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Irrigation of Urban Green Spaces: a review of the Environmental, Social and Economic benefits

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Executive Summary

For the first time both urban and rural communities are together experiencing drought. In most cities and towns across the country mandatory water restrictions have been in place for the last four or five years. These restrictions have reduced consumption by 14 - 28% and impacted on 75% of Australia's population. But long-term water restrictions come at a cost. Implied costs have been put in the order of $1.6 – 6.2 billion each year.

In this report a comprehensive review is provided of the benefits of urban green spaces and the potential impacts of long-term water restrictions on parks, sports grounds and public gardens. This sector is estimated to account for 27% of the implied cost of long-term water restrictions. A Triple Bottom Line approach is used to examine the environmental, social and economic benefits of urban green spaces and the maintenance of these values using irrigation during drought. The economic aspects are broadly covered in this report. A specific CRC of Irrigation Futures report attempts to make a dollar value estimate of the benefits of urban open space in two case study areas (benefits transfer method).

Urban green space impacts significantly on the micro-climate of a region by modifying extremes of climate, improving the hydrological cycle and improving plant health and biodiversity and adding to soil stability. Most of these advantages are dependant on the vegetation being maintained by irrigation during drought.

Urban vegetation can have a cooling effect of between 2 – 8^{o}C due to increases in evapotranspiration. This can reduce building energy consumption by 7 – 47%.

Urban green spaces can have a positive impact on the hydrological characteristics of the highly modified urban catchments. Grasses and treed areas increase water infiltration and slow run-off after rainfall. These areas are also effective at removing significant amounts of pollutants such as phosphorus, lead and nitrogen and fine sediment.

Urban parks and golf course can be important 'hotspots' of biodiversity in cities. During drought, irrigation of these areas can provide an important refuge for fauna.

The literature indicates that green space can positively affect a person's physical and mental health, and reduce the risks of contracting lifestyle diseases. Further social benefits are shown from the use of green space for participation in sporting and recreational activities. Communities as a whole also benefit from green space from an aesthetic perspective, and by its contribution to improving social cohesion.

The documented research on the positive effects of nature, including urban green spaces, on blood pressure, cholesterol and stress-reduction is suggested to be enough to call for its inclusion into Australian National Health Priority Areas. In a novel transformation, London's Trafalgar square was transformed into a 2,000 m^2 village green for two days as part of 'London's Villages' campaign in May 2007. 'People were bowled over by the calming effect on everyone. It was amazing to see the contribution that grass made in transforming urban space'.

The lack of irrigation has caused the condition of sports grounds to decline significantly to the point where some are not able to be used due to the injury risk to players. Contrary to the implied value of 'saving water' that dominates popular thinking, maintaining urban green areas such as public parks, private gardens and sporting

ovals in the face of water restrictions and rapid urbanisation is necessary for the physical, psychological, emotional and spiritual needs of a healthy community.

Urban green spaces improve residents' ability to cope with life issues in urban housing projects. When trees and greenery were immediately outside their apartments, inner city residents coped better with the demands of living in poverty, felt more hopeful about the future, and managed their most important problems more effectively.

The impacts referred to in the previous section have two broad areas of economic implication. Firstly, green open space facilitates a commercial, income-generating outcome from festivals and sporting events. The second type of implication is an economic efficiency effect resulting in an increase in net social welfare, typically in the form of reduced costs to society, such as reduced health care costs, reduced pollution, etc. but also impacting on non-priced or non market benefits such as community cohesion, aesthetic values, wildlife habitat, etc. There is another economic efficiency, earmarked for further research in an Australian context in this report, which is the potential cost-saving in building energy consumption by the inclusion of green space.

At the end of June 1997 there were 52,164 Australian parks and gardens covering 3,386,354ha which employed 16,646 workers at a cost of AU$470.2 million dollars in wages (ABS 1998). This is a significant amount of financial investment and employment in Australia's economy and needs to be recognised when decisions need to be made regarding water application to public open green space.

These urban green spaces have beneficial 'flow on' effects to neighbouring properties. Residential properties with well maintained gardens and properties close to green public spaces are valued approximately 10% higher.

This report summarises the environmental, social and economic benefits of urban green spaces reported in the literature. Across the broad range of areas clear benefits are evident. The report links the salient environmental and social benefits to potential economic benefits in offsetting the costs associated with energy consumption, water quality and air pollution control, physical and mental health, crime prevention and community building. It has however also identified a lack of Australian economical data on the benefits of urban irrigation across both environmental and social aspects.

Its findings suggest that further research would be needed to clarify the benefits of the irrigation of urban green space across the Triple Bottom Line. Suggested areas of key and additional further research, which would be needed to document and quantify these benefits in an Australian context, are listed in the conclusion of the report.

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1. Introduction

1.1. Urban Drought and Water Restrictions

Australia has suffered severe drought for over 10 years. Across large parts of southern and eastern Australia, dry conditions have now persisted since October 1996. In some areas the cumulative effects of the drought are akin to missing a full year's normal rainfall.

This drought has hit both rural and urban catchments and communities. In Melbourne, Canberra and Townsville records have been set for the lowest rainfall over the last six years (BOM 2007). The current drought is also the hottest drought. Maximum and mean daily temperatures are 1.3^{o}C and 0.8^{o}C, respectively, higher than long term averages (1960-1990). What this means is that for the last 6 years Sydney's temperatures have been more like Coffs Harbour or Brisbane. The drop in rainfall and increase in temperatures has caused this drought.

The drought and declining dam levels have resulted in prolonged water restrictions in most towns and cities throughout the country. These mandatory water restrictions have been in place, in one form or another, in Canberra since December 2002, in Sydney since October 2003, in Melbourne since November 2002, in Brisbane since May 2005, in Adelaide since 2002 and Perth. As of 2007, Hobart and Darwin are the only major cities not on some form of water restrictions.

The water restrictions in all states focus on limitations to irrigation of both public and private open space (Table 1). However, unlike previous restrictions which have been implemented for short periods of time, the current restrictions have been imposed for several years as outlined above.

Table 1. Descriptions of water restrictions for each stage in different locations. This table gives a brief summary of water restricts for differing stages Bolded text indicates which restriction is currently in place in the capital city as at November 2007.

State	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
ACT[1]	Sprinklers at restricted times alternate days, hand held hose used any time.	Dripper only; hand held hose restricted times alternate days.	**No watering of lawns; hand held hose for plants only at restricted times, on alternate days.**	Non-potable water only for external watering; no vehicle washing.			
Victoria[2]	Manual watering systems 6am-8am, 8pm-10pm alternate days.	No watering of lawns; hand held hoses with trigger nozzle for watering gardens; no hoses for washing cars.	**No watering of lawns; manual drippers at restricted times; bucket washing of windows, mirrors and lights of vehicles; hand held hoses with trigger nozzle at restricted times.**[3]	No watering of lawns or gardens; use bucket or watering can to fill pools; vehicles only washed for health and safety reasons. Repeat offenders will have a water restrictor fitted to their water supply, which will limit water flow to the home for up to 48 hours.			
New South Wales[3]	Sprinklers and hosing of hard surfaces banned.		**Hand held hosing and drip irrigation Wednesday and Sunday at restricted times (4pm-10am); no other water systems to be used.**				
South Australia[4]			**Hand held hoses with trigger nozzle at restricted times; sprinklers one day a week restricted times; washing vehicles only at commercial car wash or with buckets.**				
Queensland[5]				Outdoor sprinklers and hoses banned; watering with watering can or bucket at restricted times on alternate days.	**Outdoor sprinklers and hoses banned;, watering with watering can or bucket at severely restricted times on alternate days; some indoor water use restrictions; topping up of**		All external water use banned, unless Permit has been granted. Automatic Sensor or Timer toilets/urinals banned. Target consumption of 100 litres per person per day. [7]

					household pools prohibited, washing of personal vehicles prohibited, target consumption of 140 litres per person per day, high volume users penalised. [6]		
Western Australia	Sprinklers at restricted times alternate days, hand held hose used any time.						

[1] http://www.actew.com.au/publications/TemporaryWaterRestrictionsScheme.pdf
[2] http://www.ourwater.vic.gov.au/ourwater/water_restrictions
[3] http://www.sydneywater.com.au/SavingWater/WaterRestrictions/
[4] http://www.sawater.com.au/SAWater/Environment/WaterRestrictionsConservationMeasures/level3_indetail.htm
[5] http://www.brisbane.qld.gov.au/BCC:BASE::pc=PC_2162

Mandatory water restrictions have been successful in reducing water consumption across Australia's cities. When compared to long term average water consumption prior to water restrictions being put in place reductions in water consumption have been reported (Table 2).

Table 2. Reductions in water consumption under water restrictions. Reductions are relative to long-term average consumption prior to water restrictions.

