

Ecologically sustainable development: origins, implementation and challenges

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Abstract

The concept of sustainability has received much attention since the publication of *Our Common Future* by the World Commission on Environment and Development in 1987. Despite the institutionalisation of sustainability principles through legislation and policy around the world, progress in implementing sustainable development actions has been slow. The very open-ended definition of sustainable development provided in these documents, and the “language” used has made interpretation of what is required for implementation controversial. “Principles” of sustainable development have been developed to provide further guidance for implementation, but sustainability remains a contested and value-laden concept. Yet there is increasing recognition that the present development paths around the world are clearly *not* sustainable into the future and that we need urgently to address this *unsustainability*. Water use has become a prominent issue through broad acceptance that its use in many situations, including southeast Australia and cities such as Sydney, is unsustainable. This paper provides a broad introduction to the development of the concept of sustainability, barriers to implementation of sustainable development, and the application of sustainable development principles to water provision for a city such as Sydney, with emphasis on the use of recycled water.

Keywords: Sustainability; Ecologically sustainable development; Urban water use; Water recycling

1. Introduction

The concept of “sustainability” has been much discussed over the past 17 years. Despite millions of articles, thousands of proposed definitions and the attention of a very large number of government and non-government bodies around the

world, sustainability remains a contested concept. We seem unable to agree on *exactly* what sustainability means and how the concept should be interpreted in particular situations.

What is clear, however, is that the way in which we use resources and deal with waste

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products requires urgent attention. This is evident due to the declining state of many natural resources and the potential for continuing, and most likely increasing, human pressure on these resources. This pressure comes from population growth, the need to provide for development in poorer nations, and continuing growth in consumption. Hence, at this time, it is best to urgently address the *unsustainable* nature of natural resource use, rather than putting this on hold while we argue endlessly about *exactly* what sustainability means!

A current example of the need for such urgent attention is the looming water supply “crisis” in Sydney. A page 1 item in the *Sydney Morning Herald* on 13-1-05 was a report on research by the Water Services Association of Australia which showed that Sydney needed to cut water consumption by 54% to prevent a “dire water shortage in 25 years”. The looming deficit was seen as particularly alarming because of the assumptions in the analysis — including a very high level of water conservation by households, 25% of all new developments using recycled water, and water-efficient washing machines and appliances as standard. Changing the way people think about water including implementation of large-scale schemes for use of storm-water and grey water was seen as critical.

2. Why is sustainability important?

A definition of sustainability is yet to be provided in this paper. First the question of why we should be concerned about sustainability will be discussed and for this a dictionary definition of sustainable will suffice. The Oxford Dictionary defines “sustainable” as supportable or maintainable [1]. As will be explored later, exactly what is to be supported or maintained and at what level, is controversial and one reason for the contested nature of the concept. First, however, it is necessary to consider why there has been so much

attention given to understanding sustainability and attempting to implement “sustainable practices”.

2.1. Ecological footprint analysis

A coarse index which gives a good idea of the basis for concern about the *unsustainability* of current practices is the Ecological Footprint. The Ecological Footprint estimates the “resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area” [2]. In other words how much productive land do we each require to support all of our activities and consumption?

The WWF Living Planet Report [3] shows that the earth has 11.4 billion ha of productive land and sea. Divided by 6 billion people this allows for 1.9 ha per person to provide for all our activities. In 1999 the world average Ecological Footprint per person was 2.3 ha or 20% above the earth’s biological capacity. In other words, we are maintaining our use of the planet by eating into capital stocks of non-renewable resources and exceeding the biological capacity of the earth’s stock of renewable resources. This is clearly not sustainable by the standard dictionary definition given above. The global Ecological Footprint has grown from 70% of the planet’s biological capacity in 1961 to 120% in 1999. We are clearly living beyond our means. Future projections suggest growth to 180–220% by 2050 [3].

It is also clear that there is enormous inequity in access to and use of the planet’s resources. For example, a comparative table of national Ecological Footprints for 1995, provided by Chambers et al. [4], shows that while the global average Ecological Footprint in 1995 was 2.2 ha per capita, Australia had a footprint of 9.4 ha per capita compared with the US at 9.6, the UK at 4.6, Spain at 3.8, Egypt at 1.4 and Bangladesh at 0.6. While different Footprint analysis may provide somewhat different figures, the relati-

vities among countries tend to be similar, demonstrating great inequity. As discussed below, equity is a core principle of sustainability, so apart from living beyond our planetary means, *unsustainability* is also evident in terms of inequity among people around the world.

