THE EVIDENCE BASE FOR LINKAGES BETWEEN GREEN INFRASTRUCTURE, PUBLIC HEALTH AND ECONOMIC BENEFIT

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1. EXECUTIVE SUMMARY

This paper reviews the relevant national and international peer-reviewed and grey literature regarding the relationship between green infrastructure, human health outcomes and economic health benefits. The review reveals that there is a substantial body of evidence that shows green infrastructure is significantly beneficial for an individual's physical, mental and social health. However, despite this large body of evidence, there is still a need for more research to refine and enhance our understanding of this relationship. Further, the review shows that although there is strong physical and environmental evidence that demonstrates the effectiveness of green infrastructure as a climate change adaption strategy, the linkage between these benefits and improved health outcomes remains to be quantified. Additionally, the review identifies a few studies from the international grey literature that indicate the potential, substantial economic health value of green infrastructure. However, these studies use different methodological frameworks to do so, making it difficult to systematically evaluate and compare the monetary estimates that these studies have estimated. The explicit lack of peer-reviewed Australian studies specifically evaluating the economic health value of domestic green infrastructure projects highlights the need to for such work to be undertaken. Overall, although there is a large body of evidence that shows that green infrastructure is beneficial for human health, there still remain significant research gaps regarding the relationship between green infrastructure, human health outcomes, and climate change, and the domestic economic health value of green infrastructure.

2. INTRODUCTION AND PURPOSE

The purpose of this paper is to collate and review the relevant national and international literature (peer-reviewed and grey) on the linkages between green infrastructure, health and (to the extent possible) economic issues. This paper provides the academic backdrop to the user-friendly, brief and case-study based Advocacy Paper, which will clearly articulate the health benefits of green infrastructure in a manner that can be applied at a local government level within VASP project partner councils. It is envisaged that elements of the Advocacy Paper will also be transferable to different local council contexts across Australia, and potentially other international settings.

3. DEFINING GREEN INFRASTRUCTURE

Green infrastructure is the network of natural and semi-natural landscapes, features and green spaces in rural and urban, and terrestrial, freshwater, coastal and marine areas (Naumann et al. 2011). This network provides the foundation for the financial, socio-cultural and environmental functionality of cities and towns, contributing to the conservation of biodiversity, and benefiting human populations by maintaining and enhancing ecosystem services (Naumann et al. 2011).

Green infrastructure exists in a variety of physical forms. These forms include, public parks and gardens, greenways, street verges and open space pockets in residential and other streets, sports and recreational facilities, private and semi private gardens, green roofs and walls, squares and plazas, natural green space, utility areas, and agricultural and other productive land (Ely and Pitman, 2014).

For the purpose of this paper, green infrastructure has been defined to mostly include green and natural spaces. This is due to the scarcity of peer-reviewed research evaluating the health benefits of more recent green infrastructure developments, such as green roofs and walls.

4. HEALTH BENEFITS OF GREEN INFRASTRUCTURE – THE EVIDENCE BASE

There is a considerable amount of literature that examines the association between green spaces and human health. Overall, the weight of the evidence leans towards supporting the existence of a significant association between viewing and experiencing urban green space, and physical, mental and social well-being. The following section outlines the health benefits of green infrastructure in relation to these three elements of health - physical, mental and social.

4.1. GREEN INFRASTRUCTURE AND PHYSICAL HEALTH

4.1.1 The Health and Economic Burden of Physical Activity

The World Health Organization reports that around 31% of adults aged 15 and over are not sufficiently active, and that 3.2 million deaths each year are attributed to insufficient physical activity (WHO, 2015a). The prevalence of insufficient exercise is highest in the WHO Region of the Americas and the Eastern Mediterranean (WHO, 2015a). Further, physical inactivity has been identified as the fourth leading risk factor for global deaths (6% of deaths) (WHO, 2015b). It is estimated to be the main cause for approximately 21-25% of breast and colon cancers, 27% of diabetes, and 30% of ischaemic heart disease burden (WHO, 2015b). In 2008, Australian healthcare costs associated with lack of exercise were estimated to be $719 million (Medibank Private, 2008).

4.1.2 The Association between Green Infrastructure and Physical Activity

There is a considerable amount of evidence that shows that the built environment of an individual’s neighbourhood plays a significant role in facilitating physical activity and influencing the amount of physical activity that an individual engages in. Most research suggests that the provision of attractive, open green spaces, such as parks, or recreational spaces, provide important places for individuals to engage in physical activity (Almanza et al. 2012, Cohen et al. 2007, Coombes et al. 2010, Pearce and Maddison, 2011). Cohen et al. (2007) reported that, of its study participants, the local park was the most common place that they engaged in physical activity. Further, both park use and an individual’s level of physical activity was predicted by the proximity of their residence to the park. This finding of proximity was also significant in Coombes et al. (2010). This study examined the association between green space, frequency of the use of green space, and physical activity. The authors found that those participants who lived further away from urban green and recreational spaces were less likely to engage in physical activity than those who lived in nearby areas. Further, it has also be found that adults who reside in the highest quartile urban green space are more likely to participate in leisure-time physical activity than those living in areas with the lowest quartile of urban green space (McMorris et al. 2015).

The provision of green space to facilitate physical activity is particularly important for children, adolescents, and the elderly. In examining the relationship between exposure to green space and physical activity behaviour of children in 'smart growth' and conventionally designed communities in the US, Almanza et al. (2012) found that children who experience more than 20 minutes of daily exposure to increased levels of green space engaged in approximately 5 times the daily rate of moderate to vigorous physical activity than those children with lower levels of daily exposure to green spaces. In addition, Janssen and Rosu (2015) found that children in grade 6 to 8 residing in urban areas in Canada in neighbourhoods with higher levels of green space reported higher levels of physical activity. The authors reported that for each additional 5% increase in the proportion of neighbourhood land covered by treed areas, there was a corresponding 5% increase in the odds of increasing free-time physical activity outside of school hours and grounds (Janssen and Rosu, 2015). Further, in conducting a review of the literature examining the physical environment and physical activity levels among those aged 65 years, Moran et al. (2014) concluded that in order to promote physical activity amongst this age group, surrounding physical environments should provide, (i) high quality pedestrian infrastructure, (ii) be safe from crime and traffic, (iii) provide easy access to green space for exercise opportunities, (iv) be aesthetically appealing, and (v) provide pleasant environmental conditions.