City	Reduction in water Consumption (%)
Melbourne	28
Sydney	14
Canberra	20

It has been suggested that permanent water restrictions are a poor long-term policy tool for balancing supply with demand because they impose costs on water users (The Allen Consulting Group, 2007). The report outlined the following cost:

1. time and inconvenience costs (for example, hand watering the garden at specific times on specific days, and washing the car by bucket);
2. household investment in alternative, high cost water sources to maintain gardens (for example, garden bores, rainwater tanks and domestic recycling systems);
3. reduced amenity value from green areas around the house and in public parks and gardens;
4. foregone recreation values due to damage to sporting fields (and the associated cost of restoring damaged fields and/or potential for injury to participants);
5. direct costs to businesses reliant on large volumes of water as an input to production; and
6. indirect or flow-on costs to businesses as a result of reduced household demand for services (for example, impacts on garden nurseries and turf farms).
7. direct costs of administering permanent water restrictions policy

   (such as advertising and compliance).

While there are few estimates of the wider costs of permanent water restrictions one study found Canberra households were prepared to pay between $198 and $769 per year to offset or counter the impacts of restrictions (CIE, 2005). The preparedness of households to pay for additional water to avoid household restrictions provides some indication of the value of water. These values were subsequently aggregated to give an indication of the implied household costs of restrictions for all capital cities subjected to water restrictions (The Allen Consulting Group, 2007).

The implied cost amounts to between $800 million to 3,107 million and this is for households which account for only half the costs of restrictions (CIE 2005). Recreational tourism and the urban environment accounted for an estimated 27% of the cost while the commercial sector amounted to 17% of the costs of water restrictions. Clearly, when applied across the water restricted cities the costs of water restrictions are large – in the order of $1.6 billion to 6.2 billion each year.

Table 3. Estimated costs of long-term water restrictions to city householder (From The Allen Consulting Group 2007).

Capital city	Estimated aggregated household expenditure to avoid water restrictions ($ millions per annum)
Canberra	20 - 77
Sydney	297 – 1,154
Melbourne	238 - 923
Adelaide	77 - 300
Perth	103 – 400
Brisbane	65 - 254
Total	**800 – 3,107**

1.2. Review Outline

This report provides a comprehensive review and discussion of the social and environmental benefits of urban irrigation of urban green spaces and some of the economic values associated with these benefits. The focus is on urban green spaces (costs 3 & 4 outlined in The Allen Consulting Group [2007] report), these being parks, sporting areas and public gardens, as these areas have borne the brunt of water restrictions together with our backyards.

The main question we face in the context of drought and water restriction is: what spaces are valuable enough to preserve using irrigation? The assumption is that if a space that needs to be irrigated is not considered environmentally, socially and/or economically valuable, then vegetation loss will occur. The loss of vegetation needs therefore to be understood in the broader context of environmental, social and economic impacts of lost and damaged urban green space.

Direct and indirect benefits of irrigation are treated in the report thematically, under the headings of environmental, social and the associated economic benefits. This structure is related to the Triple Bottom Line strategy of reporting on environmental, social and economic factors (Elkington 1997). Triple Bottom Line reporting tends to enhance the thoroughness of contextual understanding and analysis. This report makes clear that whilst each benefit is addressed in turn, in many cases these benefits can be considered relational and cumulative across the Triple Bottom Line. A benefit in one area is likely to flow on to generate benefits in others.

The first section of the report details the protective, stabilizing and enhancing *environmental* benefits of urban green spaces. The term ‘green space’ can be defined as vegetated space including trees, shrubs, and grasses. Urban green space provides benefits through reducing the energy requirements for cooling in summer and heating in winter. Vegetation also provides porosity in hard landscaped urban environments preventing polluted run-off entering waterways. Another major benefit of greening urban environments is that it may enhance the biodiversity of flora and fauna - a key environmental impact of urbanisation. Finally, the section details the important role of green space in promoting soil stability and preventing erosion.

The second section focuses on the numerous *social* benefits enhanced by green open space in relation to individual and community health and wellbeing. According to ABS statistics (2000), there were 11.8 million visitors to Australia’s parks and gardens in the years 1999-2000. The preservation of urban green space is an integral part of maintaining public access to these parks and gardens and the recreational use of this green space which is a significant part of the Australian culture.

The last section of the report draws out a range of *economic* benefits that are both current and prospective. These include an increase of economic activity in the tourism sector, an increase in residential property value, an increase in tax revenue and drawing employees to cities/businesses. Whilst these economic benefits can be clearly derived from the environmental and social benefits outlined in the previous parts of the report, it should also be noted that that there are a range of opportunities for design innovation to address issues such as the need to establish and maintain new green spaces in urban environments.

2. Environmental Benefits

Urban green space impacts significantly on the micro-climate of a region by modifying extremes of climate, improving the hydrological cycle and improving plant health and biodiversity and adding to soil stability. Parks can also provide a venue for sustainable transport corridors and for dissemination of topical education and information. During drought, irrigation is required to maintain many of these beneficial characteristics of urban green spaces.

2.1. Temperature Modification

The two main processes through which trees have a cooling effect on the microclimate are direct shading which prevents solar radiation from heating the surface and evapotranspiration (evaporation and transpiration) which cools the air (Georgi and Zafiriadis 2006, Papadakis et al. 2001, Tsamis & Kyritsis 2001).

Reductions in vegetation cover led to an increase in solar radiation absorption and contribute to the phenomenon of urban 'heat islands'. In a study conducted by Owen et. al. (1998), it was reported that heat flux (warming) increased as the amount of vegetation decreased.

Green spaces can modify the climate by changing the albedo of the surface. Albedo is a measure of the amount of solar radiation reflected by a surface. Low albedo materials, for example asphalt, strongly absorb radiation and heat up. Increasing vegetation cover around buildings results in reduced temperature of the building and building materials and the temperature near the building surface (Taha 1997). Maintaining grassed areas, through irrigation, around buildings can provide a higher albedo surface than many low albedo surfaces, such as bitumen.

The cooling benefits of urban vegetation, achieved through the processes of increased solar reflection and evapotranspiration, can, according to studies outlined following, result in air temperature reduction of between 2-8 ^{o}C.

A study in the Czech Republic looked at the dissipation of solar energy and its modification by management of water and vegetation. A single tree was considered to be a 'perfect air conditioner'. A large tree with a canopy diameter of 10 m can transpire 400 litres of water per day. The latent heat exchanged for the single tree was calculated to be 278 kWh and the cooling efficiency was calculated to be 23kW over a 12 hour period (Pokorny 2001). This natural form of air conditioning requires no extra energy input, is quiet, and highly efficient. Having multiple large trees in urban green space will have a positive impact on decreasing urban temperatures.

In Greece, measurements taken in the suburbs of Sacramento showed that air temperatures under trees canopies were about 1.7 - 3.3°C cooler than the air temperatures in surrounding unshaded areas. In the same study, different tree species were used and some produced lower temperatures than others (Georgi & Zafiriadis 2006).

A study in California, USA assessed three parameters that affect urban heat islands. They were surface albedo, evapotranspiration from vegetation, and anthropogenic heating. Given the appropriate conditions, evapotranspiration can have a significant effect on the cooling process, by creating 'oases' that can be 2-8°C cooler than the surrounding air temperatures. One of the conclusions of the study was that changes in the amount of vegetation can be effective in modifying surface climate (Taha 1997).

A study carried out by Cleugh (2005) concluded that urban evapotranspiration is a substantial component of the water balance. The study found that the amount of water used in evapotranspiration was almost twice the amount of water that was lost from the studied area through run-off. By adding water to the urban landscape, quantifiable benefits in the form of cooler air temperature and energy consumption savings will result.

With the decrease in urban green space due to the increasing areas of hard landscape, the establishment of green roofs can make great use of unused urban space. A green roof is one with plants growing on its surface. This could range from a spontaneously occurring moss and lichen to a full-scale roof garden that includes trees, shrubs and hard landscaping features.

Green roof gardens can vary in extravagance, as can any garden space, depending on the planting style. Some require the intensive management of a ground level garden, and can have weight issues which have major structural implications for the building. Others have low management requirements that do not require irrigation after establishment. These incorporate naturalistic planting styles with the objective of establishing self-sustaining plant communities on the roof with minimal structural implications for the building. Some of the benefits of a green roof are that they:

- are visually attractive with a range of flower and foliage effects;
- modify rainwater – the total volume and rate of rainwater run off from the roof is reduced dramatically;
- increase thermal resistance of the roof of the building - the building is insulated from heat loss in the winter and heat gain in the summer, overall reducing energy consumption;
- reduce sound transmission through the roof;
- improve air quality by removal of carbon dioxide, release oxygen and water vapour;
- plant collection (deposited) of particulate pollutants and absorb organic volatiles;
- reduce the 'urban heat island effect'; and
- provide habitat for wildlife.