If this inequity were addressed such that all people lived like today's North Americans, Footprint analysis tells us that it would take an additional two planets to support the world's population [2]. This is clearly not a feasible option!

2.2. What does Ecological Footprint analysis suggest is required to move towards sustainability for the planet?

The figures above show that many developed countries are using disproportionate shares of the earth's productive capacity. Clearly the Ecological Footprints of these countries need to be drastically reduced. This will be necessary to provide greater equity among the world's peoples in access to resources and safe living environments. It is necessary to allow the less-developed, poorer countries the ecological "space" to develop. It is also essential that such development does not mimic development in the richer developed countries, but rather is based on sustainability principles.

To achieve these changes will require the following:

- De-materialisation of economies (i.e., we need to be able to satisfy needs (and wants) with much lower material and energy inputs) while meeting necessary economic and social outcomes (i.e., providing for needs in an equitable manner and meeting quality of life standards);
- Careful tracking of the flow of materials and energy and of management performance will be necessary to achieve de-materialisation. The extent of de-materialisation required — a factor of 10 or 90% in throughput of materials

in developed countries [5] is a major challenge, and it will be necessary, through tracking flows, to inform where most effective gains can be made;

- Tools to enable tracking of performance and outcomes in de-materialisation.

These points set the challenges for moving towards sustainability.

3. Emergence of the concept of sustainability

The report *Our Common Future* by the World Commission on Environment and Development [6] is typically credited with introducing the term "sustainability" to the environment-development discourse. This book is often called the Brundtland Report after the Chair of the Commission, Gro Harlem Brundtland. The Brundtland Report defined sustainable development as follows [6]: "Humanity has the ability to make development sustainable — to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs". The Report gives strong emphasis to assuring that the world's poor get a fair share of the resources required to sustain necessary economic growth to overcome poverty.

However, the development of the concept of sustainability and the first use of the term "sustainable development" came earlier. In 1980 the World Conservation Strategy was launched by the International Union for Conservation of Nature and Natural Resources (IUCN), United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF) and introduced not only the concept of sustainable development but also the term "sustainable" in relation to human use of the biosphere.

The World Conservation Strategy stressed that: "We have not inherited the earth from our parents, we have borrowed it from our children", thus, introducing a notion very similar to that of inter-generational equity, which is a key element

of the definition of sustainability in *Our Common Future*.

The aim of the World Conservation Strategy was stated as: “To help advance the achievement of sustainable development through the conservation of living resources”. Perhaps the World Conservation Strategy was most significant for stressing that rather than conservation and development being mutually exclusive activities, as had generally been argued up to that time, they are interdependent. The WCS stressed that development requires the conservation of the living resource base on which it ultimately depends and hence in the longer term development will not be able to take place unless we conserve our living resources. Likewise conservation will not occur unless at least minimal standards of development are met (i.e., basic needs of food, shelter and clean water).

As well, the antecedents of the sustainability debate are evident even earlier, in the discussions of limits to growth in the early 1970s [7], whilst the *concept* (but not the term) was developed at the United Nations Conference on the Environment in Stockholm in 1972 (the first world conference on environment and development).

Despite these earlier antecedents in development of the concept and term “sustainable development”, the role played by the World Commission on Environment and Development and its report, *Our Common Future*, in achieving worldwide attention for the concept of sustainable development should not be underestimated. Brenton [8] says of *Our Common Future* that: “The genius of the piece lies in its adoption and promulgation of the concept of ‘sustainable development’ ... [which] effectively bridged the intellectual and political gap which had been apparent at least since Stockholm [the first world conference on environment and development] between those (particularly in the developing world) arguing for economic growth, and those (particularly in the developed world) arguing for environmental protection. It encouraged growth,

but incorporated environmental concern in order to ensure that growth should not ultimately undo itself. In one neat formula, Mrs Brundtland had provided a slogan behind which first world politicians with green electorates to appease, and third world politicians with economic deprivation to tackle, could unite. The formula was of course vague, but the details could be left for later”.

3.1. Institutionalisation of sustainability

The UN Conference on Environment and Development (the second world conference on the environment) held in Rio de Janeiro in June 1992 was the culmination of the discussions on sustainability placed on the international agenda by the Brundtland Report. The Brundtland Report was the blueprint for the Rio conference and ensured that documents agreed at Rio, such as the Rio Declaration and Agenda 21 were based on sustainable development principles and that international agreements signed at Rio similarly included sustainability principles. These agreements included the Convention on Biodiversity and the Framework Convention on Climate Change.