In recognising the importance of the design of the urban built environment in facilitating physical activity, the Australian Urban Research Infrastructure Network (AURIN) created the Walkability Case-Study Project. The Project established the AURIN Walkability Tool for researchers, planners and urban designers to identify those characteristics of the physical environment that contribute to walkable neighbourhoods and promote health, and thus improve the walkability of a particular urban area (AURIN, 2015). Further to this, Giles-Corti et al. (2014) have proposed the development of a Transport Walkability Index for Metropolitan Melbourne, Australia.

However, despite the fact that the majority of evidence points towards the existence of a significant association between increased levels of green space and increased levels of physical activity, a small number of studies have found no association (Maas et al. 2008, Witten et al. 2008, Foster et al. 2009, Hillsdon et al. 2006). For example, after controlling for socioeconomic status, neighbourhood-level deprivation, and urban/rural status, Witten et al. (2008) found that neighbourhood access to parks was not associated with sedentary behaviour or levels of physical activity in New Zealand. In addition, Ord et al. (2013) found that the availability of green space in a neighbourhood was not associated with levels of physical activity in Scotland.

4.1.3 The Association between Green Infrastructure and Obesity

Some studies have shown that there is an association between higher levels of green space and lower levels of obesity (Bell et al. 2008, Neilson and Hansen, 2007). In examining whether neighbourhood greenness and residential density are independently associated with 2-year changes in the Body Mass Index (BMI) of children and adolescents aged 3 – 16 years, Bell et al. (2008) found that higher levels of green space were significantly associated with lower BMI after a two year follow-up period. In other words, higher levels of greenness were associated with lower odds of children and adolescents increasing their BMI over the two year study period (OR = 0.87 95% CI: 0.79, 0.97). Nielsen and Hansen (2007) reported that access to a garden or green space is associated with a lower risk of obesity in Danish adults. However, other studies have found no or a weak association (Potwarka et al. 2008; Potestio et al. 2009).

4.1.4. The Association between Green Space and Morbidity

Few studies have assessed the association between access to, and levels of green space and cause-specific morbidity. Maas et al. (2009) examined the association between cause-specific diseases and the percentage of green space within 1km and 3km radius around neighbourhoods in the Netherlands. The authors found that having 10% more green space than average within an individual's neighbourhood was protective of particular diseases including chronic heart disease, upper respiratory tract infection, asthma, chronic obstructive pulmonary disease, migraine and serve headaches, vertigo, acute urinary tract infection and diabetes mellitus. However, in general, this significant association was only found for levels of green space within the 1km radius. In examining the association between access to, and use of, green spaces and risk of cardiovascular mortality and morbidity in the city of Kaunas in Lithuania, Tamosiunas et al. (2014) found that the prevalence of cardiovascular risk factors and the prevalence of diabetes mellitus were significantly lower in individuals who were regular park users.

4.1.5 The Association between Green Infrastructure and Birth Outcomes

There is some evidence of an association between green space and birth outcomes (Dadvand et al. 2012, Laurent et al. 2013, Hystad et al. 2014, Grazuleviciene et al. 2015). In examining whether surrounding levels of greens space or distance to city parks affects birth outcomes, Grazuleviciene et al. (2015) found that an increase in distance to a city park was associated with an increased risk of preterm birth and a decrease of gestational age. The authors also found that there was a statistically significant association between low levels of surrounding green space and term low birth weight (Grazuleviciene et al. 2015). The authors concluded that higher levels of surrounding greenness and closeness to a city park have beneficial effects on birth outcomes. Further, consistent with this finding, Hystad et al. (2014) found that an interquartile increase in greenness (0.1 in residential NDVI) was significantly associated with higher term birth weight (20.6g; 95% CI: 16.5, 24.7). The findings of Dadvand et al. (2012) were suggestive of a beneficial impact of surrounding high levels of greenness on measures of foetal growth, but not of pregnancy length.

However, conflicting evidence does exist, where no association has been found between foetal growth and the presence of green spaces within an individual's neighbourhood (Markevych et al. 2014).

4.1.6 The Association Between Green Infrastructure and Mortality

Few studies have examined the association between neighbourhood levels of green infrastructure and mortality risk. Mixed results have been found, with some studies finding evidence of an association (Takano et al. 2002; Hu et al. 2008; Villeneuve et al. 2012) and others not finding any such evidence (Richardson et al. 2010a; Richardson et al. 2012).

In examining the association between accessible and proximate green public spaces and the longevity of senior citizens in two cities in the Tokyo metropolitan area, Takano et al. (2002) found that the probability of a five year survival of the senior citizens increased with accessible green space for taking a stroll near their place of residence, and parks and tree lined streets near their place of residence. Indeed, after controlling for the potential confounding effects of age, sex, martial status and socioeconomic status, the presence of walkable green streets and spaces near the elderly residence showed significant predictive value for the survival of the senior citizens over the five years (Tankano et al. 2002). Further, in conducting a longitudinal study, Villeneue et al (2012) found that increased levels of green space were associated with reduced non-accidental mortality (RR = 0.95, 95% CI = 0.94-0.96). Reductions in mortality were observed with increased residential green space for each underlying cause of death that was assessed, with the strongest association found for respiratory mortality (RR = 0.91, 95% CI = 0.89-0.93). There is some evidence to suggest that the association between mortality and green space might differ in accordance with gender (Richardson et al. 2010b). Indeed, Richardson et al. (2010b) found a significant association between higher levels of green space and decreased risk of cardiovascular and respiratory death for males, but not for females.

In direct contrast to these studies, Richardson et al. (2012) found that after controlling for the potential confounders of income, ethnic composition, air pollution, and automobile dependence, there was no association between levels of greenness and mortality from heart disease, diabetes, lung cancer or automobile accidents in the United States. Further, no significant association between useable or total green space and mortality was found in New Zealand (Richardson et al. 2010a). The findings of these two studies are consistent with Bixby et al. (2015), who found that after adjusting for the confounders of age, income deprivation, and air pollution, the risk of death from all causes, and cause-specific deaths, for both genders aged 15-64 did not differ between the greenest and the least greenest cities in the UK.