2.2. Air quality

Green roofs in urban areas can have a positive effect on reducing airborne pollutants. Green space on urban roofs have been proven to significantly reduce diesel engine pollutants and ozone (O_3). A 37% and 21% reduction in sulphur dioxide and nitrous oxide respectively has been achieved in the vicinity of green roofs (Getter & Rowe 2006).

A modelling experiment by Taha (1997) concluded that on a large scale, increased numbers of urban trees will increase the air quality in an urban area. Low volatile organic compound emitting species can reduce urban ozone (O_3) levels. Pollutants can also be removed by trees through particle interception. Pollutants can become attached to the leaf's surface where it can re-enter the atmosphere or be washed off onto the earth's surface by rain, or fall when attached to a plant part (Guevara-Escobar et al. 2007; Nowak, Crane & Stevens 2006).

A modelling experiment was conducted in the US to estimate the amounts of Carbon monoxide (CO), nitrogen oxide (NO_2), O_3, sulphur dioxide (SO_2), and particulate matter less than 10µm that was removed by urban trees throughout 48 United States (55 cities). The results varied between cities as they were dependant on existing tree cover. The study concluded that urban trees in the United States are estimated to reduce annual pollutants by 711,000 tonnes, valued at US$3.8 billion. Urban trees have an effect on reducing air pollutants and improving general air quality in cities and the study suggests that more trees should be planted to increase reduction of these pollutants (Nowak, Crane & Stevens 2006).

The importance of green space in offsetting the negative implications of urbanisation needs to be recognised. Green space can decrease temperature in the urban climate, creating a more liveable environment. To maintain these green spaces during prolonged droughts irrigation may be required.

2.3. Reduced Building Energy Consumption

Urban green space can reduce building energy consumption. As outlined above, the presence of vegetation reduces air temperatures and, secondly, direct shading of building can reduce the demand for cooling energy. Green space can also indirectly reduce CO_2 emissions by reducing the amount of energy required to cool buildings (Akbari et al. 2001; Coutts et al. 2007).

In Sacramento, it is predicted that a 10% increase in tree cover in the city could decrease the amount of cooling energy required by up to 24% (Jo & McPherson 2001). A Chicago study quantified shade, evapotranspiration and wind reduction of the existing vegetation on the indirect decrease in atmospheric carbon, and determined effective planning strategies to reduce emissions (Jo & McPherson 2001). The study indicated that a large tree with a canopy of 10 metres positioned 6.6 m from the east or the west wall of buildings provided the largest carbon reduction through the saving of cooling energy of 7 - 8%.

The Jo and McPherson (2001) study compared two blocks with very different vegetation cover. Block one had a large amount of vegetation, block two had minimal. The average energy saving for the time of maximum cooling needs was 3.5±0.9% for block one and 0.4±0.1% for block two. The conclusion was that blocks with a higher number of trees had higher cooling energy savings. The energy savings cannot be directly compared to Australian conditions as there are many differences in climatic

conditions between the two countries, however it is a good indication that energy saving would also be possible in Australia. Quantifying potential energy savings in buildings in Australia has been identified as an area of future research.

The energy savings of a tree has been quantified by Akbari et. al. (2001), who stated that "Over the life of a tree, the savings associated with these benefits (reduction in building air conditioning, lowering air temperature) vary by climate region and can be up to US$200 per tree. Peak power and cooling energy savings from trees that shaded two houses in Sacramento were recorded over the summer of 1992. Cooling energy savings of 30% resulted from the shade the trees provided which converts to about 3.6 to 4.8kWh/day. This is supported by another experiment conducted that measured the cooling savings of two sites, which were shaded by 16 trees. The results indicated energy savings of 47% and 26% respectively (Akbari, Hashem et al. 1997).

In the USA, about one sixth of its generated electricity is used to air condition buildings. This equates to about forty billion US dollars per year. Half of this electricity use is in Urban Heat Islands (Rosenfeld et al. 1998). Air-conditioning costs and energy use could be reduced with the implementation of green space as an energy saving technique.

Trees scattered through a neighbourhood can reduce heating consumption, not only through the cooling processes of evapotranspiration and direct shading, but also by reducing wind spends through surface roughness. Decreasing wind speed reduces the amount of cold air that can flow into a building which is a major catalyst in the loss of heat during winter (Jo & McPherson 2001). The effect of trees in reducing temperature is also recognised in Akbari et. al. (1997) and Papadakis et. al. (2001).

The energy balance of a building is largely dependent on its surroundings. Vegetation plays a big role in the process. As previously discussed, urban heat islands impact on the energy consumption of buildings greatly (de la Flor & Dominguez 2004). A study conducted in Tokyo, Japan, on the effect of Tama Central Park in reducing energy consumption in the localised area found there to be an estimated US$650 between 1300 and 1400 hrs in electricity consumption on a hot summers day (Ca, Asaeda & Abu 1998). Using this knowledge, it can then be applied to the urban environment to help reduce energy costs and usage.

As previously mentioned, rooftop gardens are a useful tool in the utilisation of unused urban space. Rooftop gardens have been evaluated to show reductions in energy requirements. In a plan created in Singapore, the desire for a greener city is expressed. The option of green roofs had been suggested and a study was conducted to reveal the energy savings that would occur if the buildings had green roofs. A green roof can intercept up to 87% of solar radiation that would otherwise be absorbed by the building resulting in savings in air conditioning costs. Using a model DOE-2 simulation program to determine the energy and cooling consumption and cooling load of a hypothetical commercial building with different types of roofs, it was concluded that an installation of a rooftop garden on a five storey building could reduce energy consumption by 1-15% (Wong et al. 2003).

The use of green space will reduce building energy consumption as discussed in the above literature. Given the amount of greenhouse gases that would otherwise be released into the atmosphere, the importance of maintaining existing and increasing areas of urban green space is again emphasised.

2.4. Impact on the Hydrological Cycle

Urban green spaces can have a positive impact on the hydrological characteristic of urban catchments. The hydrology of urban areas have been highly modified by constructed impervious surfaces such as roads and roofs which increase the velocity and volume of run-off from urban catchments (Shepherd 2006). Treed and grassed areas slow the movement of water from catchments and facilitate infiltration of the water into the soil. This has positive benefits on water infiltration and storage in the soil, run-off reductions, nutrient and pollutant removal and groundwater quality.

Green space such as turf grass provides not only aesthetic and social benefits from the presence of vegetation, but it also provides recreational opportunities for the community such as its use on golf courses, parks, and gardens. There are approximately 1.1Mha of turf grass in Australia (Aldous 2005).

Turf grass greatly moderates the overland flow of water, reducing, and in some instances preventing run-off that can cause erosion and nutrient contamination of streams (eutrophication) (Beard & Green 1994; Carpenter et al. 1998; Gross 1990). Turf increases infiltration of water into the soil promoting solute movement into the soil (Beard & Green 1994; Roy, Parkin & Wagner-Riddle 2000). Using this process to an advantage, grassed areas are increasingly being used to treat urban run-off such as storm water run-off from urban roads and highways.

Grassed areas are effective in removing sediment and nitrogen bound to sediment, but less effective in removing phosphorus, fine sediment and soluble nutrients (Deletic 2005). A study conducted by Barrett et.al. (1998) looked at the effect of two grassed strips alongside a highway and revealed reductions in suspended solids (85%) and a 31-61% decrease in total phosphorus (P), total lead (Pb) and total nitrogen (N). Given continuous urban expansion, increased road use that leads to more pollutants entering storm water, this form of green space should be viewed as a valuable resource.

Trees also modify the way water moves throughout the urban catchment. Increases in the canopy cover of vegetation can reduce urban run-off. In Ohio, a 22% increase in canopy cover resulted in a decrease in run off by 7% (Shepherd 2006). Irrigation during prolong droughts is required to maintain such canopy cover and slow run-off during eventual periods of heavy rain.

The energy benefits of evapotranspiration are greater with evergreen species than with deciduous species (Guevara-Escobar et al. 2007). Perennial vegetation can also reduce the likelihood of salinity problems which occurs in some of our urban areas such as Sydney. Trees and shrubs help maintain local water tables and any associated salts below the soil surface (Connellan 2005).

Significant run-off of nutrients can lead to waterway pollution and cause problems such as eutrophication, which is commonly associated with high concentrations of phosphorus. This can affect the quality of the downstream water from the city as pollutants are carried in the water and transferred to downstream water supplies and also to land if flooding occurs (Deletic 2005; Niemczynowicz 1999; Pauleit, Ennos & Golding 2005; White & Greer 2006).