Following Rio, nations around the world progressively included the principles of sustainability in their domestic legislation such that, at least on paper, sustainability became institutionalised. However, progress at implementing actions in keeping with sustainability has been slow. The third world conference on the environment and development, the World Summit on Sustainable Development (WSSD), was held in Johannesburg in 2002. The official UN website for the summit (www.johannesburgsummit.org/ accessed 9 April 2004) says the following about progress since Rio: “progress in implementing sustainable development has been extremely disappointing since the 1992 Earth Summit, with poverty deepening and environmental degradation worsening. What the world wanted, the General Assembly said, was not a new philo-

sophical or political debate but rather, a summit of actions and results”.

Hence the challenges for the WSSD were large, yet the WSSD failed to attract the same level of attention as did the Earth Summit in 1992. The two key documents from the WSSD are The Johannesburg Declaration on Sustainable Development and the Plan of Implementation of the WSSD. Both can be found in the official report of the Summit at: <http://ods-dds-ny.un.org/doc/UNDOC/GEN/N02/636/93/PDF/N0263693.pdf?OpenElement> (accessed 9 April 2004).

Key themes at the WSSD included emphasis on the importance of partnerships — voluntary multi-stakeholder initiatives focusing on implementation of sustainability — and the recommendation of a decade of Education for Sustainable Development starting in 2005. Hence, it is fair to say that despite the enormous attention given to sustainability at least since the 1992 Rio World Conference on Environment and Development, that progress has been disappointing. Before considering why that should be so, it is important to consider terminology relating to sustainability. Various terms in relation to sustainability have been used above but not yet explained.

3.2. Sustainable development, sustainability and ESD

So far in this paper the terms “sustainability” and “sustainable development” have been used interchangeably, and ecologically sustainable development (ESD) has not been mentioned. For many, it is appropriate to use these terms interchangeably, but for others a distinction can be made: “sustainability” refers to the ultimate goal or destination (i.e., a “sustainable state” in relation to the environment, society, economy); “sustainable development” is the path or framework followed to achieve it. Exactly what defines the state of being, of what *is* sustainable (whether it be a society, logging, fishing etc.), is informed by

science but ultimately depends on personal values and world views. Similarly, what is considered as a necessary path and time frame (i.e., sustainable development) will vary amongst individuals [9].

ESD is a peculiarly Australian term and arose in the early stages of a government-initiated discussion of sustainable development in Australia in 1990. It seems that the environmental groups, concerned that the sustainable development discussion process would be hijacked by business and industry and interpreted as just *economically* sustainable development, successfully fought for inclusion of the *ecologically*, in the “official” terminology. This is the term that has been used since then in Australia including in legislation and policy.

3.3. Tripartite nature of sustainability and ESD

Regardless of the range of definitions of sustainability and ESD, and the lack of agreement over the interpretation of the concept, there seems to be general agreement that it involves simultaneous satisfaction of economic, environmental and social factors. Meeting environmental criteria in a society which fails to meet economic and social goals concerning justice and equity does not make for sustainability.

4. Barriers to implementing sustainable development

4.1. Sustainability, sustainable development and ESD — contested concepts

Despite broad agreement on their tripartite nature, these concepts remain confusing to people and this has hampered progress in implementing sustainable development. Examination of the Brundtland definition of sustainable development (given above) demonstrates the problems in interpreting and implementing sustainable development by following that definition.

Suppose you are an engineer planning for urban water supply and are required to do so in accordance with sustainable development. How will the Brundtland definition help you to go about your task? Most likely it will provide more questions than answers! For example, what exactly are the needs of the present (as against wants or desires)? Whose needs? Is society at large likely to agree on what the needs of the present are? How can we know future generations' needs? This will surely depend on technological change and climate change as well as social change into the future. Change in technology and societal views has moved fairly fast in recent years. Can we confidently predict what will be the environmental impact of the development in question, and how this can be judged in relation to sustainability?

It is clear that the answers to these and the many other relevant questions rest not only on scientific knowledge (which may be incomplete or even non-existent for the questions posed) but also on value judgements on issues such as quality of life. It is therefore not surprising that the concept of sustainable development has led to numerous interpretations and remains contested.

