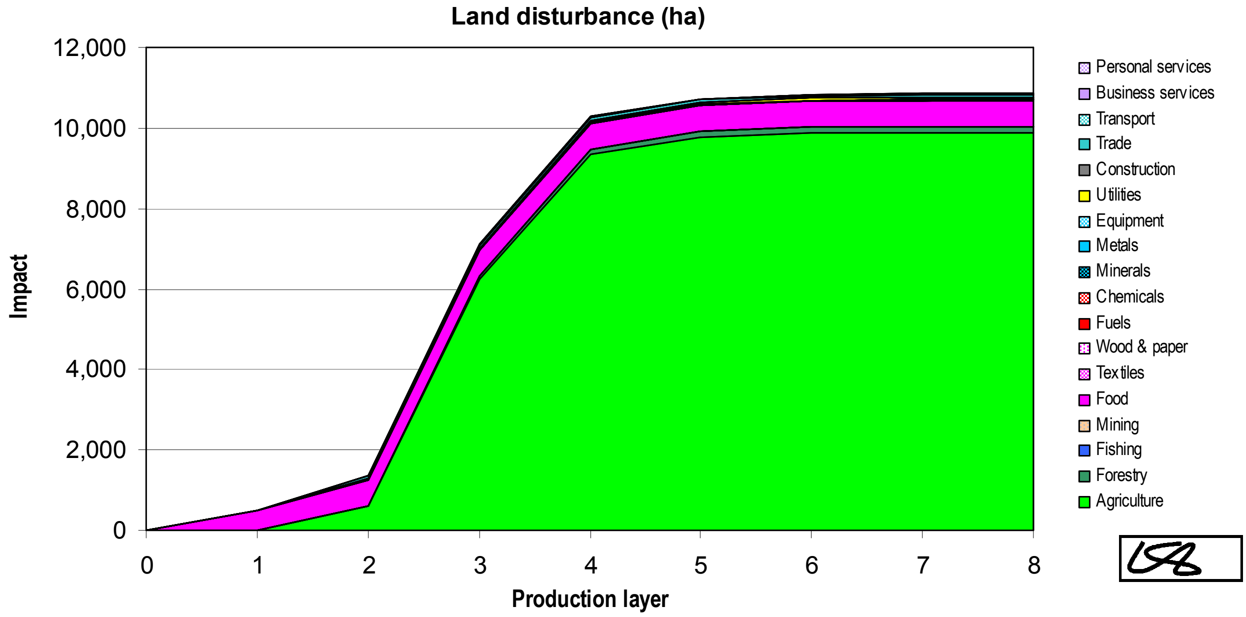
For example, in the following graph of operating surplus, one can see a large proportion of the 137 m$ profit share of the bread sector occurs in the food sector itself (which as we will confirm later, is dominated by profit in the bread sector itself). No other sector takes a significant amount of this profit, and most notably, the agriculture sector, does not share much in the profit generated by the sale of the bread product.



In the energy indicator graph shown below, direct energy use by the bread sector, such as natural gas to fire ovens, is dominant (shown as the pink area that begins at production layer 1 (meaning on-site)). Electricity use (as yellow) is also significant, but since it is generated off-site, it appears as a production layer 2 impact. One can see that energy from agriculture is very small. The only other significant contribution is from mining, and that refers to 2nd production layer energy involved in the extraction of the natural gas that the bread sector uses.



The final commodity breakdown graph below shows land disturbance, which in the ISA model is a measure of the departure of land from its natural state. In this indicator, almost all of the impact occurs in agriculture. This represents the significant land disturbance involved with modern cropping practices, as well as the substantial land areas involved. Most of this impact is production layer 3. In this case the supply chain (moving upstream) is bread sector, to flour supplier, to farm.



The final and most detailed breakdown that is possible in the ISA framework is called structural path analysis (SPA). An SPA effectively shows individual branches of supply chains (such as the red lines depicted in Figure 1). The table below shows the top 5 SPAs for the indicator gross operating surplus. As consistent with the 1st area graph above, the major profit impact (69%) occurs in the bread sector itself, with relatively little flow-on profit going upstream to the suppliers. In fact the profit flowing to the wheat farmers is less than 0.5% of the total profit. To put this in context, consider that profit presents an organisation or sector's capability to invest, improve and address environmental issues (for example). Given that the majority of the land disturbance impact occurs on farms (see graph above), with such a low profit share going to farmers, it is demonstrated that they do have few resources (from this major supply chain) to address land degradation issues from their activities.