4.2. GREEN INFRASTRUCTURE AND MENTAL HEALTH

4.2.1. The Health and Economic Burden of Mental Illness

Mental health is an integral part of human health and well-being. The WHO Mental Health Action Plan (2013-2020) reports that mental, neurological and substance use disorders account for 13%

of the total global burden of disease (WHO, 2013). In 2010, mental and substance use disorders accounted for 183.9 million Disability Adjusted Life Years (DALYs) (95% UI 153.5 million to 216.7 million) and 7.4% of all DALYs worldwide (95% UI 6.2% to 8.6% (Whiteford et al. 2013). Further, mental and substance use disorders were the leading cause of Years Lost due to Disability (YLDs) worldwide (Whiteford et al. 2013). The global economic burden of mental disorders is profound. In 2010, it was estimated that the global cost of mental disorders was US$2.5 trillion, and this cost is projected to increase to US$6.0 trillion by 2030 (WEF, 2011). High-income countries bear around 65% of this economic burden, and it is anticipated that is burden will be similar during the next two decades (WEF, 2011).

In the domestic context, mental disorders account for 14.2% of the national health burden, equating to 374,541 DALYs (Mental Health Council of Australia, 2008). The 2007 National Survey of Mental Health and Wellbeing reported that 45.5% of the total population would experience a mental health disorder at some point in their lifetime, and that 1 in 5 of the population aged between 16-85 years experienced a mental disorder within the previous twelve months (ABS, 2008). Between 1992-1993 and 2010-2011, the total federal government expenditure on mental health services increased 179%, with the federal government spending $4.2 billion more of public funds on mental health services in 2010-2011 than in 1992-1993 (Department of Health and Aging, 2013). Indeed, it is estimated that each year approximately $28.6 billion is spent supporting those individuals with a mental disorder (Medibank Private, 2013).

4.2.2 The Association between Green Infrastructure and Stress

There is a well-established association between viewing, or experiencing, natural environments and lower levels of self-reported stress and improved measures of physiological stress (Hansmann et al. 2007, Thompson et al. 2012, Roe et al. 2013). This empirical evidence is strongly supported by a widely accepted theory, known as the stress reduction theory (Ulrich et al. 1991). This theory advocates that viewing natural elements, such as trees and green spaces, or experiencing the natural environment, activates our parasympathetic nervous system to reduce stress and arousal levels (Ulrich et al. 1991).

Further to this theoretical framework, Thompson et al. (2012) has identified that there are three potential behavioural mechanisms that may operate synergistically to reduce an individual’s stress levels when viewing or experiencing a natural environment. First, as part of experiencing a natural environment, it is often common for individuals to engage in some form of physical activity, such as going for a morning run around the local park. The positive effects of physical activity on stress reduction and mood enhancement are well known (Thompson et al. 2012). Second, natural environments, particularly urban green spaces, provide the opportunity for positive social interaction and contact, where individuals may arrange to go to a park or recreational space together, or arrange to meet there. The ability of social interaction to enhance an individual’s mood is well known (Thompson et al. 2012). Third, natural environments are frequently sought out by individuals to relax and recover from demanding situations and tasks (Thompson et al. 2012).

Much of the research that has examined the relationship between natural environments and stress has shown that the viewing of a forest, or a forest experience, is significantly associated with lower levels of perceived stress, improved measures of physiological stress and enhanced mood, feelings and emotions (Annerstedt et al. 2010, Park et al. 2010, Shin et al. 2011, Hansmann et al. 2007; Tsunetsugu et al. 2013). Park et al. (2010) reported that experiencing a forest area promoted lower concentrations of cortisol, lower pulse rage, lower blood pressure, greater parasympathetic nerve activity, and lower sympathetic nerve activity than urban environments in Japan. Hansmann et al. (2007) found that regular visits to an urban forest and city park in Zurich, Switzerland resulted in significant decreases in headaches and self-reported levels of stress, and significant increases in overall well-being. There is some evidence to suggest that the magnitude of this association may differ according to the distance to the forest (Annerstedt et al. 2010) and the length of time that was spent in the forest (Annerstedt et al. 2010; Hansmann et al. 2007).

More recently, there has been a focus within the literature on using objective measures of physiological stress, rather than using self-reported measures of an individual's stress levels (Thompson et al. 2012). These recent studies have shown that viewing or experiencing green space reduces physiological measures of stress including blood pressure (Hartig et al. 2003), heart rate (Song et al. 2014) and salivary cortisol (Roe et al. 2013). Aspinall et al. (2015) investigated the use of mobile EEG as a method to record and assess the emotional experience of a group of walkers through three different types of urban environments in Edinburgh, UK. These three environments included, urban shopping street, path through a green space, and a street in the CBD. The results showed evidence of lower frustration, engagement and arousal, and higher mediation when moving through the green space, and levels of higher engagement when moving out of it. However, some studies have failed to show any physiological differences in blood pressure and heart rate (Ottosson and Grahan, 2005).

Some studies have shown that green space may indirectly reduce stress levels by serving as a buffer against the adverse health impacts of stressful life events (Ottosson and Grahn, 2008, van de Berg et al. 2010). Ottosson and Grahn (2008) found that the mental health of those individuals who experience nature regularly is less affected by a personal crisis than those who have few such experiences. Van de Berg et al. (2010) showed that the number of health complaints and overall perceived general health by those who experienced stressful life events were moderated by the amount of green space that was within a 3km radius of their homes. In other words, participants that had a high amount of green space within a 3km radius were less affected by personal stressful life events than those that had a low amount of green space within the 3km radius (van de Berg et al. 2010).

There is evidence to suggest that viewing natural elements in the workplace can improve the cognitive function of employees, reduce their stress levels, and enhance their overall work productivity (Kaplan, 1993, Chang and Chen, 2005, Shin, 2007, Lee et al. 2015a, Lee et al. 2015b).

Lee et al. (2015)'s most recent research showed micro-breaks spent viewing a city scene with a flowering meadow green roof improved the attention span of the study participants.

Further, there is some evidence to suggest that those individuals living in greener neighbourhoods have a lower risk of short sleep (Astell-Burt et al. 2013).

4.2.3 The Association Between Green Infrastructure, Depression & Anxiety

Fewer studies have investigated the association between green infrastructure and specific mental disorders including depression and anxiety. Studies have found that exposure to green space is associated with reduced depressive symptoms, enhancing cognitive function of those with depression. For example, in examining whether walking through and interacting with nature improves short-term memory performance and mood with major depressive disorder (MDD), Berman et al. (2012) found that, in comparison to the urban walk, participants exhibited significant increases in memory function after the nature walk and increases in mood were observed. Further, Cohen-Cline et al. (2015) reported that greater access to residential green space is associated with decreased levels of self-reported depression symptoms, but reported that the results provided less evidence for effects of stress or anxiety. Bratman et al. (2015) found that walking through a natural setting, compared to an urban setting, resulted in affective benefits, such as decreased anxiety, and cognitive benefits, such as increased working memory performance. However, in contrast to these studies, Miles et al. (2011) found no significant association between green space levels and depressive symptoms for residents of Miami, Florida.