4.2. *Language of sustainable development — a barrier to implementation?*

Many have also argued that the language of sustainable development does not engage the public. For example, Holliday et al. [10] explored the dissatisfaction of various groups in society with the concept of sustainable development. In relation to the general public they suggest: "After all its [sustainable development] main message is that in thinking about environment and development issues, as in thinking about one's own life, one must figure out how to live off interest and not capital. One must not eat one's seed corn, burn down one's house to keep warm or use one's drinking water to wash the car. The public is not excited by such thinking. Thus it is unlikely

to read about sustainable development in its newspapers or hear about it on radio or television. Surveys in the USA found that few had heard the expression, but, on hearing it, they took *sustainable* to mean *static* — requiring that one always drive the same car, have the same amount in the bank, and live in the same house. So the term *sustainable development* is unlikely to rally millions to the cause of sustainable development".

On the other hand, the corporate world has cleverly coined the phrase "triple bottom line" to describe this tripartite nature of sustainability in familiar business language. The triple bottom line refers to satisfaction of not just the long recognised bottom line of meeting economic goals (profits) but also the need now simultaneously to meet environmental and social goals (or bottom lines) in carrying out business.

The term was developed by the UK firm SustainAbility run by John Elkington, an internationally renowned adviser to corporations on sustainability and business. Elkington refers to *sustainable value creation* as the key contribution of corporations to sustainability; that is, to create long-term value on an economically, socially and environmentally sustainable basis [11]. The term "triple bottom line" certainly seems to have had resonance with a wider sector than the business world and this no doubt has helped implementation of sustainability principles.

4.3. *Institutional barriers*

Regardless of people's understanding of, and commitment to, sustainability outcomes, the institutional frameworks of society need to facilitate actions in keeping with sustainability. If government processes favour short-term thinking and actions as opposed to the longer-term thinking, planning and investment required for sustainability, then it is little wonder that progress towards sustainability is slight or nonexistent!

Similarly, an holistic approach is required for sustainability. There is, for example, little sense

in turning a water problem in an urban area into an energy–greenhouse–climate change problem by solving the water problem with desalination fuelled by high-fossil-fuel energy use and carbon dioxide release. To avoid this, not only is an holistic analytical approach required, but also this needs to be supported by institutional structures in government (e.g., government agencies and ministerial arrangements) and, more broadly, that facilitate this type of approach.

Beyond these structural arrangements, economic and regulatory drivers also need to facilitate decisions in favour of sustainability outcomes. The right price needs to be paid for scarce natural resources, but with recognition of and means to treat, possible equity issues.

5. Principles of sustainability and ESD

As a guide to assist interpretation and implementation, principles of sustainable development have generally been included in documents which advocate sustainable development. Indeed, the World Commission on Environment and Development in launching their report, *Our Common Future*, issued the Tokyo Declaration at the close of its final meeting. This declaration included a set of principles to guide nations' policy actions for integrating sustainable development into their goals.

Within Australia two key documents set the scene for the incorporation of principles of sustainable development in legislation and policy throughout the country. These are the 1992 National Strategy for Ecologically Sustainable Development [12] and the 1992 Intergovernmental Agreement on the Environment [13].

There are four principles of ESD which are commonly used in Australian legislation and policy. These are:

- improved valuation, pricing and incentive mechanisms.
- intergenerational equity
- the precautionary principle
- conservation of biological diversity and ecological integrity

Often the principle of intra-generational equity will also be included in Australian policy. In brief, these principles are explained as follows:

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5.1. Intergenerational equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. This requires a long-term view with regard to all aspects of the infrastructure put in place and biophysical impacts of activities. It also requires attention to the influence of institutional arrangements on decision-making such that institutional arrangements will facilitate (rather than hinder) decisions which emphasise long-term thinking.

5.2. Precautionary principle

The precautionary principle aims to guide action in situations of scientific uncertainty regarding environmental impact, and requires that when there is a reasonable possibility of serious or irreversible harm to the environment, protective action should be taken *in advance* of clear evidence of harm.

Hence, the precautionary principle goes beyond the aim of conventional environmental risk management that seeks to prevent damage to the environment once the risk of that damage is known or proved (that is better called *prevention* than *precaution*). Rather it suggests that in particular circumstances it is not satisfactory to wait until damage has occurred, but that we should take action to protect the environment in advance of conclusive proof that such damage *will* occur [14,15].

5.3. Conservation of biological diversity and ecological integrity

The conservation of biological diversity and

ecological integrity should be a *fundamental* consideration in decision-making. This principle is especially important in Australia which is one of 12 regions of the world classed as mega-diverse in terms of biodiversity, and the only one which is part of the developed world. This gives special responsibility as Australia should be in a sufficiently wealthy position to ensure appropriate conservation of its unique biodiversity for the world at large. This responsibility needs to be considered in the context of Australia's poor biodiversity conservation record and the overall relatively poor knowledge of its biodiversity. Given these factors, application of the precautionary principle in Australia is particularly important in situations affecting biodiversity.