Gross operating surplus

Rank	Path description	Path value	Path order	Percentage in total impact
1	Bread	94,550,577 $	1	69.10%
2	Wholesale repair and servicing > Bread	3,335,775 $	2	2.44%
3	Food products > Bread	2,485,037 $	2	1.82%
4	Plain flour > Bread	2,336,834 $	2	1.71%
5	Confectionery > Bread	1,721,323 $	2	1.26%

These results are a small snapshot of the output of the ISA framework. They can inform many of the issues that are at the heart of the assessment of the production of bread.

5. Action!

Before being able to answer the question: What are the impacts of true cost pricing in products and services on financial, social and environmental systems? We need to examine the assumption underlying the question: that 'true cost pricing' is either definable or attainable.

The ODB forum uncovered a range of issues around the concept of 'value', and what can be counted as a 'cost', as well as who is in a position to place a 'value' on that 'cost'. However if we do agree on what is valued, somehow translate that value into monetary terms, and then calculate the 'true cost' of a loaf of bread, would everyone be able to afford, or even be willing to pay, the price for it? And so the debate about 'value' and 'cost' will occur over again. And because we are lucky enough to live in a democracy and hold free speech as a right it will keep on occurring – as it should. Each time however it will occur in a new context that will have evolved out of this and all previous (and future) debates.

We cannot control the debate, we cannot tell people what and how to value. The only thing that we can have some control over is the context that is developed over time and in which the debate occurs. The ODB prize is now part of the context as are, for example, the Capital Ownership Group that is working towards reduction of inequality through strategies to provide broad ownership of productive capital, and the Business Alliance for Local Living Economies that encourages local networks for sustainable living. The context has numerous facets and ranges from local to global in its extent.

Actions arising directly from the ODB prize will also be part of the future context. Perhaps one of those actions will be to provide a coherent framework for the many local and global ideas and endeavours that already exist in this and similar fields. All are essential to the evolving context of awareness. The ISA contribution would fit into this framework as a consistent and reliable framework for providing detailed information to form the basis for decision making. It would reveal the complex interrelationships inherent in transactions in modern economies.

Actions arising directly from an ISA contribution to the overall framework can include:

* Development of US specific user-friendly TBL software for organisations
* Provision of online and paper-based training and support for organisations
* Development of resources that help businesses (eg. farm, bakery) interpret and gain leverage from their TBL results
* Community engagement strategies to promote the use of personal calculators
* Community education strategy to show how TBL reporting can provide information to help equip small business and consumers to realise their market power.

Future action based on TBL reporting can include:

* Labelling to show embodied water or greenhouse gas or employment, etc
* Cash registers that, along with the price, ring up the greenhouse gas ‘cost’ or the water ‘cost’ or the hours of employment embodied in the good or service
* Development of a TBL auditing and authenticating strategy and service

A good analytical system can provide a part of the overall strategy. However it will have little effect unless it is widely adopted. For it to be widely adopted it will need to fit into a wider story; one that includes all of the more personal and local stories that make up the ‘true value’ of anything.

Climate change, water use, health and safety and intellectual property rights are not usually in the forefront of the purchaser’s mind when buying bread. However, although purchase decisions are often made in a matter of seconds they are not made in a vacuum. They are made out of someone’s accumulated life history. Each particular life history depends on genes, the body s/he was spilled out with and history of interactions since conception. Whether or not something is noticed by us and becomes part of who we are depends on our ‘readiness’ to notice a difference. And we become ‘ready’ to notice a difference as we interact over a life time with other living systems in our environment (or context) which includes communication (Bateson, 1972; Maturana & Varela, 1987; Murray, in press). Thus being surrounded by accessible[29] information is a powerful tool for change. The more accessible information our environments contain the more likely we are to encounter a specific ‘difference’ that stands out from the noise for us (i.e. something of personal meaning in the general noise).

Having access to the full upstream production costs of a loaf of bread presents a powerful capability. It can identify where in the supply chain we should concentrate efforts. When combined with a story that provides local and specific details such information has a chance of being heard. Thus more consumers will be able to make informed decisions and the more this information becomes part of life the more likely those decisions **can** be made in a matter of seconds.

[29] To be accessible information must not exclude people through use of jargon, must be attractive to a range of audiences, available through a range of media, easily located and pervasive, so ubiquitous that it becomes ‘common knowledge’. It can include labelling, consumer education; advertising, school education, multi-media general interest programs; provision of kits, resources and support materials.