The distance from green space appears to be important in examining the association between green space and symptoms of mental disorders. For example, Reklaitiene et al. (2014) found that women living greater than 300m from a green space and who used the park space for more than 4 hours per week showed higher odds (1.11-3.3) and 1.68 (0.81-3.48) of depressive symptoms, and poor and very poor perceived general health, as compared to those who used the park for less than 4 hours per week and their residential proximity was greater than 300m. Interestingly, a significant association between green space and depressive symptoms was only found for women. Further, in examining the association between proximity to urban parks and psychological distress in Los Angeles, US, it has been found that mental health is significantly related to residential distance from parks (Sturm and Cohen, 2014). This study revealed that the highest MHI-5 scores were among those participants with a rather short walking distance from the park (400m), and these scores decreased significantly with increasing distance. These findings are consistent with those of Nutsford et al. (2012) who reported that decreased distance to attractive, accessible green space, and increased proportion of green space was associated with decreased treatment counts for anxiety and mood disorders in urban environments in Auckland, New Zealand.

Interestingly, Beyer et al. (2014) reported that the assessed effect of green space reducing depressive and anxious symptoms is similar to the effect of other well-known risk factors for depression, anxiety and stress. For example, results of this study indicated that the difference in depressive symptoms between an individual that lives within an area with no tree canopy and an area with 100% tree canopy cover is larger than the difference in symptoms associated with an individual who is uninsured compared to an individual with private health insurance (Beyer et al. 2014).

Beyer et al. (2014) also highlighted that those individuals from low socioeconomic backgrounds and no private health insurance had higher levels of anxiety, stress and depression. As a result of this, the authors advocated that low socioeconomic populations could benefit from increased exposure to green space and infrastructure (Beyer et al. 2014). In support of this, Mitchell et al. (2015) also found that socioeconomic inequalities in mental health outcomes were lower amongst those urban dwellers that indicated they had rather good access to recreational and green areas, in comparison to those study participants that reported they had difficultly with access to these spaces within their neighbourhood (Mitchell et al. 2015).

4.2.4 The Association between Green Infrastructure, Emotional & Behavioural problems

Several studies have reported an association between exposure to nature and green space and alleviated symptoms of behavioural problem and emotion problems in children, in particular, attention deficit hyperactivity disorder (ADHD). For example, in examining the effect of exposure to nature on cognition in children aged 7 to 12 years with ADHD, Faber-Taylor and Kuo (2009) found that those children who were assigned to walk through the park reported significantly improved concentration than those children that undertook the downtown walk (urban setting) or the neighbourhood walk. Further, Amoly et al. (2014) investigated the association between exposure to green and blue spaces (beaches) and indicators of behavioural development and symptoms of ADHD in school children in Barcelona, Spain. The authors found statistically significant inverse associations between green space playing time and total difficulties (using the Strengths and Difficulties Questionnaire – SDQ); that is, an increase in green space playing time was significantly associated with SDQ total difficulties (Amoly et al. 2014). In addition, Kuo and Faber-Taylor (2004) found that exposure to natural settings during after-school and weekend activities can reduce the symptoms of ADHD in children.

Kaplan (1974) reported that engagement in a wilderness survival program increased confidence and self-esteem of children aged 15-17 years in the US. Further, in determining educator's perceptions about the benefits of contact with nature for children's mental, emotional and social health, Maller (2009) reported that hands-on contact with nature, as facilitated by curriculum-based nature activities in schools is perceived by educators to improve self-esteem, engagement with school and a sense of empowerment. Indeed, different forms of interacting with nature, or activities are perceived to have different outcomes.

4.2.5. Potential Synergistic Benefits of Physical Activity in Green Surrounds

Several studies have revealed that separate, independent associations exist between green space and physical health outcomes, and green space and mental health outcomes. However, few studies have explored whether there is a synergistic benefit in engaging in physical activities and being exposed to nature at the same time (that is, 'green exercise'). Pretty et al (2005) examined this research question, and found that those participants exposed to rural and urban pleasant scenes whilst exercising on a treadmill had significantly higher self-reported levels of self-esteem and positive mood.

4.2.6 The Association between Green Infrastructure and Recovery from Illness

Green infrastructure is associated with improved recovery from illness. A small number of studies have reported that viewing, or being exposed to, green space assists in patient recovery from illness. For example, Nakau et al. (2013) found that urban green space improved quality of life and reduced cancer-associated fatigue in cancer patients. Further, after assigning 23 surgical patients to hospital rooms over looking green space and gardens, Ulrich (1984) reported that these patients had shorter post-operative hospital stays, received fewer negative evaluative comments in nurses notes, and took fewer potent analgesics than those patients that were recovering in rooms with windows overlooking a brick wall of a neighbouring building. There is also some evidence to suggest that green and natural environments have positive effects for those elderly patients with Alzheimer's and dementia (Graham Cochrane, 2010).

4.2.7 Longitudinal Studies Examining the Association Between Green Infrastructure and Mental Health

Most of the studies that examine the association between green space and mental health outcomes use a cross-sectional study design. As a result of this, inferences regarding causality are difficult to make. A few studies have attempted to use more robust study designs to overcome this limitation. For example, Alcock et al. (2014), in adopting a longitudinal study design, sought to examine the effect that home relocation to an urban area with high levels of green space and low levels of green space had on an individual's mental health in England. Individuals that relocated to urban areas with high levels of green space had significantly better mental health outcomes in all three years after relocating (Alcock et al. 2014). In contrast, individuals who moved to less green areas showed significantly worse mental health in the year preceding the move, but returned to baseline in the post move years (Alcock et al. 2014). Further, White et al. (2013) used data from an 18 year panel survey in England to compare self-reported psychological health of the same individuals at different time intervals, comparing their mental health status at different locations to which they moved. The authors found that individuals are happier when they are living in urban areas with increased amounts of green space. Indeed, when compared to when they lived in areas with lower green space, they showed significantly lower mental distress and significantly higher overall-wellbeing (White et al. 2013). There is also some emerging evidence to suggest that the relationship between urban green space and mental can vary throughout the lifetime of an individual, highlighting the need for longitudinal studies in this area (Astell-Burt et al. 2014).