5.4. Internalisation of environmental costs taking into account improved valuation and incentive mechanisms

There is consensus that the environmental and social costs of resource use must be integrated into decision-making relating to the use of those resources. One facet of this is to internalise the externalities so that external considerations become part of decision-making on resource use. In other words, the right price needs to be paid for activities which have an impact on the environment — a price which properly accounts for the impact. Were this done, many fewer damaging alternatives (such as renewable energy sources and recycling of water) would become much more competitive in the marketplace. There are many economic tools that can be used to achieve internalisation, and this has been a fertile field for discussion and implementation trials in recent years.

5.5. Intragenerational equity

Intragenerational equity is about equity *within* a single generation. Equity need not necessarily mean *equality*. It may mean “unequal treatment of

unequals to produce less inequality” — to ensure that the worst-off members of society receive an *adequate* minimum standard of economic support and environmental quality.

Intragenerational equity is related to environmental issues and sustainability as follows:

- The burdens of environmental problems are disproportionately borne by the poorer or weaker members of society.
- Poverty may lead to environmental degradation. People who are struggling to meet basic needs will not have the luxury of environmental concerns.
- Measures to protect the environment may have an impact on particular sectors of society whilst benefiting another sector.
- All members of society do not have equal access to influencing environmental decision-making. Knowledge, skills, power and decision-making structures differentially benefit or disadvantage individuals and groups in society.

There is considerable concern and awareness that the potential for inequities may be introduced or further entrenched through readjustments taken for environmental management objectives. The move to market-based solutions for allocation of environmental resources and internalisation of environmental costs may, for example, achieve efficiency at the expense of equity. Equity considerations should be given a prominent place in discussion of adjustments to achieve better environmental management. Intragenerational equity concerns both equity among nations and equity within nations.

6. Applying ESD principles to water recycling

From the perspective of ESD, water recycling needs to be considered in a set of nested contexts, ranging from broad to narrow considerations. As discussed above, this is necessary to provide the

holistic and integrated approach required for sustainability.

At the broadest level the context concerns the vital role of water in ecosystems: what is the impact of water extraction for human uses on the functioning of ecosystems and on biodiversity? At this level the biodiversity and ecological integrity principle and the precautionary principle are especially relevant, as well as thinking long-term about impacts (intergenerational equity).

Also at a broad contextual level, social concerns regarding equity of access to water is an important consideration. How should the relative needs of agriculturalists and urban dwellers be compared and how should both of these be traded off against environmental flow needs? How should water be priced for these different uses? To what extent should the footprint of water harvesting extend across jurisdictional and/or ecological boundaries (e.g., to what extent should Sydney be relying on the Shoalhaven system to prop up its water supply)? Consideration also needs to be given to the very different ideological views that contribute to a spectrum of values-based positions on the appropriate share of water between nature and human uses. How can these views be heard effectively in society and are people empowered to participate meaningfully in the debate? Is there equity in this regard? Each of these questions needs to be considered with respect to the principles of sustainability.

Also important at this broad contextual level is climate change. A long-term view needs to consider how rainfall may be altered as the enhanced greenhouse effect causes climate to change. Equally, it is important to consider the impact on greenhouse-induced climate change from water provision methods.

From such broad contextual analysis using ESD principles as criteria, the likely *supply* of water for urban centres, such as Sydney, can be estimated. Where should that water be drawn from, and how much should be extracted for human use?

At a narrower level — that is, moving deeper into the nest of contexts which require consideration in applying ESD principles to water recycling — another set of considerations emerge and need to be judged using sustainability principles as key criteria. Taking the water supply situation for Sydney (as outlined briefly above) as an example, the following issues require consideration when judging the role that water recycling might play.

It is clear that population growth, climate change and increasing demand for replacing environmental flows make supplying Sydney with water, in a manner in keeping with sustainability principles, a massive challenge. Simply seeking a greater throughput of water in the urban system through fossil-fuelled desalination plants, building another dam remote from Sydney (e.g., Welcome Reef), or through increasing inter-basin transfers are options which do not meet ESD criteria. Desalination, if fuelled by fossil fuels, turns a water problem into an energy–greenhouse–climate change problem. This does not demonstrate the holistic approach required for sustainability. Deriving water from more remote locations is not sustainable in the sense of social equity, unless there is really something to be gained for the affected communities outside the Sydney region. If there are financial gains for the affected communities, it is still necessary to consider the possible ecological impact and how these sit with the biodiversity and ecological integrity principle of ESD.