6. References

Atkins, P. & Bowler, I. (2001). *Food in Society: Economy, Culture, Geography*. Oxford University Press: New York,, US

Ayo, J. A. (2001). The Effect of Amaranth Grain Flour on the Quality of Bread. *International Journal of Food Properties*, 4(2), 341-351.

Bateson, G. (1972). *Steps to an ecology of mind*. Ballantine Books, Inc.: New York, N.Y.

Brown, L. (2006). World Grain Stocks Fall to 57 Days of Consumption. Earth Policy Institute. http://www.earth-policy.org/Indicators/Grain/2006.htm accessed from the web 9/08/06

Chen, Z., Chen, J., Shi, P. & Tamura, M. (2003). An HIS-based change detection approach for assessment of urban expansion impact on arable land loss in China. *International Journal of Remote Sensing* 24 (6) pp 1353-1360

Copenhagen Consensus (2006). Copenhagen Consensus 2006 – A United Nations Perspective Held in collaboration with Georgetown University, Washington DC 16th and 17th June 2006

Córdoba J and Midgley G (2003). Addressing organisational and societal concerns: An application of critical systems thinking to information systems planning in Colombia. In: Cano J (ed). *Critical Reflections on Information Systems: A Systemic Approach*. Idea Group Publishing: Hershey PA, pp. 159-208.

Counihan, C. & Van Esterik, P. (eds) (1997). *Food and Culture: A Reader*. Routledge: London. (UK)

Curtis, B.C. (2002). Wheat in the World. In Curtis, B.C. Rajoram, S. Gomez, H. & H. Gomez Macpherson (Eds) (2002). *Bread Wheat: Improvement and Production.* Food and Agriculture Organization of the United Nations: Rome

Dept for Economic and Social Affairs (2000). *International Rivers and Lakes No 33 June*. UN, New York and the Economic Commission for Latin America and the Carribean, Santiago, Chile. Division for Sustainable Development, Dept of Economic and Social Affairs, UN, New York.

Dept of Agriculture, Fisheries and Forestry (2001). Food News Bulletin, Commonwealth Government of Australia, September.

Fieldhouse, P. (19965) Food and Nutrition: Customs and Culture. Nelson Thornes: Cheltenham United Kingdom

Fragar, L. & Franklin, R. (2000). *The Health and Safety of Australia's Farming Community, a report of the National Farm Injury Data Centre for the Farm Safety Joint Research Venture*. Rural Industries Research and Development Corporation and Australian Centre for Agricultural Health and Safety.

Gallego, B. and M. Lenzen 2005. A consistent input-output formulation of shared consumer and producer responsibility. *Economic Systems Research* 17(4), 365-91.

Gallopin, G.C. (1997). Indicators and Their Use: Information for Decision-making. In *Sustainability Indicators*. M. Bedrich & S. Billharz (Eds). John Wiley & Sons, Chichester, UK, pp13-27.

Gill, B.S. & Friebe, B. (2002). Cytogenetics, Phylogeny and Evolution of Cultivated Wheat. In B.C. Curtis, S. Rajoram & H. Gomez MacphersonH. Gomez & McPherson (2002). *Bread Wheat: Improvements and Production*. Food and Agriculture Organization of the United Nations: Rome

Gill, B.S. & Friebe, B. (2002). Cytogenetics, Phylogeny and Evolution of Cultivated Wheat. In B.C. Curtis, S. Rajoram & H. Gomez MacphersonH. Gomez & McPherson (2002). *Bread Wheat: Improvements and Production*. Food and Agriculture Organization of the United Nations: Rome

Jordan, M. C. (2000). The Privatisation of Food: Corporate Control of Biotechnology. *Agronomy Journal. American Society of Agronomy* **92**, pp803-806.

Karoly,D., Risbey, J. & Reynolds, A. (2003). Global Warming Contributes to Australia's Worst Drought. http://www.climnet.org/pubs/WWF_2002_Drought_web.pdf. accessed from the internet 21/08/06.

Kuhnlein, H. V. & Receveur, O. (1996). Dietary Change and Traditional Food Systems of Indigenous Peoples. Annual review nutrition 1996.16:417-442. Downloaded from arjournals.annualreviews.org by University of Sydney on 07/05/06.

Lenzen M. and Murray J. (2001), The role of equity and lifestyles in education about climate change: experiences from a large-scale teacher development program, *Canadian Journal of Environmental Education* **6**, 32-51, 2001.

Lenzen M., Dey C. and Murray J. (2002), A personal approach to teaching about climate change, *Australian Journal of Environmental Education* 18, 35-45, 2002.

