Improving Health in Cities Using Green Infrastructure: a Review

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Abstract Health is defined as being a state of complete physical, mental and social well-being. There is sufficient evidence to support the idea that the connectivity of green areas provides those health benefits. In policy areas valuation of health is important. There is a clear need to evaluate the potential economic implications of green infrastructure linked to health effects and health service budgets facilitating interdisciplinary research for urban planning. Research is needed to examine the relationship between the benefits of landscape contributed individually and the sum of benefits in interaction with each other. This paper will review green infrastructure and the evidences that support its multiple benefits.

Keywords green infrastructure - health
Introduction

Rapid urbanization has created numerous challenges to human health and well being. Green infrastructure facilitates systematic and strategic landscape planning which recognizes the valuable service that nature provides to the human environment. Green infrastructure is a holistic solution to urban challenge. A sustainable and multi-functional green infrastructure ensures the maximization of health benefits. Climatic amelioration provided by green areas is likely to become a major issue in relation to climate change concerns. This paper will review the green infrastructure and health improvement and the necessary to develop and use interdisciplinary approaches to provide a better understanding of the challenges of land use planning and management.

Green infrastructure and health

Green infrastructure is a new term but not a new idea (Benedict, 2006). The concept basically links green areas to human habitat for improved health benefits. The WHO (1992) defines health as being a state of complete physical, mental and social well-being. There is sufficient evidence to argue that the components of green infrastructure make a contribution in all of these dimensions. While they are desirable, green infrastructure in the form of private gardens largely depends on the socio-economic status of individuals and thus may not provide enough opportunity for everybody to enjoy benefits to health and wellbeing. Hence effective landscape planning can provide opportunities for everybody to have access to some of these benefits. The links between socio-economic status and health have been researched and found to be positive (Douglas, 2005; Dunn, 2000; Dunnett, 2002).

(Dunnett, 2002) estimated that in the UK there are 27,000 urban parks, covering 14% of cities and towns and adding up to a total of 143,000 hectares. About 74% of adults agree that green spaces are important for their general health. Local authorities believe in the benefit of urban green spaces. Investing in green infrastructure is cost effective. Hence local authorities in the UK create good quality green space and encourage people to walk, run, cycle and play for health improvement. Recreational parks and green areas provide opportunities for healthy physical activity and stress
Maler (2009) studied the relationship between exercise and open green space. He reported that green infrastructure will help the government reach targets to increase levels of physical activity and to provide a significant economic reason to maintain green space.

Urban green features like street trees, private gardens and city parks contribute multiple environmental benefits that are difficult to replace. But they need to be strategically planned. Hence it is a priority for today’s urban landscape planners to ensure that the functionality of green areas is properly understood and implemented. Existing green areas need to be conserved. It should be possible to enhance the green cover in critical locations, for example, planting more trees at city centre roadsides, or near to schools and hospitals where there is more human exposure, to enhance the health benefits obtained from them.

The physical and mental health benefits of urban green space have been well documented. Some classical studies are reviewed here. Douglas (2005) reports that green areas provide fresh energy that helps people to relax. Stress levels when driving through green areas was found to be much lower than in built-up areas (Ulrich, 1997). Less sickness was reported among prisoners who had greater contact with green areas (Moore, 1981). Studies by Ulrich examine green areas and their health benefits. In his research he reported that hospital patients who were able to enjoy a view of nature recovered from gall bladder surgery more quickly and required less pain relief or anxiety medication and also showed fewer complications and complaints (Ulrich, 1984). Residents of areas with good green infrastructure demonstrated increased longevity, a higher level of physical activity as well as better health among senior citizens (de Vries, 2003). Viewing green spaces from the residence is shown to reduce psycho-physiological stress, intra-familial aggression as well as improving blood pressure, muscle tension and skin conductance (Hartig, 2008; Kaplan, 1995; Laforteza, 2009; Li, 2005).

All these studies add to the mounting evidence of the benefits provided by urban green areas and health improvement. But there are a lot more benefits brought about by the restoration of the environment. The next section will review some of those benefits.
Green infrastructure and environment

Several studies have established relationships between different urban green structures and improved environmental functions (Yang, 2009). The evidence is strong enough to make the case for the inclusion of green vegetation in urban planning, especially while planning the expansion of existing towns and in the creation of new urban settlements.

Mature trees will be very important for their role in providing other benefits such as providing shade and intercepting pollution and rainfall. During summer, trees provide a cooling function for a longer period than does grass. The creative use of the most promising green infrastructure incorporating these benefits should be recognized in the planning process across all scales. They address the need for multifunctional urban landscapes. A part of the process of such landscape planning could be an evaluation of tradeoffs and conflicts between structures and their related purposes.

As (Barker, 1997) outlined, the multiple benefits and uses of green networks have stimulated new approaches to green space planning (Handley, 2003; Harrison, 1987; Harrison, 1999). Clean air is now regarded as an essential part of a good quality of life. The Department of Environment Transport and the Regions (1997) states that people have the right to expect that the air they breathe will not harm them. Here, there is an explicit assertion of the connection between environment and quality of life. Tightened restrictions and progressive standards set by the government, for example, air quality standards, have provided the improvements we experience today. But there is a lot more to be done to maximise the health benefits provided by urban green areas.