4.3 GREEN INFRASTRUCTURE AND SOCIAL HEALTH

It is widely acknowledged that supportive, positive social interactions and relationships are critical in facilitating the healthy functioning of communities (Coley et al. 1997). In exploring the causes of positive social functioning and cohesion, the literature has revealed that the design of an individual's physical environment can influence social behaviour and social interactions (Coley et al. 1997; Baum & Palmer, 2002). Further, access to community services and amenities can influence social capital and social cohesion (Altschuler et al. 2004). As Frumkin (2002) notes, most social commentators have attributed urban living to a 'sense of social isolation and loneliness' (p.208). It is suggest that this may due to the fact that increased levels of urbanisation are often associated with decreased levels of green space (Frumkin, 2002; Uzzel et al. 2002; Kingsley and Townsend, 2006).

Community gardens are an important example of green infrastructure by providing opportunities for enhancing social capital, facilitating social networks, and as a result, improving the overall social health of a community. For example, in examining the extent to which a local community garden (the 'Dig In' Community Garden Program) provides opportunities for enhancing social capital in Melbourne, Australia, Kingsley and Townsend (2006) found that the program produced numerous benefits for surrounding residents. These benefits included increased social cohesion (this involves the sharing of values enabling identification of common aims and the sharing of codes of behaviour governing relationships), increased social support (having people to turn to in times of crisis) and social connections (the development of social bonds and networks between those that participate in the garden) (Kingsley and Townsend, 2006). Further, in a qualitative assessment of the social health benefits of community gardens, Zoellner et al. (2012) found that the major benefits included increased community cohesion, improved nutrition and increased physical activity. In addition, Armstrong (2000) observed that community gardens facilitated improved social networks and organisation capacity in the communities in which the gardens were located. There is also some emerging evidence to suggest that community gardens can contribute to improved physical, mental and social health for those individuals recovering from illness (Spees et al. 2015).

Green infrastructure is also particularly important for facilitating social interaction and cohesion in low socioeconomic neighbourhoods. For example, in examining how the availability of green space influences the use of outdoor public spaces in two Chicago public housing developments, Coley et al. (1997) found that access to green space encouraged greater use of these areas by the residents, providing increase opportunities for improved social cohesion and social interaction.

Research indicates that increased access to green space is associated with reductions in crime, violence and aggression. Bogar and Beyer (2015) reviewed the state of evidence on the association between green space, violence and crime in the United States. The authors concluded that the current evidence is supportive of an association between green space, violence and crime; neighbourhoods that have higher levels of green space have lower levels of reported violence and crime. For example, Branas et al. (2011) showed that the 'greening' of vacant lots was associated with consistent reductions in gun assaults across the four sections of Philadelphia, and consistent reductions in vandalism were observed in one section of Philadelphia. Further, Garvin et al. (2012) found that the 'greening' of vacant lots showed a non-significant decrease in the total number of police reported crimes, and those living around the 'greened' lots reported feeling significantly safer than those that lived around the control vacant lots.

4.4 GREEN INFRASTRUCTURE, CLIMATE CHANGE AND HEALTH

There is a large body of evidence that indicates green infrastructure is an effective adaptation strategy for climate change. This is due to its demonstrated ability to mitigate the urban heat island effect, reduce air pollution levels, its involvement in carbon sequestration and storage, and water management. Despite the existence of this large body of work that quantifies the physical benefits of green infrastructure in climate change adaption and mitigation, there is very little research that quantifies the impact that these physical benefits will have on human health outcomes.

Several studies have quantified the impact that green infrastructure has on mitigating the urban heat island effect (Emmanuel and Loconsole, 2015; Jim, 2015; Brown et al. 2015; Doick et al. 2014; Feyisa et al. 2014). For example, in evaluating the effectiveness of green infrastructure in reducing the urban heat island effect in Glasgow, Scotland, Emmanuel and Lonconsole (2015) found that an increase of green cover of approximately 20% above present levels could reduce a third to a half of the anticipated extra heat burden of urban heat island effect in 2050. Indeed, the study also reported that this 20% increase in green cover could reduce surface temperatures by 2 degrees. Further, Doick et al. (2014) examined in impact of Kensington Gardens, one of London's largest greens paces, on reducing the city's night-time temperatures. The authors found that the extent of cooling ranged from 20m to 440m around the gardens. The mean temperature reduction over these distances was approximately 1.1 degrees on nights within the summer months, reaching a maximum of 4 degrees cooling on some nights (Doick et al. 2014). In addition, in New York City, Susca et al. (2011) reported a difference of two degrees, on average, between the most and least vegetated areas in four areas in the city.

In terms of air quality, some studies have quantified the reduction in air pollution levels as a result of implementing green infrastructure (Tallis et al. 2011; Tiwary et al. 2009). For example, Tallis et al. (2011) found that the urban tree canopy of the Greater London Authority (GLA) is currently estimated to remove between 852 and 2121 tomes of PM_{10} per annum and this is representative of 0.7% to 1.4% of PM_{10} from the urban boundary layer. If the urban tree cover was increased from the current 20% to 30% of the GLA land area, it was projected that 1109-2379 tonnes (1.1-2.6%) of PM_{10} would be removed from the atmosphere by 2050. Further, Yin et al. (2011)

estimated that in the summer season, urban vegetation in the Pudong District in Shanghai, China has the potential to remove 9.1% of total suspended particles, 5.3% of SO_2, and 2.6% of NO_2 from the atmosphere.

Despite these studies revealing the clear physical benefits of green infrastructure as a climate change adaptation strategy, studies quantifying this physical benefit in terms of health outcomes are sparse. However, in using a 10x10km area of the East London Green Grid (ELGG) as a case study, Tiwary et al (2009) estimated the role of natural vegetation in reducing the levels of PM_{10} pollution. In doing so, the authors modelled health outcomes, and estimated that 2 premature deaths and respiratory hospitals admissions would be averted each year if vegetation levels were increased (this vegetation comprised of 75% grassland, 20% A.pseudoplatanus, and 5% P.menziesii).