Correctly applied irrigation to green space can cause a reduction in nutrient surface run-off from fertilisers. An experiment was carried out on the effect of watering fertilised land and the resulting run-off of nitrate (NO_3) and phosphorus (P) if a significant rainfall were to occur within 72 hours of application. The amount of phosphorus in the run-off water was 13.8% without watering in, and 3.4% with watering in. For nitrogen, the

percentage of nitrogen in the run-off water was 1.5% without watering in and 0.8% with watering in. The watering in, in this case, was an application of 0.64mm (Shuman 2004).. This study recognizes that nutrient contamination in waterways is reduced through well managed irrigation.

Vegetation has an important role in stream hydrology. Naturally, riparian vegetation species establish where they will be able to set seed and germinate, and withstand flooding. Urbanisation can affect this ability of species to establish, due to urban expansion, neglect, and can modify the natural flow of river systems. Riparian vegetation has a role in filtering contaminants that would otherwise enter the waterways (Carpenter et al. 1998; White & Greer 2006). The value of green space in quality control of streams cannot be overlooked as it can reduce detrimental effects that occur to our natural resources such as the effects of run-off.

We have outlined the important role green space can play in the hydrological cycle of urban catchments. Irrigation can enhance this role by sustaining vegetation cover during dry periods and preventing eroding run-off from heavy rainfall when it occurs.

2.5. Biodiversity

Urbanisation significantly reduces the amount of habitat available for fauna and flora. Areas near densely populated areas have undergone massive habitat conversions (Balmford et al. 2001). Global estimates, in 2001, indicate a possible 50% or more of all species could be at risk. As biodiversity plays a critical role in the long term sustainability of the natural ecosystems, prevention of decreasing biodiversity, or at least, reduction of this needs to occur. Promoting urban biodiversity by the use of green space in urban areas is a feasible option.

The population of trees in urban areas can hold significant rank in terms of the national tree populations. In the US, trees in urban areas account for 25% of the country's canopy cover (Alvey 2006). Trees are one of the main sources of habitat for many faunal species so the need for the number of trees to be upheld is important for the survival of these species in the urban environment. Research into levels of biodiversity in urban areas is increasing (Balmford et al. 2001; Cornelis & Hermy 2004; Jim & Liu 2001).

Bird populations have been found to be proportional to the existing volume of vegetation (Savard, Clergeau & Mennechez 2000). Sandström et. al. (2006) recognise that there is a decreasing number of bird species when moving from regional to urban areas. The value of vegetation, therefore, in preserving or even increasing bird populations should be considered when valuing or designing urban green space.

The correct floral species needs to be selected when replacing existing plantings not only for the biodiversity of flora, but also as different tree species attract different species of fauna such as bird varieties. The maintenance of biodiversity of flora is also important taking into account that the number of exotic pests and diseases is rising. An example of this is 'Dutch Elm disease' which is a disease that could potentially eliminate the entire elm population in Melbourne, Australia if it is introduced. Biodiversity can also be kept at a residential scale by preserving vegetation during construction.

Large green spaces such as golf courses provide a habitat for floral and faunal species in the urban environment as there is much less disturbance of the area than in busy urban streets. Although this is not a concise solution to urban biodiversity, golf courses

do provide refuge for animals in the urban environment (Hodgkison, Hero & Warnken 2007; Tanner & Gange 2005).

A study was undertaken to compare the biodiversity of golf courses in Surrey, UK with the surrounding landscape. The study showed a higher diversity of tree species and no difference in diversity of herbaceous vegetation. The golf course had a higher diversity of bird populations (Tanner & Gange 2005). Keeping golf courses and preserving them in an urban environment will not only benefit the human population, but also the floral and faunal populations.

Urban parks also host a large amount of biodiversity. In a monitoring study of parks in Flanders, North Belgium, the report concluded that "Urban and suburban parks may be considered important 'hotspots' of biodiversity in cities" (Cornelis & Hermy 2004). The importance of continuing to preserve these parks is essential to conserving the natural biodiversity in cities.

Faunal species such as worms are vital both for biodiversity and soil health. The presence of worms is a general indication of the potential productivity of the soil and they improve soil structure by creating macropores and forming aggregates. Usually, where large populations of earthworms exist, bacteria, viruses, fungi, insects, spiders, other soil animals, and humus will also exist (Lee 1985; Murphy 1993). Earthworms also enhance the nutrient composition of the soil by distributing decomposed plant litter and other organic debris from the soil surface to further down the soil profile and also from their waste products. The primary food is dead plant material (Lee 1985). The biodiversity of not only earthworms will be reduced but also the populations of all soil biota and soil fertility if green space is left to degrade.

By maintaining and expanding current green space, not only is the biodiversity of the flora going to be preserved, but also the biodiversity and population size of faunal species living in the urban environment.

2.6. Soil Stabilisation

Green space is important for soil stabilisation by promoting vegetation which binds soil aggregates preventing wind and water erosion. This was clearly illustrated in the 1960's in Beijing, China, when all turf and many trees were removed from public open spaces. This lead to major air pollution from dust storms, health problems and increased air temperatures resulted (Carrow 2006).

Vegetation decreases soil erosion both above and below ground. Above ground, they intercept raindrops, which increase infiltration. Plant roots contribute to reducing soil erosion by acting as a binding agent to increase soil strength by holding soil particles in place and therefore decrease the likelihood of erosion occurring. Erosion types such as gully erosion can be potentially controlled by effective management of vegetation cover with plant species that have a fibrous root system (Valentin, Poesen & Li 2005).

Soil is strong in compression, but weak in tension, while plant roots are strong in tension and weak in compression. Together they provide much stronger earth than they would in isolation (De Baets et al. 2006; Gyssels et al. 2005; Zhou & Shangguan 2007). This is supported by a study conducted by Baets et. al (2006) which demonstrated the significance of grass roots in preventing topsoil run-off. An experiment conducted by Zhou and Shangguan (2007) on the effects of ryegrass roots and shoots on erosion under simulated rainfall found up to a 95% reduction in sediment loss after 27 weeks when comparing fallow areas to planted areas.

The potential benefit of vegetation on noise reduction is recognised in Beard (1994). However this benefit can be provided by non-irrigated vegetation and was not identified as a major benefit within the literature reviewed.

Without urban green space, the urban environment may encounter very large soil stability problems such as dust and sediment loss. By maintaining green space, stability in the soil is retained. In some cases it may be necessary to use irrigation to maintain this green space resource to prevent soil stability problems.

3. Social Benefits of Green Space

The case is presented in the literature that exposure to green space positively affects a person's physical and mental health, and can reduce risks of contracting lifestyle diseases. Further social benefits are shown from the use of green space for participation in sporting and recreational activities. Communities as a whole also benefit from green space from an aesthetic perspective, and by its contribution to improving social cohesion.

Australia is one of the most urbanised nations on earth: 84.7 per cent of its residents are classed as living in town or cities (UNHCHS 2001) and most urban cities are growing so rapidly that humans are being disconnected from their natural environment faster than they can adapt to their urban surroundings (Stilgoe 2001). As the following research suggests, this disengagement of the community from nature has the potential to negatively affect the physical and psychological health of people and substantially increase the associated economic burden to the nation. Maller et al. (2005) goes so far as to call our present situation a 'global contemporary health epidemic'.

Australia spends around $79 billion a year on health, which is nearly 10% of Gross Domestic Product (GDP). This figure includes everything from bandages, vitamins and pain relievers, to major operations, and medical research. In 2003/04, health spending represented between eight and nine per cent of GDP (Health and Aged Care 2006).

3.1. Preventative Health Care

The biophilia hypothesis suggests that there is an instinctive bond between humans beings and other living systems. The term 'biophilia' literally means 'love of life or living systems'. Closeness to nature is the core principle, and it is suggested that this closeness increases well-being, and its rediscovery can lead to transformations in people and nature. It also suggests that disconnections are harmful - both to individuals and to societies and cultures at large (Pretty et al. 2003).

Urban green spaces are underutilised as a means of disease prevention. The documented research on the positive effects of nature on blood pressure, cholesterol and stress-reduction is suggested to be enough to call for its inclusion into Australian National Health Priority Areas of 'Mental Health' and 'Cardiovascular Disease' (Malleri et al. 2003).

These two disease categories are a significant burden on Australia's economy and state of public health. WHO estimates that mental health disorders alone constitute 10% of the global burden of disease. Estimates are that by 2020 mental health disorders will rise to 15% of the global burden of disease and depression will constitute one of the largest health problems worldwide (Murray et al. 1996).

There is scope for a large scale preventative health care program encouraging the use of 'nature' as alternative therapy. Currently, the therapeutic benefits of nature are to a limited extent being utilised by Australian hospitals and health care agencies (Townsend 2006). For example:

- The Royal Children's Hospital (Vic) and the Westmead Children's hospital (NSW) has a sensory garden which provides patients, their families and staff with a sense of normality and tranquillity.

- The Royal Talbot Rehabilitation Centre is running a horticulture therapy program with patients in its Acquired Brain Injury unit.