Increasing tree cover by 10% could reduce total heating and cooling energy use by 5 to 10% (McPherson, 1992). Street trees are a major source of building shade. They provide a cooling effect of from 2-7%. The species composition, age, structure, health and geographic distribution of urban vegetation have a significant impact on the benefits. But the relationship between urban tree structures, coverage, functions and value need to be better understood so that tree planting and management decisions will maximise net benefits for urban areas.
Studies have indicated that increasing tree coverage by 25% can reduce afternoon air temperatures by between 6 to 10°C, and simulations of a 30% vegetation cover reduced temperatures by as much as 6°C. Others have shown that vegetation in streets can reduce temperatures by 2°C. Comparisons of temperatures in city parks and surrounding urban areas in Japan have demonstrated differences of 2.5 to 4°C (Asaeda, 1997). Vegetation provides cooling through evapo-transpiration which also adds humidity to what is frequently uncomfortably dry city air.

Increased urban temperatures contribute to cause photochemical smog. Data from the US suggests that for every 3°C increase in temperature there is a 10% increase in polluted days (Akbari, 1992). The value of green open spaces within cities for ameliorating local climatic conditions is widely appreciated, and is frequently quoted as one of the beneficial functions of green space. The Berlin Biotope Strategy has taken this further than most cities by recognising five broad climatic zones within the city which are characterised by variations in air temperature, humidity and soil water; these reflect the moderating influence of green space.

The local authorities’ view of a green space was found to be focused exclusively on the provision of sport and recreation facilities to the exclusion of natural green space. Therefore, the importance of street trees in ameliorating the local climate of urban areas needs to be more fully appreciated at the local level, and their value for shading buildings more fully understood, particularly in relation to future climate change. Handley (2003) in evidence to the Commission, has outlined ways in which research on these issues can assist in reducing the effects of climate change in UK towns and cities.

The closer the area of green space is to home, the more valuable it is. The connectivity of green areas is an important element in providing many of the health-related benefits of green space, especially through walking and cycling. The Town and Country Planning Association guide (2004) highlights the importance of retaining and enhancing existing natural features, and maintaining local distinctiveness as part of the approach.

A sustainable and multi-functional green infrastructure ensures the maximisation of health benefits. There is also a climatic amelioration provided by green areas, a feature which is likely to become a major issue in
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relation to climate change concerns. Understanding the environmental functions of the green infrastructure is particularly relevant to assessing climate change impacts in urban areas and developing adaptation strategies. There are advantages to be gained from the maintenance of effective green infrastructure. Good practice guidance on green infrastructure is required to achieve sustainability and a holistic approach to assessing its benefits is required.

There are a number of levels at which green infrastructure can be used in urban design and planning which are summarised by Town and Country Planning Association (2004):

Existing green infrastructure such as the regional parks and community forests require both conservation and new ideas and efforts to link them to their potential public, for example improving the commuting facility. Within a built environment including, for example, street trees, communal and neighbourhood green space, a new element, such as a green roof, requires effective design based upon human exposure. Newly created green infrastructure as part of new urban developments, including greenway linkages and sustainable urban drainage systems, must also be well and carefully planned.

Valuation of health impacts

The valuation of non-market impacts, such as trees mitigation of air pollution, is a challenging but important element of appraisal in any policy-making process because of the extent of the investment now devoted by governments in the cause of better public health. In policy areas the valuation of the impact of pollution on health is important. Some methods of formal evaluation are used when health impacts are to be weighed against the market and non-market benefits of a particular element in the environmental ecosystem. There are a number of techniques available. (Dixon, 1986; Navrud, 2007; Ninan, 2007; Willis, 1999; Willis, 1995; Willis, 1991) stated that economic valuation could be conducted after the filtering process of pollution impacts, with willingness to pay (WTP) and cost of illness (COI) approaches. The monetary value per case which is needed by these approaches can be obtained by using purchasing power parity in the country where the study is carried out (Liu, 2008). Monetary value is multiplied by the number of cases for every impact and then the result is summed up. The
The valuation of health benefits is one of the Department of Environment, Food and Rural Affairs' (DEFRA) objectives in regard to the protection of public interests in relation to environmental impacts and health (DEFRA, 2007). Any effective programmes or policies are examined with regard to their potential costs and the value of their anticipated benefits. Economic valuation techniques are used to enumerate these. They are the product of a joint effort between health economics and environmental economics. The main objectives of these techniques are to compare benefits and costs, to set priorities and help ensure the effective use of scarce resources and to get the attention of decision makers.

According to Dixon (1986) the negative impacts in urban areas can be assessed by four major economic valuation techniques. In summary these are:

1. **Health impacts:** Health Impact Assessment is important and these are the valuations that receive the most attention. Health Impact Assessment is useful in drawing the attention of decision makers to the evaluation of policies (Ostro, 1994).