Thus, demand management seems an essential component of any ESD solution to this problem. However, given the high level of demand cuts needed, enhancing supply in a sustainable manner also seems necessary. A possible sustainable way to enhance supply is by gathering more water within the greater Sydney region. This could be done through installation of domestic rainwater tanks, harvesting of stormwater, and through re-use and recycling of greywater and sewage. Even these options for enhancing supply need to be put

through the sustainability filter. For example, a life-cycle analysis (LCA) approach is necessary to look at all the resources used in providing domestic rainwater tanks and the overall environmental impact associated with these. It is also important to recognise that this impact is widespread and involves an energy–climate change impact for manufacture and transport, as well as the impact associated with mining of steel or manufacture of plastics for tanks. This LCA would need to be compared with similar analysis of other options for providing the same amount of water.

Similarly with water recycling, water re-use and harvesting of stormwater, a LCA is required to analyse the overall impact. In each of these cases it will be necessary to assess the locational relationship between the source of the recycled water and the potential sites for use. What infrastructural hardware will be necessary to deliver the water to the sites of use and what materials and energy will be required for supplying that infrastructure and for its running and maintenance? The answers to these questions will be different for greenfield sites and for retrofitting in established areas. Consideration will also need to be given to the energy and resource impact of treating greywater, sewage and stormwater to levels suitable for particular uses, including to a drinking water standard. What is appropriate for one part of the city may not be a sustainable solution for another area once the life-cycle impact is taken into account.

It seems clear that there is no single solution to dealing with Sydney's water crisis. Rather, a combination of actions targeted at both the demand and supply side, including recycling, need to be analysed against sustainability criteria to decide on the best options over the longer and shorter terms. Clever tools (including LCA) are needed to identify the best options in specific situations and the solutions are likely to vary across the greater Sydney region. For example,

for greenfield sites, implementation of water-sensitive urban design principles is essential, but may prove difficult in established areas.

As well, a massive change in attitude to water use both at the personal and industrial level is necessary. The uses that are possible for recycled water depend on the attitude of consumers. Are Sydney people prepared to drink water recycled from stormwater or sewage? Or, will use of recycled water be restricted to industry, parks and gardens, and for toilet flushing in residences? If the latter, then there will be a cost in materials and energy for dual piping, or if the former, specific sites for use of recycled water need to be identified.

Education needs to play a key role in attitude change. In this regard the current work of the NSW Council on Environmental Education and its sub-group, the Environmental Education Coordinating Network (EECN) is important. The EECN is bringing together a wide range of government agencies and non-government organisations to focus on education for sustainable water use at present. The role of the EECN is to facilitate a coordinated plan for water education with complementary roles for all participating organisations.

7. Conclusions

Applying sustainability principles to the role of water recycling in an urban area such as Sydney shows that a complex holistic and integrated analysis is required that considers the inputs and outputs to the urban system as well as the dynamics of that system. Tools such as LCA need to be employed covering a broad context spatially, and in terms of issues considered. At all times the principles of ESD need to be kept at the centre of the analysis.

However, it is also important to recognise that decisions relating to ESD, while informed by science, are also values-based and hence ideology

plays an important role. In this regard it is important to note that sustainability decisions may be addressed at a range of levels — from a superficial through to a deep interpretation of sustainability.

Three levels may be identified:

1. "End-of-pipe" approach to sustainability — This approach with respect to water management for Sydney would emphasise maintenance of supply — a high input, high output approach — but with attention to ensuring that outputs of, say, sewage to the ocean, are appropriately treated so as not to cause environmental harm. This is a superficial approach to sustainability of water use for a city.

2. Cleaner production approach — This approach places emphasis on the workings of the system and minimisation of inputs to and outputs from the system. Efficient (and sustainable) ways of harvesting and re-using or recycling water are explored.

3. Assessing products and services — This is the deepest of approaches and would involve all considerations from (1) and (2), but in addition would give strong consideration to detailed analysis of the life-cycle aspects of various alternatives for meeting urban water needs and to the wider water use footprint of urban dwellers. For example, emphasis is placed on demand-side education, and this may include the water use intensity of various foods and other products with the aim of encouraging consumption which minimises water use.

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