- Jesuit Social Services (JSS) provides bush adventure therapy experiences for young people struggling with difficult life circumstances, through its 'TOE' (The Outdoor Experience) program.

- In addition, JSS has recently received funding from the Alcohol Education and Rehabilitation Foundation to refurbish a heritage-listed property in the heart of Yarra Bend Park as a site for outdoor program activities to allow a smoother transition into 'normal life' after the bush adventure experience.

3.2. Benefits of urban green space on mental health

Depression costs the Australian economy $3.3 billion in lost productivity each year. Six million working days are lost, with another 12 million days of reduced productivity. Economic studies indicate that each employee with untreated depression and related conditions will cost their organisation nearly $10,000 a year (National Depression Initiative, Beyondblue 2006).

The utilisation of urban green spaces and contact with nature could have a positive impact, particularly in terms of facilitating a more optimistic or positive attitude, enhancing social support, reducing stress and tension, and by providing opportunities for physical exercise.

London's Trafalgar square was transformed into a 2,000 m^2 village green for two days as part of 'London's Villages' campaign in May 2007. 'People were bowled over by the calming effect on everyone. It was amazing to see the contribution that grass made in transforming urban space' (www.visitlondon.com).

Physical exercise has recently been proven to be as equally effective as medication in the treatment of depression in elderly people. Research recently compared incidence of depression in three treatment groups where indoor aerobic exercise, antidepressants, or a combination of both were prescribed. After four months the clinical symptoms of approximately 65% of patients in all groups had reduced so significantly that they were no longer classified as clinically depressed (Malleri et al., 2003).

There are few studies that quantify the effects of 'green exercise' as opposed to indoor exercise but recent research conducted in the UK has hypothesised that 'green exercise' will improve health and psychological well-being (Pretty et al. 2007). This study measured the effects of 10 green exercise case studies (including walking, cycling, horse-riding, fishing and conservation activities) on 263 participants. It was found that green exercise led to a significant improvement in self-esteem and total mood disturbance. Self-esteem and mood were found not to be affected by the type,

intensity or duration of the green exercise, as the results were similar for all 10 case studies. All these activities generated mental health benefits, indicating the potential for a wider health and well-being benefit from green exercise (Pretty et al. 2007). Green exercise and the maintenance of green open spaces therefore have important implications for public and environmental health.

Environments such as urban public parks that enhance physical and psychological health need to be investigated further in relation to their benefits in residential, educational, workplace, community and social settings from an Australian perspective.

Kaplan in his recognition of the fact that most daytime hours for many people are spent at work, has found that nearby nature, even when only viewed from a window, had a substantial beneficial effect in the work setting, affecting job satisfaction and well-being (Kaplan 1995).

An extensive study published in the Netherlands in 2001 determined the link between green space and health. The study analysed the health information of 10,000 residents of the Netherlands and overlaid this information with land use data that covered every 25 x 25m square of the nation, allowing the researchers to know which people lived near city parks, agricultural land, forests and nature areas.

The results revealed that in greener environments people report fewer health complaints and have better mental health. An interesting discovery of the research was that when it comes to health, all kinds of green are equally effective; the benefits are the same whether one is living near agricultural area, forest or city parks (De Vries 2003).

3.3. Benefits of urban green space on Attention Deficit Syndrome (ADD)

Attention deficit hyperactivity disorder (ADHD) is one of the most commonly diagnosed mental disorders among children, although it also occurs in adults. Many children will carry symptoms of ADHD through to adulthood and if untreated, this will result in significant impairment in their ability to study, work and manage their lives (ADDults with ADHD (NSW) Inc. 2007).

Children with ADD have chronic difficulty paying attention and focusing on tasks. They are impulsive, prone to outbursts and are at times aggressive. Often their behaviour results in family conflict, peer rejection and academic failure (Taylor et al. 2001). A study of 96 children in the 7-12 age group, formally diagnosed with ADD or ADHD, has found that the symptoms of children are relieved after contact with nature and that the greener the setting, the greater the relief (Taylor et al. 2001). By comparison, activities indoors such as watching TV, or outdoors in paved, non-green areas, leave ADD children functioning worse.

3.4. Benefits of urban green space on Obesity

The rate of overweight and obesity has almost doubled amongst Australian adults over the last two decades with Australia now being ranked as one of the fattest developed nations, closely following the USA (Australian Department of Health & Aging 2002)

Analysis of the 2001 National Health Survey found that around half of Australians aged 18 years and over were either overweight or obese. In just over 10 years, the proportion of Australian adults who were overweight or obese increased by around

25%. It is estimated that at least 60% of Australians aged 18 years and over will be overweight or obese by 2010, and that this will increase to 65% by 2020 (Australian Department of Health & Aging 2002). In the USA, direct costs of obesity have been estimated to be around 9% of the total health care costs and in Europe, between 1% and 5%. Estimates for Australia in 1995/6 suggest that the true costs of obesity may be between $680 million to $1,239 million per annum.

Importantly, the escalating cost of health care with progression of an obesity related disorder, such as diabetes, has been calculated as almost doubling over time with normal progression of the disease. This suggests that the economic burden is not only significant, but is likely to get worse even if there is no further growth in the prevalence of obesity.

Overseas studies have found that obese people attain lower levels of occupational prestige (and lower incomes) than non-obese persons. In addition, other studies have found that obese persons as a group receive more sickness and unemployment benefits than persons within a normal weight range (Australian Department of Health & Aging 2002)

When people have nowhere to walk or participate in sports they gain weight, therefore obesity is more likely in neighbourhoods that are unwalkable. Studies reviewed in the *American Journal of Preventative Medicine* revealed that a “creation of or enhanced access to places for physical activity combined with informational outreach” produced a 48% increase in frequency of physical activity (Khan et al., 2002). This may be particularly significant as like in North America, Australian suburbs tend to be designed to facilitate car rather than personal mobility. (Newman et al. 1999)

An obese person suffers an increased risk from blood pressure, hypertension, high blood cholesterol, an array of associated heart disorders, poor reproductive health and is also at risk from psychological problems such as depression and low self esteem. By providing opportunity for physical activity, urban green spaces can facilitate an increase in physical and psychological health leading to reduction in obesity (Australian Department of Health & Aging 2002).

3.5. Urban Green Space and Childhood Development

Urban green spaces are necessary for the healthy development of children as a means of encouraging play and gaining access to nature. Some experts advise that children today are not getting enough access to nature owing to fear of crime in distressed areas, parental paranoia about “stranger danger” in more affluent areas, media hype of infrequent child violence, and overexposure to technologies like computers and video games. Richard Louv has coined this problem “nature-deficit disorder,” and says that children miss out on growth opportunities when they are not allowed to explore nature during play (Gies 2006).

For small children, playing is learning. Play has proven to be a critical element in a child’s future success. According to the Association for Childhood Education International, play helps develop muscle strength, co-ordination, language, cognitive thinking, and reasoning abilities (Isenberg et al. 2002). Public parks and green spaces encourage play and interaction with other children.

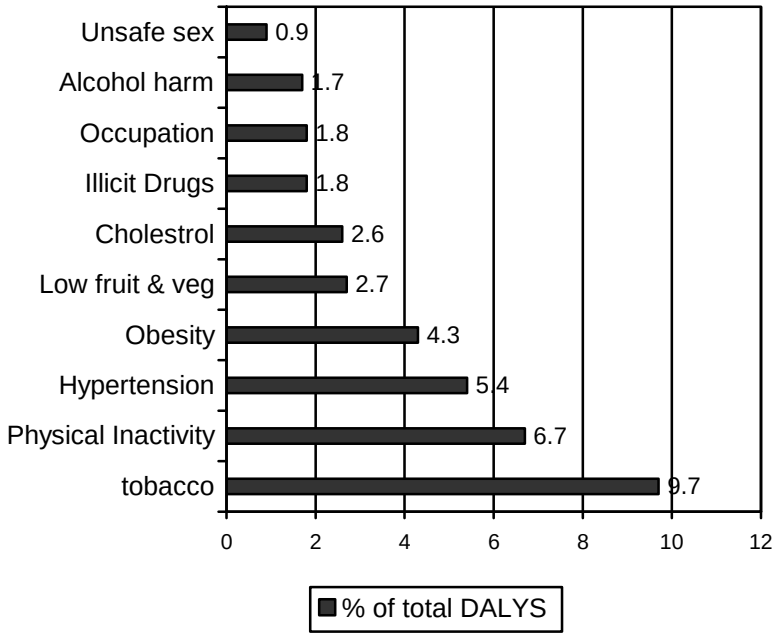
3.6. Benefits of urban green space in relation to physical inactivity

Physical inactivity is an important population health risk factor, equivalent to tobacco use or poor diet in the risk that it poses for ill-health (Stephenson et al. 2000). Physical inactivity contributes to the risk of 6,400 deaths p.a. in Australia from Coronary Heart Disease, colon cancer, and up to 2,200 more deaths due to other conditions, including breast cancer and stroke. These deaths are potentially avoidable if the sedentary and low active population became at least moderately active. The annual direct health care cost attributable to physical inactivity is around $377 million per year (Stephenson et al. 2000).