2. **Productivity impacts:** According to Dixons (1986) if individuals or firms need to install special measures to protect themselves from pollution, these are measurable in terms of economic costs. Also, if polluted air reduces the productivity of natural systems, this is classified as an additional productivity cost. Also, in some situations, pollution (especially air pollution) may be so critical that industries are closed or transportation is restricted. Both of these steps impose important economic and social costs on society.

3. **Ecosystem impacts:** Ecosystem impacts are harder to measure and value and the true impact may not be felt for many years. Often they are included in a qualitative manner, for example vegetation dieback due to pollution (Rapport, 1998).

4. **Aesthetic impacts:** Dixon (1986) says that people feel "hurt" if they live in a polluted environment, which results in a loss of social wellbeing. Both rich and poor have a "willingness to pay" for a cleaner environment, but for the poor, low income levels do not
allow them to take effective counter-measures. Richer people have a larger ability to pay for an improved aesthetic environment.

Given its primary concern with human well-being, the study will focus on the valuation of health impacts. Rapid progress in economic valuation means that many environmental impacts can now be valued and placed within the framework of a more traditional economic analysis.

Epidemiological analysis can only determine if the pollution is a real problem or not, while economic analysis can help determine the monetary value of some of these impacts on health, productivity, ecosystems, and aesthetics. In the case of air pollution, the approaches normally used are dose-response relationships that link changes in levels of ambient pollution to changes in health outcomes for various diseases.

As Committee on the Medical Effects of Air Pollutants (COMEAP) in 1998 reported that the health impact can be assessed by the dose-response function, which gives a rough idea of the possible importance of the various outcomes. The dose-response function (DRF) relates the quantity of environmental deterioration that affects a receptor (e.g. population) to the physical impact on this receptor (e.g. incremental number of hospitalizations). In the narrow sense of the term, it should be based on the dose actually absorbed by a receptor.

In January 1998, the COMEAP published a report on the quantification of the health effects of air pollutants in the UK. It advises on how best to reflect on any cost-benefit decision in air quality policy. It primarily addresses methodological issues to produce estimates of costs and to consider the merits of an alternative approach to the valuation of health effects when estimating the health care cost implications of changes in levels of air pollution.

Some measure is needed of the importance of the quantified health effects so that they can be compared with the other implications of the policy concerned. The main aim of the appraisal was to ensure that society spends its money on the most significant risks, and that the costs do not exceed the benefits. To compare the costs and benefits directly, the benefits need to be in the same units as the costs. A monetary value for the benefits that reflects the preferences of those at risk can be obtained by finding out what they
would be willing to pay to reduce a particular risk. Although reductions in risks are typically non-marketable goods, people actually pay for measures to reduce the risks either directly or indirectly or through taxation and they trade off small risks against other things which are important to them. Hence valuation techniques can be used for the assessment.

As all of these findings suggest that a complete green infrastructure has potential economic implications linked to health benefits and reduced health service budgets it becomes necessary to develop a methodological approach that clarifies the magnitude of the benefits and allows adoption strategies to be tested. There is sufficient evidence to draw to a conclusion that green infrastructure makes a significant contribution to health. But lack of methodologies that assess the health benefits may affect the implementation in the policy arena. A more holistic assessment of green infrastructure is required.

As COMEAP (1998) reports no suitable study of willingness to pay (WTP) for reductions in environmental deterioration, mortality and morbidity risks has been found in the literature. But there are studies of reductions in risk of deaths in road accidents. People generally perceive risks as involuntary, poorly understood and uncontrollable; however, they perceive road accident risk as largely voluntary, well understood and easy to control.

**Conclusion**

To deliver maximum benefits a holistic assessment should be considered for the green infrastructure approach. It is necessary to develop and use interdisciplinary approaches that integrate biological, social and other sources to provide a better understanding of the challenges of land use planning and management. Rigorous methodological approaches in order to advance land use planning and management are necessary. There is a clear need to evaluate the potential economic implications of green infrastructure linked to health effects and health service budgets, facilitating interdisciplinary research for urban planning. Research is also needed to examine the relationship between the benefits of landscape contributed individually and the sum of benefits in interaction with each other. Clearer measurements of psychological well-being related to trees (of all kinds and in different kinds of areas) and their perceptual significance need to be
addressed. Climate, water management, biodiversity and health each has a part to play in terms of ecological services and health benefits provided to human beings, but a proper methodological assessment is required for assessment. A well researched and assessed green infrastructure model might help to provide a more informed and systematic way to consider the competing priorities of green infrastructure within landscape planning process. The planting design would uphold the ability to plant selectively, with planting targeted around the hot-spots of environmental deterioration, in order to realize the maximum benefits. Taken together, these attributes suggest that trees should be considered as an integral part of an urban landscape. Thinking should be joined-up with a clear understanding that the value of the sum of landscape elements is greater than the value of the individual elements.

1 Biotype in this context means a group of species of the same genotype. Berlin Biotype Strategy is an inventory (databank on various biotypes) used for spatial planning.

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