5. THE ECONOMIC HEALTH VALUE OF GREEN INFRASTRUCTURE

There exists a significant lack of peer-reviewed literature assessing the economic health value of green infrastructure projects. Indeed, the few studies that have sought to place a monetary value on the health benefits of green infrastructure projects have emerged from the international grey literature (e.g. Bird, 2004; Mourato et al. 2010, KMPG, 2012).

There is not a single prevailing methodological framework that is used to evaluate the economic health benefit of green infrastructure projects; studies have used different methodological approaches to estimate the potential economic health value of these projects. This makes it difficult to systematically evaluate and compare the monetary estimates that these studies have calculated. Although, there have been attempts to develop standard methodological frameworks to assist in evaluating the economic benefits of green infrastructure (see, for example, the Green Infrastructure Valuation Toolkit that was developed in the UK by a collaborative effort of several private and public agencies).

Despite the methodological differences, the general approach of these studies has been to estimate the potential healthcare savings that result from improved physical or mental health due to the presence, or increased levels of, green infrastructure. For example, some studies have estimated the potential healthcare savings that result from an individual’s engagement in physical activity due to the presence of parks and open spaces (Bird, 2004, CJC Consulting, 2005, Harnik and Welle, 2009, Mourato et al. 2010), and other studies have estimated the potential healthcare savings that result from the reduced prevalence of mental illness due to increased levels of green space (KMPG, 2012). The monetary estimates that these studies have calculated reveal the substantial potential economic health value of green infrastructure.

5.1 International Case Studies

This section will provide a brief overview of a selection of studies that have sought to estimate the potential economic health value of green infrastructure, and summarise the monetary savings calculated.

5.1.1. The Economic Health Value of an Urban Park and Foot Path, UK (Bird, 2004)

Bird (2004) calculated the potential economic health value of an urban park and footpath due to engagement in physical activity for a number of cities in the UK (Table 1 and Table 2). In order to do so, Bird (2004) first estimated the proportion of physical activity that an urban park and footpath can contribute to the total amount of physical activity undertaken. This was estimated by answering several questions that included; the number of visits that the local population make to the park, the number of visits that involve physical activity, of those visits that involve physical activity, the number that fulfil the recommended 30 minutes of moderate exercise, the catchment area covered by the park, the population density, and the current cost of physical inactivity in the population. The potential value of the contribution of green space in facilitating physical activity was then estimated as the costs saved from avoided physical inactivity (Bird, 2004). The calculations were not adjusted for age, sex, and socio-economic profiles.

Following this, Bird (2004) estimated that the potential savings for the national economy due to urban parks were estimated to be between £1.6 million and £8.7 million per annum, and this included savings to the National Health Service (NHS) of between £0.3 million and £1.8 million per annum. The potential savings for the national economy due to footpaths (3kms in length) were estimated to be between £0.1 million and £1 million per annum, and this included savings to the National Health Service of £21,000 to £213,000. The large range in savings was attributed to the different population densities of the selected cities that were examined (Bird, 2004).

Table 1. Potential value of physical activity when 20% of the population within 2km use a 8-20 hectare green space to reach their activity target of 30 mins 5 days a week. The savings reported in this table are expressed as savings per annum. This table has been sourced and adapted from Bird (2004).

Urban Area	Population Density (population/Sq km)	Potential Savings to National Economy (£000s)	Potential Savings to NHS (£000s)
Inner London	9,297	8,717	1,815
Portsmouth	4,671	4,380	912
Manchester	3,652	3,424	713
Newcastle	2,294	2,151	448
Edinburgh	1,699	1,593	332

Table 2. Potential Value of physical activity when 16% of the population within 1km use a 3km footpath to reach their activity target of 30 mins 5 days a week. The savings reported in this table are expressed as savings per annum. This table has been sourced an adapted from Bird (2004).

Urban Area	Population Density (population/Sq km)	Potential Savings to the National Economy (£000s)	Potential Savings to NHS (£000s)
Norwich	3,117	1,023	213
Middlesborough	2,485	815	170
Wirral	1,975	648	135
Surrey Health	838	275	57
West Lancashire	313	103	21

5.1.2. The Economic Health Value of Accessible Green Spaces for Physical Health, UK (CJC Consulting, 2005)

CJC Consulting (2005) evaluated the economic health value of green space by estimating the cost savings associated with improved physical health due to reduced physical inactivity as a result of changes in green space in the UK (Table 3).

The report estimated if that green space facilitated physical exercise such that the proportion of sedentary males and females in the UK population fell by 1% (that is, 23% to 22% for the male population and 26% to 25% for the female population), then this would result in a total saving of £1.44 billion per annum. In particular, the estimated reduction in the number deaths and cases of chronic heart disease, stroke and colon cancer was calculated to equate to approximately £1.05 billion, £299 million, and £98 million respectively in healthcare savings each year.

Table 3: The annual economic health benefits from a 1% unit change in the sedentary behaviour of the UK population due to engagement in physical activity as a result of accessible green space. The figures reported in this table are per annum. This table has been sourced and adapted from CJC Consulting (2005).

	Mortality		Morbidity		Total
	Number of Cases	Cost (£Million)	Number of Cases	Cost (£Million)	Cost (£Million)
CHD	766	1005.19	14,414	41.85	1047.04
Stroke	223	292.63	445	5.50	298.13
Colon Cancer	74	97.12	137	0.50	97.62
Total	1,063		14,996		1442. 79

5.1.3. The Economic Health Value of the Mersey Forest, UK (Regeneris Consulting, 2009)

The Mersey Forest is the largest of England's 12 Community Forests selected to be the focus of a long-term tree planting programme to enhance the local environment for the benefit of the local community, wildlife and economy. The forest regeneration programme has primarily involved the planting of new trees, land reclamation, bringing woodland into management, creating access to green space and recreational activities, managing and improving habitats, engaging local communities and business support activity for forestry business (Regeneris Consulting, 2009). In 2009, The Mersey Forest commissioned Regeneris Consulting to perform an economic assessment of the social, health, and environmental benefits generated from the forest regeneration programme.

The economic modelling framework that Regeneris Consulting (2009) used to evaluate the economic benefits of the project was based on the Natural Economy North West Framework (UK), and a literature review that served to derive useful benchmark figures in relation to economic benefits (Regeneris Consulting, 2009). The economic benefits derived from engagement in physical activity due to the Mersey Forest's accessible green and recreational spaces were estimated to be £122,000 per annum in gross terms, and the net additional benefit was estimated to be £33,000 per annum. These total figures consist of Gross Value Added (GVA) benefits arising from reduced absenteeism and premature death, and healthcare savings to the National Health Service. The economic health benefits derived from the reduction in air pollution levels were estimated to be £116,000 per annum (Table 4).