These estimates indicate that one quarter of deaths occur in people under 70 years of age and that 1,764 life years could be gained for every 1 per cent increase in population moderate activity levels.

Data from the Australian Burden of Disease (BOD) study indicated the relative contribution of physical inactivity as one of the major risk factors for disease and disability. Overall, physical activity ranked second, after tobacco, in terms of contribution to ill-health in Australia (Mathers et al. 2001).

Figure 1. Percentage of total burden attributed to physical activity in Australia – Adapted from the AIHW Burden of Disease and Injury in Australia, 1999



(DALYS – Disability Adjusted Life years)

These social impacts suggest that maintaining access to urban green spaces is critically important as a means of increasing physical activity and promoting individual and community health and wellbeing.

Modifying the environment to include green spaces has the potential of passively encouraging a more physically active lifestyle (Isenberg et al. 2002). These modifications could occur in the design of urban environments, in the workplace and in the home. Access to recreational facilities appears to be related to participation in health programs and can result in gains in fitness and participation in vigorous activity (Isenberg et al. 2002).

3.7. Public parks and social equality

Recent studies show that average life expectancy in the OECD countries correlates closely with the degree of equality. The USA is the richest country in the world, in terms of GDP per capita, but it is also the most unequal in the OECD – and has the shortest life expectancy (Townsend, 2006). A less equal society is more likely to be violent which therefore has an impact on the wellbeing and mental health of the community. The consequences of the widening division between rich and poor are that resentment and social tensions arise.

Low income neighbourhoods of minorities and the poor have historically lived in paved industrialized areas with few public amenities (Pincetl 2003). Therefore, the benefits of urban green space has an important role to play in the social health of communities and making inner-city neighbourhoods more liveable. They offer opportunities for recreation and exercise to at risk and low-income children, youth, and families who might not be able to afford gym membership or exercise elsewhere. They also provide places in low-income neighbourhoods where people can experience a sense of community.

In Los Angeles Anglo-Saxon neighbourhoods have access to more than 18 to 50 times the park space of Afro-American Latino neighbourhoods (Pincetl 2003).

Table 4. Relationship between the amount of park space and ethnic group in Los Angles, USA.

Neighbourhoods dominate ethnic group[1]	Park space (acres/1,000 residents)
Anglo-Saxon	31.8
Afro-American	1.7
Latino	0.6

[1]Neighbourhoods where the ethic group makes up 75% or more of the residents.

The inequitable distribution of urban public parks amongst certain socio-economic and cultural groups has the potential to harm residents and create substantial health care costs due to physical inactivity. There is a need for further research to be conducted into this area from an Australian perspective.

The inequitable distribution of natural vegetation has been noted in a recent study analysing residents' ability to cope with life issues in urban housing projects. The research involved 145 urban public housing residents assigned to buildings with and without nearby green space. Attention functioning and effectiveness in managing major life issues were compared. When trees and greenery were immediately outside their apartments, inner city residents coped better with the demands of living in poverty, felt more hopeful about the future, and managed their most important problems more effectively (Kuo et al. 2001).

There is a correlation between poverty, minority status, obesity, ill health, and neighbourhood factors that discourage exercise, including the absence of parks and recreation facilities. Inner city public housing development could therefore be designed to incorporate green space as a way of reducing the inequalities, poor health and social exclusion of its residents.

3.8. Benefits of urban green space on social cohesion

The findings of an Australian study suggests that groups such as 'friends of parks' that are involved in civic environmentalism not only work to restore the environment, but members experience an increased level of social connectedness and trust through interacting with others in their local community. In the process they experience improved physical and mental health through an increased opportunity for time spent in a natural environment (Townsend et al. 2003).

A study by the Office for the Status of Women (2001) found that residents expressed a fierce protectiveness and appreciation of their parks and gardens. Most considered them to be their own backyard, possible making up for their own lack of residential space.

There is clear evidence that social capital influences and affects health. In considering the health of a population, Baum (Sullivan at al. 2003) highlights the link between the quality of social interaction and the health of populations and suggests that the quality of social relations have a significant influence on their health. Therefore having access to urban green belts has the potential of increasing social cohesion within a community.

An observational study of 59 common outdoor spaces of a large public housing development, found that the more trees and grass present, the more those spaces were used by residents (Sullivan at al. 2003). This created more opportunities for informal social interaction. Compared to residents living near barren spaces, residents closer to green spaces enjoyed more social activities, had more visitors, knew more of their neighbours and had stronger feelings of belonging.

The results from this study of low economic status neighbourhoods could be incorporated into more affluent neighbourhoods as strong social ties are important in both circumstances (Kuo et al. 2001).

This research is important to consider in relation to the concept of 'social capital' which is defined as the resources available to individuals and groups through social connections and social relations with others. Research suggests that differences in social capital may explain differences in mortality within and between different population groups (Sullivan at al. 2003).

Baum reports on a US study which found that, by comparison with 'people who had many social ties, those who were socially isolated were 6.59 times less likely to survive a stroke, 3.22 times more likely to commit suicide and 1.59 times less likely to survive coronary heart disease' (Baum 1999).

Well known research by House et al. reports that death rates are two or three times as high among people with low levels of social integration compared to people with high levels (House et al. 1988).

Creation of urban green spaces could be used as a cost efficient means of facilitating social cohesion within a community.

Research supports the belief that community involvement in neighbourhood parks is linked to an increase in 'social capital'. That is, when people work together toward shared goals, such as working in a community garden or creating a park, they get to know one another and look out for one another.

These benefits, lead to concrete community improvements such as fewer incidents of violent crime; fewer property crimes, including graffiti; reduced juvenile delinquency; higher educational achievement; lower rates of asthma and teen pregnancy; and better response to the community's needs by central governments because they stand on a united front (Sherer 2004). Neighbours then feel part of a community, trust one another, and are willing to intervene when trouble arises.

The Project on Human Development in Chicago Neighbourhoods conducted a $50 million study on the causes of crime, substance abuse, and violence, finding that 'in neighbourhoods where 'social capital' or 'collective worth' was strong, rates of violence were low, regardless of socio demographic status and the amount of disorder' (Townsend et al. 2006).

The research identified in this section clearly suggests that the presence of green space in urban communities provides the opportunity for social capital to flourish.

3.9. The role of urban green space in reducing Juvenile delinquency and Crime related incidents

Increased urbanisation has meant an almost three-fold increase in the number of inner city high rise occupants in Melbourne and Sydney (Pyper 2004). The rapid transition from living in traditional detached homes with private gardens to high density apartment living reduces the amount of contact residents have with the natural environment. This reduction of contact with urban parks and gardens has the potential of increasing the negative affects of living in the inner city such as incidents with crime and juvenile delinquency (Sampson et al. 2001).

In a study of a Chicago public housing development, involving 98 apartment buildings over two years, it was found that apartment buildings surrounded by trees and greenery were significantly safer. Higher levels of greenery reduced total crimes by 52% (Sampson et al. 2001). The research revealed that the greener the surroundings, the fewer the crimes against people and property. It is believed that greenery helps by reducing aggression, since people feel more relaxed and by bringing people together outdoors, which increases surveillance and indicates that a building is cared for by its residents, and that they watch over it and each other.

Tall trees and open, grassy areas with low shrubs and flowers that preserve visibility are recommended as potential crime deterrents. It must be noted that criminals can use dense vegetation like shrubs to conceal their activities and blocks views which can evoke fear and fear of crimes. However, not all greenery blocks views and gardens should be constructed to dispel fear of crime.

In a study of the relationship between the outdoor environment and family violence in an inner city public housing project, involving 145 residents, it was found that families with trees and greenery in their immediate outdoor surroundings had safer domestic environments than families in buildings barren of nature (Townsend et al. 2003). Levels of mental fatigue were also higher in buildings devoid of nature, and aggression accompanied this mental fatigue.

3.10. Benefits of Gardens for the Elderly

There is significant literature that suggests involvement in gardening benefits physical and psychological health in the elderly. A recent study in the UK suggests that chronic

illness and disability are not inevitable consequences of aging and may be alleviated by developing community gardening programs that support older people to live fulfilling lives. The study was undertaken in the Northwest of England where 23% of its population is aged over 60 years. It aimed to examine how communal gardening activities may be beneficial to the health and mental well being of older people (Milligan et. al. 2003).

Three key findings were discovered from the research.