Lenzen, M., Murray, J., Sack, F. & Wiedmann, T. (2006). Shared Producer and Consumer Responsibility – theory and practice. Accepted for publication in *Ecological Economics.*

Lloyd, Michael 1994. How green are my suppliers? - Buying environmental risk. *Purchasing & Supply Management* Oct, 36.

Lockie, S., Lyons, K., & Lawrence, G. (2000). Constructing 'green' foods: Corporate capital, risk, and organic farming inAustralia and New Zealand. *Agriculture and Human Values* 17: 315-322. Kluewer Academic Publishers.

Maturana, H. (1988). Reality: The search for objectivity or the quest for a compelling argument. *Irish Journal of Psychology*, **9**, 25-82.

Maturana, H. R. & Varela, F. J. (1987). *The Tree of Knowledge: The Biological Roots of Human Understanding*. New Science Library, London: Shambhala.

McKerlie, K., N. Knight, and B. Thorpe 2006. Advancing Extended Producer Responsibility in Canada. *Journal of Cleaner Production* 14, 616-28.

McMichael, P. (2001). The impact of globalisation, free trade and technology on food and nutrition in the new millennium. Proceedings of the *Nutrition Society*, **60**, 215-220.

Munksgaard, J. Lenzen, M. Jensen, T. C. & Pade, L-T. (2005). Transport Energy Embodied in Consumer Goods: A Hybrid Life-Cycle Analysis. *Energy & Environment*, **6**(2), 283-301.

Murray, J. (in press). Cybernetic Circularity in Teaching and Learning. *International Journal of Teaching and Learning in Higher Education.*

Murray, J., Dey, C., & Lenzen, M. (2006). Systems for Social Sustainability: Global Connectedness and the Tuvalu Test. Accepted for publication in *Cybernetics and Human Knowing*.

O'Brien, L., Morrell, M., Wrigley, C. & Appels, R. (2001). Genetic Pool of Australian Wheats. In Bonjean, A.P., Angus, W. J. (Eds) (2001). *The World Wheat Book: A History of Wheat Breeding*. Lavoisier Publishing, Paris, France.

Oakley, R. & Buckland, I. (2004) What if Business as Usual Won't Work? In *The Triple Bottom Line: Does it all add up?* A. Henriques & J. Richardson (Eds). Earthscan, London, UK, pp131-141

Ochoa-Arias, A.E. (1998). An Interpretive-Systemic Framework for the Study of Community Organisations. *Systemic Practice and Action Research*. ***11***.(5).

Ochoa-Arias, A.E. (2004). An interpretive systemic exploration of community action in Venezuela. In, *Community Operational Research: OR and Systems Thinking for Community Development*. Midgley, G. and Ochoa-Arias, A.E. (eds). Kluwer/Plenum, New York.

Pena, R.J. (2002). Wheat for bread and other foods. In Curtis, B.C. Rajoram, S. Gomez, H. & Mcpherson (Eds) (2002). *Bread Wheat: Improvement and Production.* Pp 1-17

Pretty, J. (2003). Agroecology in Developing Countries: The Promise of a Sustainable Harvest. *Environment (Washington DC)* [Environment (Wash. DC)]. Vol. 45, no. 9, pp. 8-20. Nov.

Richardson, J. (2004). Accounting for Sustainability: Measuring Quantities or Enhancing Qualities? In *The Triple Bottom Line: Does it all add up?* A. Henriques & J. Richardson (Eds). Earthscan, London, UK, pp 34-44

Rigby, D. & Cáceres, D. (2001). Organic farming and the sustainability of agricultural systems. *Agricultural Systems* 68 pp21-40

Tainter, J. A. (2006). Social Complexity and Sustainability. *Ecological Complexity 3*. pp91-103 Science Direct http://www.elsevier.com/locate/ecocom

Ulrich, W. (2002). Honoring C.W. Churchman: Towards Future-Responsive Management. Revised prepublication version of "Can we secure future-responsive management through systems thinking and design?". *Interfaces 24,* No. 4, 1994, Special Section in Celebration of C.W. Churchman's 80 years, ed. by E. Koenigsberg and J.P. van Gigch, pp. 26-37.

von Foerster, H. (1992). Ethics and Second-Order Cybernetics. *Cybernetics and Human Knowing*, *1*(1), 9-19.

Warrilow, D.A. (2006). Overview of Climate Change Impacts. Department of Environment, Food and Rural Affairs (DEFRA). *Climate change and sustainable development*, New Delhi, 7-8 April.