Table 4. The total economic health benefit of The Mersey Forest's Objective One Funded Investments (£000s). This table is sourced and adapted from Rengeris Consulting (2009).

	Gross (£000s).		**Net Additional (£000s).**	
	Annual	Net Present Value (calculated over 50 years)	Annual	Net Present Value (calculated over 50 years)
Health and Well-being: Exercise (GVA)	74	2,686	20	722
Health and Well-being: Exercise: (cost saving)	48	1,763	13	474
Health: Air pollution absorption	116	2,717	116	2,717

5.1.4. The Economic Health Value of Green Space, UK (Mourato et al. 2010)

Mourato et al. (2010) estimated the economic value of improved physical and mental health derived from increased physical activity created by the provision of natural habitats and green spaces in the UK. In doing so, they first measured the physical and mental health impact of physical activity, calculated the economic value of the health benefits of physical activity, and then estimated the probability of additional exercise with changes in green space (Mourato et al. 2010).

The authors estimated that changes in natural and green space that resulted in a 1% decrease in sedentary behaviour in the UK population would provide a total economic health benefit of £2billion (using WTP (Willingness to Pay)-based values) per annum for a range of physical and mental health conditions (Table 5). However, if those individuals aged 75 years and over were excluded from the assessment, then the total economic health benefit decreased to £750million per annum.

Table 5. The total economic health value derived from a 1% decrease in the sedentary population in the UK. The calculated estimates are expressed as £million, per annum. This table has been sourced and adapted from Mourato et al. (2010). WTP = Willingness to Pay. VPF = Value of Preventable Fatality.

	Mortality			**Morbidity**			**Total**	
	Number of cases of averted deaths			Number of cases of averted illnesses			Including >75 year olds	Excluding > 75 year olds
	Including >75 year olds	Excluding > 75 year olds	VPF	Including >75 year olds	Excluding > 75 year olds	WTP to avoid	WTP to avoid	WTP to avoid
CHD	597	192	£949.1	20,871	5,919	£287,4	£1,236.5	£415.2
Stroke	177	32	£281.4	1,092	689	£195.1	£476.5	£57.7
Colo-rectal cancer	74	33	£177.7	141	78	£40.7	£158.3	£251.1
Depression				8,259	7,466	£44.1	£44.1	£39.9
Total	848	257	£1,348.2	30,363	14,152	£567.2	£1,915.4	£763.8

This report also calculated the economic health benefits derived from increasing an individual's view of, or access to, various forms of green space in the UK (Table 6). This included the economic health impact of changes in an individual's view of nature, use of their own garden, frequency of visits to green spaces, and increasing the proportion of broadleaf woodland, freshwater, and farmland cover within a 1km radius of their home. Broadly speaking, the authors arrived at these estimates by tentatively assigning a monetary value to the Quality Adjusted Life Years (QALYs) associated with the changes in green space (Mourato et al. 2010).

Table 6. The economic health value of contact with nature in the UK. This table was sourced and adapted from Mourato et al. (2010).

Type of Green Space	Change in Green Space	Tentative Annual Value (per person)
Having a view over green space from your house	No view to any view	£135-£452
Use of own garden	Less than weekly to weekly or more	£171-£575
Use of non-countryside green space	Less than monthly to monthly or more	£112-£377
Local freshwater, wetland, and flood plain land cover	+1% within 1km of the home	£20-£68
Local enclosed farmland land cover	+1% within 1km of the home	£4-£12
Local broad-leaved/mixed woodland land cover	+1% within 1km of the home	£8-£27

5.1.5. The Economic Health Value of the Green Cycle Belt of Bruges, Belgium (Vandermeulen, 2011).

In using their own economic modelling framework, Vandermeulen et al. (2011) assessed the economic value of the 'Green Cycle Belt of Bruges' in Belgium. The authors proposed that the economic evaluation of green infrastructure should occur at two distinct levels including; (i) the project level, that estimates the direct benefits of the specific green infrastructure project (through performing a cost-benefit analysis) in two target groups – commuter cyclists and recreational cyclists, and (ii) the regional economy level, that assesses the indirect value of the development for the region (via a multiple analysis). At the time of their assessment, the proposed bicycle route was designed to connect the inner city of Bruges with surrounding municipalities to allow city residents and tourists to travel around the city by bicycle.

In relation to the economic health value of the project, the authors identified that the health benefits of cycling would lead to a reduction in healthcare costs and a reduction in costs associated with sick leave. It was estimated that the annual economic health value at the project level from increasing cycling was €47, 041.

5.1.6. The Economic Health Value of Parks and Recreational Spaces for 11 US Cities (Harnik and Welle, 2009).

The US Trust for Public Land's Center for City Park Excellence has produced a series of reports that have assessed the economic value of parks and recreational spaces for 11 US cities and counties (Harnik and Welle, 2009). They developed a Park Health Benefits Calculator to estimate the collective healthcare savings of city residents associated with physical activity as a result of available park and recreational spaces for a given year. The estimated healthcare savings of residents for each of the 11 US cities and counties ranged from approximately US$4,300,000 to US$90,200,000 (Table 7).

Table 7. The estimated collective healthcare savings of city residents due to increased physical activity as a result of accessible park and recreational spaces for 11 US cities and counties. Table sourced and adapted from the series of reports (Harnik and Welle, 2009).

US City	Year of Valuation	Total Value of Healthcare Savings ($US)
Sacramento, California	2009	$19,871,863
San Diego, California	2007	$45,122,000
Philadelphia	2007	$69,419,000
Boston	2007	$78,042,000
Wilmington, Delaware	2008	$4,322,000
Denver	2010	$64,955,500
Nassau and Suffolk Counties, New York	2010	Nassau County: $73,300,000 Suffolk County: $90,200,000
Mecklenburg County, North Carolina	2010	$81,489,217
Seattle	2011	$64,087,756
Virginia Beach	2011	$32,472,475
San Francisco	2014	$49,221,673

5.1.7. The Economic Health Value of Increased Green Space in the Netherlands (KMPG, 2012).

KMPG (2012) estimated the healthcare savings that would arise from increasing the proportion of green space in the Netherlands for three different scenarios. Their economic valuation methodology was based on four main stages; (1) determining the relevant interventions for changes in costs and benefits, (2) determining the relevant relationships between effects, (3) quantification, and (4) expressing this in monetary terms.