1. Older people experience natural and built landscapes in different ways. While the natural landscape had a positive effect on their mental well being, the experience of the everyday built environment reflected a heightened 'fear of crime' amongst older people. Therefore there was greater importance attached to the home and the domestic garden as a site of relaxation and security.
2. Development of communal gardening activity was seen to contribute to social inclusion of older people in that it promoted the development of their social networks.
3. Communal gardening activity not only allowed participants to gain a sense of achievement, satisfaction and aesthetic pleasure from their involvement with nature, but while successfully nurturing their plants what became evident was members also nurtured those less able members of the group, creating a greater sense of community.

While the above study reveals the benefits of social networks in healthy aging a recent research conducted in Japan revealed the importance of walkable green spaces for senior citizens' longevity in high density urban areas (Takano et al. 2003).

The authors analysed the five year survival of 3,144 people born in 1903, 1908, 1913, or 1918 in Tokyo in 1992. What became apparent was the probability survival of participants increased in accordance with the space for walking near the residence, parks and tree lined streets near the residence, and their preference to continue to live in their current community.
Living in areas with walkable green spaces positively influenced the longevity of urban senior citizens independent of their age, sex, marital status, functional status, and socioeconomic status. The importance of urban green areas for the health of senior citizens should therefore be emphasized in urban planning for the development of densely populated cities.

3.11. Benefits of Green Space for Organised Sport

Organised sport is another use of urban green space that offers the opportunity for community engagement in healthy activities. The importance of sport to humanity is highlighted by the declaration of 2005 as the United Nations Year of Sport and Physical Education. Kofi Annan said 'Sport is a universal language that can bring people together, no matter what their origin, background, religious beliefs or economic status' (www.un.org). In a multicultural country such as Australia, this cannot be discounted.

Illustrating the importance of sport to Australians, some 7 million adults attended at least one sports event during 2001-02, with the most popular watched sports being Australian Rules Football and horse racing (ABS 2007), both events taking place in urban green space. In fact, the first sporting club established in Adelaide in 1847, was by the horse racing fraternity, at what is now known as Victoria Park (www.adelaide-parklands.org).

In 2001, 62.4 per cent of Australian adults or 9.1 million persons participated in physical activities for recreational purposes. About 4.6 million of these people participated in organised sport. The most popular physical recreation activity was walking for exercise (ABS 2007). On average, Australian households spend AU$15.70 per week on sporting activities (ABS 2006).

Each week more than 1.6 million Australian children play organised sport (www.irrigation.org.au). For children, the most popular organised sport was soccer (www.ausport.gov.au).

A major motivating factor for school aged girls to participate in sport was socialising, doing activities with friends and families, and enjoying the sense of being part of a team. In rural areas in particular, sport is seen as a kind of 'community cement' and is associated with reduced antisocial behaviour among young people (www.ausport.gov.au).

The golfing industry is very large in Australia. The value of irrigation in golf courses can be quantified if the irrigation is deemed essential for revenue. A semi private club with an income of AU$800,000 and a water consumption of 100ML, can be quantified as a gross return of AU$8,000 per ML (Connellan 2007). The golfing industry had 1116200 participants in the year 1997-1998 (ABS 1999).

A sports field with an annual usage of 25,000 user hours and a total water consumption of 7.5ML will provide 3,333 user hours per ML (Connellan 2007). A large loss in recreational user hours on sports fields will occur if urban green space is allowed to degrade. Without this green space, much social interaction within the society will be lost, and possibly a general decrease in fitness level and general health and well being.

3.12. Sustainable Transportation

If high quality trail surfaces are provided, linear public open space can encourage walking and cycling as an alternative to motor vehicles, representing a sustainable transport option and encouraging physical activity with its accompanying community health benefits (www.banyule.vic.gov.au).

3.13. The Educational role of parks

Parks provide a largely untapped platform for disseminating environmental education and training programs including access, interpretation, regulation, safety, aesthetics, heritage, flora, fauna, appropriate use and behaviour, current issues, activities, etc. (www.banyule.vic.gov.au).

An example of education in parks is the Museum of Economic Botany in Adelaide Botanic Gardens, which was established in 1881, and claims to still be relevant to critical research and resolution of our current environmental predicament. Sustainability requires environmental reconciliation, a reciprocal relation to plants and other living things. Botanic Gardens traditional mission was to 'change the world ... through transforming public consciousness through intelligence, imagination, wit and whimsy - respectful of its past, engaged with its present, open to our future' (www.environment.sa.gov.au).

4. Economic Benefits

The impacts referred to in the previous section have two broad areas of economic implication. The first being that of economic activity from which the green open space facilitates a commercial, income-generating outcome, such as from festivals and sporting events. The second type of implication is an economic efficiency effect resulting in an increase in net social welfare, typically in the form of reduced costs to society, such as reduced health care costs, reduced pollution, etc. but also impacting on non-priced or non market benefits such as community cohesion, aesthetic values, wildlife habitat, etc.

This section examines some of the commercial implications of urban open space in terms of employment effects, tourism, asset values and associated industries.

4.1. Economic value of sports areas

The most visible impact of drought for many communities in recent years has been reduced availability of turf areas used for organised sports such as football (various codes), cricket, soccer and athletics. The impact has been significant for both rural and urban communities.

In addition to enhancing community health active recreation provides direct benefits which can be expressed in terms of the water used to develop and maintain the sporting areas.

One approach outlined by Connellan (2007) presents the potential return from the input of water to the output or outcome from the irrigated area. The performance of irrigated agricultural enterprises is sometimes expressed in terms of productivity as well as in terms of efficiency of application. In the case of horticultural crops, this measure is relatively straight forward. For example, the water productivity for an orange crop may be 2500 kg per ML and for grapes 3700 kg per ML. This term can then be converted to the Gross Return per ML to provide a measure of the value of irrigation water. Gross returns per ML for grapes may be in the range of $2000 to $3000 per ML (Connellan 2007). The direct economic benefits of sports fields are not as readily determined.

An output from a recreation area is the amount of use provided by the area. A measure of use is the “user hour” which is the product of the number of participants and the hours of use by the participant. A sports field with an annual usage of 25,000 user hours and a total water consumption of 7.5ML will provide 3,333 user hours per ML (Connellan 2007). A large loss in recreational user hours on sports fields will occur if urban green space is allowed to degrade. Without this green space, much social interaction within the society will be lost, and possibly a general decrease in fitness level and general health and well being.

In some states considerable resources are being directed towards assisting sporting organisations and local government in achieving sustainable irrigated sports fields. The Victorian Department of Planning and Community Development, in 2007, allocated in $4.7 million to assist country sports facilities to cope with the impact of drought. Under the *Drought Relief for Community Sport and Recreation Program* 2008 $9.3 million is available to help local communities to develop sustainable approaches to water management. These examples demonstrate an increasing value placed by some governments on these facilities.

The contribution of irrigated green space to society can be gauged by examining the golf industry in Australia. According to a report titled *The PGA Report* prepared by Ernst & Young, in August 2006, the value of the Australian golf economy was estimated at $2.71 billion. It also estimates that 1.25 million people play golf and 23,000 people are directly employed within the golf industry. Water is a critical input to golf. The employment rate, a key social indicator, derived from golf is significant at approximately 200 employees per gigalitre of irrigation water used

The value of irrigation in golf courses can be quantified, in water consumption terms, if the irrigation is deemed essential for revenue. A semi private club with an income of AU$800,000 and a water consumption of 100ML, can be quantified as a gross return of AU$8,000 per ML (Connellan 2007).

As noted by Tyrvaeinen and Vaeaenaenen (1998) green spaces have important amenity values which contribute to the quality of urban life. Any deconstruction of green space causes negative externalities, e.g. the loss of non-priced benefits. Amenity values should be systematically assessed and measured in monetary terms to assess the profitability of green space benefits and to economically assess different land use options.

4.2. Increased Economic activity related to urban green spaces

In Australia there were 52,164 separate recreational parks and gardens at the end of June 1997 which covered 3,386,354ha and included national parks, employing 16,646 people at a cost of AU$470.2 million dollars in wages (ABS 1998). This is a significant amount of money and employment in Australia's economy and needs to be recognised when decisions need to be made regarding water application to public open green space.

Urban planners and urban park advocates both agree that open urban spaces are important and have the ability to enhance and characterize an image of a city, e.g. Central Park in New York, Royal Parks in London, Red Square in Moscow and the Royal Botanical Gardens in Sydney (Tajima 2003). These urban amenities matter even more as cities compete for skilled workers. More cities are beginning to recognize the importance of urban green spaces to attract skilled workers and firms (Glaeser et al. 2001).

A survey conducted in Melbourne found that 90% of human resource managers felt that city parks and gardens improved staff morale in their businesses and 55% of the respondents used parks and city gardens for employee events. The economic benefits may relate to a reduction in work related stress, absenteeism and increased worker productivity. The importance of vegetation has been recognised in Melbourne with the city of Melbourne valuing their green space which includes 55000 mature trees at AU$500 million dollars.