Scenario One: Healthcare savings arising from the reduced prevalence of individuals with depression if green space levels were increased by 10% in the Bos en Lommer district in Amsterdam were calculated. The report estimated that the proposed increase in green space would reduce the number of individuals (aged 16 years and over) living with depression by 132 in this district in 2014. This reduced prevalence was calculated to result in €223,000 in healthcare savings for that year, and it was predicted that these savings would increase to €254,000 in 2044 (KMPG, 2012). Overall, the report revealed that the combined health care and labour costs savings for this district if green space levels were increased by 10% would amount to €802,000 in 2014, and increase to €871,000 in 2044.

Scenario Two: Healthcare savings arising from the reduced prevalence of diabetes for the present generation of 5 to 12 year olds over their whole life span due to increased green space levels in the Bos en Lommer district in Amsterdam were calculated. The total economic health benefits over their whole life span were estimated to be approximately €51,000, and the authors concluded that these curative healthcare costs were quite small.

Scenario Three: KPMG estimated the economic health value of increasing green space by 10% for the entire country. It was estimated that this particular type of intervention would result in approximately 84,000 fewer patient visits to general practitioners for a range of diseases, resulting in an overall saving of more than €65 million in national healthcare costs per annum (Table 8).

Table 8. Total estimated savings in healthcare costs in the Netherlands increased green space levels per annum. This table was sourced and adapted from KMPG (2012).

Disease	Number of Fewer Patients	Estimated Savings in healthcare costs (€)
Gastro-intestinal tract infections	1,770	1,031,841
Migraine	7,587	480,374
Diabetes	2,529	2,820,041
Asthma and COPD (+ respiratory tract)	27,820	11,548,806
Neck and back complaints	24,026	4,231,571
Depression and Anxiety	20,232	43,984,118
Coronary heart disease	506	1,340,682
Total	**84,470**	**65,437,433**

6. DISCUSSION AND CONCLUSIONS

The aim of this background paper was to review the current international and national evidence base on the linkages between green infrastructure, human health, and to the extent possible, economic benefits.

There is a significant body of work that has examined the association between green infrastructure and human health. The large majority of this work has demonstrated that green infrastructure is significantly beneficial for an individual's physical, mental and social health. In terms of an individual's physical health, there is strong evidence to suggest that green infrastructure, particularly parks, green spaces, and recreational facilities, are able to facilitate physical activity, and there is some evidence to suggest that these forms of green infrastructure are associated with a lower risk of obesity, some diseases, mortality, and positive birth outcomes. In terms of an individual's mental health, much of the evidence indicates that viewing or experiencing green space or natural environments is associated with reduced levels of perceived stress, improved measures of physiological stress, enhanced cogitative functioning, positive mood, feelings and emotions, reduced symptoms of depression and anxiety, improved emotional and behavioural problems, and improved recovery from illness. In terms of social health, there is strong evidence to suggest that green infrastructure, especially in the form of community gardens, is able to improve a community's social cohesion and capital, and some emerging evidence to suggest that it may reduce criminal, violent and aggressive behaviour, leading to safer communities. Overall, taken together, this evidence is indicative of the substantial health benefits that can be derived from green infrastructure.

However, there still exist significant research gaps in this body of work. There is an overall lack of understanding of the particular characteristics of green infrastructure, such as biodiversity levels, aesthetic value, vegetation type and density, proximity to residential housing, and accessibility that are most important to improving an individual's health and are most valued by individuals during their nature experience. There is little consensus regarding the optimum length of time that an individual should view, or experience green infrastructure, especially green spaces and natural environments, to gain either the physical, mental, and social health benefits of that experience. Most of the work that has sought to quantify the health benefits of green infrastructure has focused on green spaces and natural environments, and very little has quantified the health benefits of more recent green infrastructure developments, such as green roof and walls. There is also need to enhance our understanding of whether vulnerable sub-populations receive greater health benefits from green infrastructure developments than the general population, such as ethnic minorities, low-socioeconomic groups, the elderly, the young, and those with pre-existing medical illnesses.

There is a significant body of work that supports the effectiveness of green infrastructure as an adaption strategy for climate change. This is because green infrastructure has the ability to, amongst other things, mitigate the urban heat island effect, reduce air pollution levels, and improve water management. However, the extent to which these measured physical benefits result in improved human health outcomes remains to be determined. Indeed, there has been little work to date that has quantified and evaluated the human health benefits of using green infrastructure as climate change adaptation strategy. As a result of this, the human health benefits of this strategy can only be inferred from the established physical and environmental benefits.

The review identified a small number of studies from the international grey literature that have assessed the economic health value of green infrastructure. The general approach of these studies has been to estimate the potential healthcare savings that result from improved physical or mental health due to the presence, or increased levels of, green infrastructure. The monetary estimates that these studies have calculated reveal that green infrastructure has the potential to provide substantial economic health benefits. However, these studies have used different methodological approaches and assumptions to estimate the potential benefits, and as a result of this, it is difficult to systematically compare the monetary estimates that these studies have calculated. These studies have also emerged from different geographical regions including the United Kingdom, Western Europe, and the United States. It is unlikely, due to differences in disease prevalence, the quality and quantity of green infrastructure, and healthcare systems, that these monetary estimates would be directly transferable to the Australian context. However, these methods could be carefully considered to clarify to what extent they could be adapted to the Australian (and Victorian) context. This review highlights the real and urgent need to standardise the methodology used to evaluate the economic health value of green infrastructure projects and subsequently calculate monetary estimates in the Australian context.

Therefore, the main conclusions of this review are;

- There is strong evidence that green infrastructure provides substantial physical, mental and social health benefits. However, more research is needed to refine our understanding of the relationship between green infrastructure and health outcomes, especially within the Australian context.
- There is strong physical and environmental evidence that demonstrates the effectiveness of green infrastructure as an adaptation strategy to climate change. However, the extent to which these demonstrated physical and environmental benefits result in measured, improved human health outcomes is unknown. There has been limited research work to date that has sought to quantify and evaluate the human health benefits of using green infrastructure as a climate change adaptation strategy.
- There is some international evidence that indicates the potential, substantial economic health value of green infrastructure. There is an explicit lack of Australian studies evaluating the economic health value of domestic green infrastructure projects, highlighting the need for such studies to be conducted.

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