The tourism sector is also positively affected by the maintenance of public parks and gardens. A study conducted in 1998 found that Melbourne's gardens and parks were a valuable economic and social asset to the region. They contributed $15 million in export sales to the metropolitan economy, $1.25 million from organized bus tours, $2.4 million form the Melbourne International Flower Show and $11.6 million from parks related to the Moomba festival (Maller et al. 2002).

Melbourne's tourism sector benefits substantially from public parks and gardens and is reflected in the survey conducted of related businesses revealing that:

- 92% felt the parks & gardens were important in attracting visitors
- 83% felt that tourism would be affected by a decline in city parks
- 41% felt that businesses would be affected by a decline in city parks (Maller et al. 2002).

4.3. The Value of Green: Increasing Property Value and Tax Revenue

People are willing to pay a larger amount for property located close to parks, open space and greenery. Recent surveys discovered that 50% of respondents would be willing to pay 10% more for a house near a park and 57% said that if they were in the market for a home they would they would select neighbourhoods close to parks and open space (Crompton 2000).

The area around Homebush Bay had been used as an ammunitions dump, a slaughterhouse, and a dumping ground for toxic industrial chemicals. The transformation of the site for the 2000 Olympics was a major success of the Games and also helped improve property values in the area immediately around the park (Dann 2004).

Residential properties with well maintained gardens and properties in close proximity to green public spaces are valued approximately 10% higher (Real Estate Industry Australia 2007).

The increased value of property neighbouring parks may be of benefit to the local government as the higher value of these homes means increased property taxes, which in certain circumstances may be sufficient enough to finance the purchase and development of the park (Crompton 2000). Australian local governments collected $8,920 million in property taxes in 2005/06. It is therefore to their advantage to maintain public parks and urban green spaces as property taxes are the only form of taxation revenue collected by local government (Dann 2004).

Maintaining public parks, private gardens and green sporting fields benefits the community socially, economically and environmentally; it provides an advantage to property owners in increasing value of homes and of economic benefit to local governments as increased tax revenue (Real Estate Industry Australia 2007).

4.4. Design as a Sustainable Economic Development

Much of Australia's green space is earmarked for urban development but there is little known about the risks to human health associated with its loss. If 'green space' does have a positive impact on human health as has been suggested in the literature review, could design be utilized to revive the urban landscape for the positive benefit of public health? (Pyper 2004).

For example, further research into the physical properties of urban parks, gardens and sports fields that offer maximum health benefits may offer developers some basic design principles. Also of consideration are older suburbs that may have the potential of being 'retro-fitted' with green spaces to improve their health benefits. This could have a significant impact on preventative health and the economic drain of an ageing society (Pyper 2004).

The proximity of urban green spaces to where people live is not the only factor that influences whether it will be utilised by the community. Basic features such as

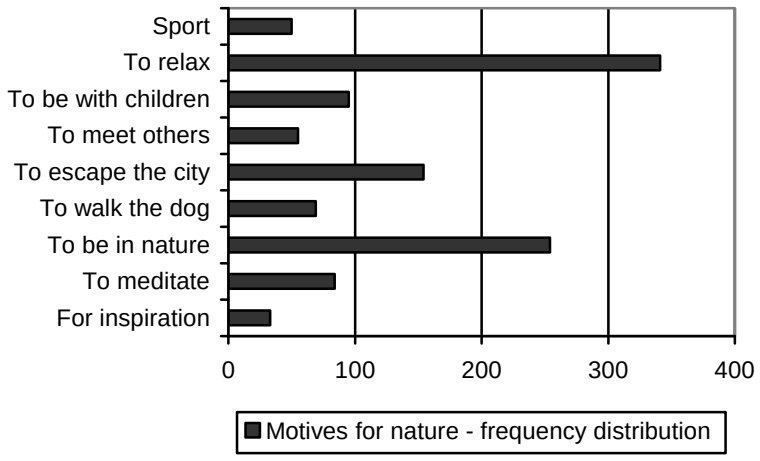
adequate lighting, availability of toilets and drinking water, park layout and maintenance all affect how much the park will be used (Frumkin 2003).

The rise in interest in principles of universal design, "the design of products and environments to be useable by all people, to the greatest extent possible, without the need for adaptation or specialised design" (Centre for Universal Design, NC State University, 1997) offers a case in point. A current research partnership between Penrith City Council and University of Western Sydney is investigating the role of universal design in overcoming barriers and enhancing accessibility in relation to open public space in Penrith city. The aim of the project is to synthesise findings into a strategic planning tool to be utilized by council in planning open recreational spaces (Penrith City Council 2007).

Revealing the 'motivation' behind people visiting urban green spaces will also allow developers to be better informed about the needs of users in creating public parks and other green spaces. A recent study in the Netherlands discovered the main motivation for people using public parks was a 'need to relax', an important motivating force in a rapidly urbanizing society (Cheisura 2004). A frequency analysis of people's motives to visit nature shows that 'to relax' accounted for 73% of the answers to the question 'Why do you come to public parks' (Figure 2).

There is a need for this type of research to be conducted from an Australian perspective in urban areas to determine people's motives in visiting natural areas, the various activities they carry out and the needs they expect to be fulfilled. This information may then help decision makers to plan strategies in harmony with public needs and expectations. This research would also be beneficial for urban park designers as it would reveal the physical attributes of urban public parks in fulfilling the needs of the user.

Figure 2. A frequency analysis of people's motives to visit nature - Netherlands.



It should also be noted that strategic and sustainable design innovation may play a role in addressing the perceived discrepancy between the water needs in the urban context and the availability of water to meet those needs.

4.5. Industry

Some indicative figures regarding the size and value of the open green space industry in Australia are reported below.

- In June 1997, there were 52,164 separate recreational parks and gardens in Australia which covered 3,386,354 hectares and including national parks, employed 16,646 people paying $470.2 million dollars in wages (ABS 1998).

- There are approximately 1.1 million hectares of turf grass in Australia that is used in a range of businesses and activities. The turf grass industry alone employs around 80,000 people (Aldous 2005).

- Power (2005) stated that in Brisbane, sports turf infrastructure development was valued at $62.5 million per annum.

5. Conclusion: Key Findings

This research paper has revealed that water restrictions and reduced urban irrigation has contributed to a decline in urban green space and may have a significant impact not only on the environment but also the public health of Australian society.

The review of the literature on the benefits of urban green space has highlighted the environmental benefits of maintaining urban green space. Urban green space impacts significantly on the micro-climate of a region by modifying extremes of climate, improving the hydrological cycle, improving plant health and biodiversity and adding to soil stability.

Maintaining healthy urban trees during conditions of drought has been shown to be a potential energy consumption and cost saving through summer shading of solar radiation. Alternative means of creating green space such as 'green space on urban roofs' have also proven to positively impact on the environment through improved air quality and reduction of air borne pollutants.

The expanding urban sprawl in Australian cities has put at risk many of the native species of flora and fauna. By maintaining and expanding current green space, not only is the biodiversity of the flora preserved but also the biodiversity and population size of faunal species living in the urban environment.

The decline of 'urban green space' has the potential to negatively impact the public health of the Australian population. In particular the report highlights the increase in physical and mental health problems in the Australian population and the unequivocal benefits of urban green spaces in alleviating the symptoms associated with these health problems. Organisations such as The Royal Children's Hospital (Vic), Westmead Children's hospital (NSW), The Royal Talbot Rehabilitation Centre and Jesuit Social Services have successfully run either horticulture programs or implemented 'tranquillity gardens' as a means to treat patients with a broad range of problems from alcohol rehabilitation, depression, surgery recovery, brain injury and symptoms associated with an increasing aging population. These programs are evidence of the healing benefits of 'green space' and highlight the potential economic benefits to the Australian health care system.

Urban irrigation may also have a significant role to play in maintaining a sense of social equity in Australia as the divide between 'rich and poor' widens. There has been evidence presented in the above paper that suggests that the provision of green irrigated spaces in low income areas has a positive impact on the rate of domestic violence, juvenile delinquency and crime. Green space therefore not only provides an aesthetically pleasing environment for residents where they can exercise, 'relax' and maintain a sense of community but also reduces the costs associated with delinquent behaviour and property damage.

There has been a significant lack of Australian data on environmental and social benefits of urban irrigation. In sum there is a need for research from an Australian perspective on:

- the energy saving potential of utilising green spaces in urban environments;

- the potential harm associated with the inequitable distribution of urban green space amongst certain socio-economic and cultural groups and potential health care costs;
- the extent to which urban green space enhances physical and psychological health across residential, educational, workplace, community and social settings;
- the role and potential of design innovation in enhancing existing environmental, social and economic benefits of urban green space and generating new benefits.

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- NOTES -

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