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Nature-based cities: Greening for sustainability and liveability

Literature review and best practice case studies

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Executive summary

A growing proportion of the global population lives in cities – humanity is now predominantly urban. As we face global-scale pressures and challenges of climate change and sustainability, the health and liveability of our precincts and cities, and their contributions towards addressing these global challenges is increasingly important. Just as many of the sustainability challenges we face emanate from cities, so too are cities potentially the locations for the solutions to these challenges.

Creating nature-based cities, in which green spaces are essential elements that are integrated in the urban fabric, the infrastructure and the spaces and places within our cityscapes, is critical for sustainable and liveable urban futures. The report highlights research from across the last 20 years, with case studies of global exemplar projects, to point to new approaches to creating nature-based cities for sustainability and liveability.

The objective of this report is to inspire new benchmarks for urban regeneration projects in Australia and to provide guidance to urban planners and developers on the factors contributing to creating better cities – cities that prioritise and foster community cohesion, environment sustainability, and health and wellbeing perspectives.

This report considers the three dimensions of sustainability: environmental, social and economic, to highlight green space contributions, functions and benefits. These research findings are then brought together in a 'framework for designing nature based cities'. The framework highlights 12 features that together support the design of urban green spaces that deliver multiple functions and meet a diversity of needs.

As approaches to urban planning and design have evolved to increase a focus on liveability, prosperity and sustainability, creating 'nature-based cities' is arguably the next key direction for cities of the future.

Planning and designing green spaces for thriving cities

To support the planning and design of multifunctional urban green spaces, we identify from research the key elements that should be considered and incorporated into urban green space design. The design framework is structured to bring together research on *nature's contributions* with research on *designing parks for health and well-being across a life course*.

'Nature's contributions' are conceptualised across three categories:

- 'Nature for nature': nature's intrinsic value, biodiversity and habitat; nature for nature ensures ecosystems are healthy and thriving and therefore able to provide the associated contributions to society and culture;
- 'Nature for society': nature's utilitarian values, climate resilience, air and water quality, urban heat mitigation;
- 'Nature for culture': community cohesion, physical and mental health and wellbeing; connection with nature.

The design elements highlight the key features that should be integrated across green space networks, to meet the needs of both people and biodiversity. People's needs and uses of green spaces vary across their life stages, with green spaces used for both social connection and solitude, for children's adventure and discovery, for active recreation and exercise, as well as quiet contemplation and connecting with nature. In addition, well-designed green spaces that integrate tree canopy, well-watered vegetation and pervious surfaces can contribute to cooler urban temperatures, cleaner air and water.

Designing green spaces that are planted with locally indigenous species, and incorporate structural complexity (multiple layers of vegetation) can increase biodiversity habitat. Biodiversity is the critical ingredient for sustainability and thriving environments: for urban green spaces to provide the range of benefits and functions that humans enjoy, and on which our survival and quality of life depends, requires healthy and thriving ecosystems.

Green space planners and designers of local green space networks should seek to incorporate as many as possible of the design elements set out in the framework below.

Framework: Designing nature-based cities

Nature's contributions	Key functions	Design elements
Nature for nature	Biodiversity habitat	Indigenous species Vegetation structural complexity Diverse, connected network Nature connection for people
Nature for society	Climate regulation, cooling Water management, runoff Air quality Carbon sequestration Urban agriculture, food production	Tree canopy Well-watered vegetation Pervious surfaces
Nature for culture	Community connections Social cohesion Health and wellbeing Economic activity	Active Social Adventure Nature connection Visitor facilities (including commercial facilities)

This report presents research findings that reinforce why we need green spaces in cities, including inner urban development, and the benefits of urban green spaces. Multi-functionality of green spaces is critical in an inner urban context, and indeed throughout most cities, where land is at a premium; open spaces must be designed to serve multiple functions and address multiple needs from diverse green space users, whose needs shift across their life stages. Urban planners, designers and developers can play a vital role in creating thriving and sustainable nature-based cities with well-designed green space networks.

1. Introduction

Urban and semi-urban settlements cover less than 5% of the Earth's surface, yet the majority of the global human population is now urban: in 2018, 55% of humans lived in cities, a figure expected to rise to 65% by 2050 (Geschke et al., 2018, Palliwoda and Priess, 2021). Cities, often located in or near 'biodiversity hotspots', bioregions with significant richness in endemic species (Seto et al., 2012), are continuing to expand and densify, driven in part by human population growth (Scott et al., 2016). Anthropogenic stressors, including habitat removal, encroachment and pollution, are significant sources of disturbance for urban ecosystems. Compounded with the effects of global warming and the modification of natural ecological processes, they cause environmental degradation resulting in habitat fragmentation, increased pollution of waterways, air, and soil, and damage by invasive species (Mimet et al., 2013, Grimm et al., 2008). The lack of connection with nature and experiences in natural areas also has detrimental impacts on people's health and wellbeing, and children's social, emotional and psychological development (Colding et al., 2020, Holt-Lunstad et al., 2015, Louv, 2008, Wolf et al., 2015). A growing number of city planners, urban designers and developers around the world have been mobilising and partnering with urban ecologists and landscape architects to protect and restore urban natural environments to counteract the detrimental effects of urbanisation, and realise the evidenced health, wellbeing, social and environmental benefits (Hunter et al., 2019).

The protection of existing urban ecosystems, and the restoration or creation of new urban green spaces is then paramount for several reasons. Cities that integrate green spaces into their urban matrix achieve more than just providing beautiful amenities; they also allow for nature to provide the ecosystem services that sustain and improve human life, physical health, and psychological well-being (Scott et al., 2016). In an effort to counteract the loss of natural urban habitats, concepts of urban ecology, green infrastructure and nature-based solutions have been applied as powerful tools to halt biodiversity loss and support the delivery of ecosystem services essential for human life. Projects to restore and conserve forests, wetlands, reefs and other coastal ecosystems, the installation of green roofs and walls, and landscaping to prevent landslides have been shown to bring important benefits to the environment, human health and well-being, as well as to the economy (Cohen-Shacham et al., 2016).

This review highlights recent findings and research developments that emphasise and reinforce the critical necessity for inclusion of green spaces to create healthy, sustainable, resilient and thriving neighbourhoods and cities. The review considers the three dimensions of sustainability: environmental, social and economic, to highlight green space contributions, functions and benefits. Environmental dimensions include the beneficial effects of urban nature, the delivery of ecosystem services and functions. Social dimensions include increased social cohesion, community engagement, and public safety, as well as improvements in physical and mental health and well-being that have been linked, directly or indirectly, to exposure to nature. Economic dimensions include the potential cost savings and economic gains derived from a healthy urban green spaces. The review points to a significant aspect of successful greening strategies: multifunctionality. The review concludes by presenting global best practice case studies of urban renewal projects that have actively worked to incorporate urban greening, and the environmental, social and economic benefits that have been realised as a result.

2. Urbanisation processes and provision of urban green spaces

Mounting concerns about the declining availability, quantity and quality of urban green spaces, combined with growing awareness on the need to develop and re-develop cities intensively (densification), rather than extensively (urban expansion), and in particular reclaiming brownfields and disused industrial land, have resulted in a considerable focus on how cities around the world have invested in urban renewal projects that are designed in ecologically sustainable ways (Nilon et al., 2017, Swanwick et al., 2003).

While the practice of integrating nature in city environments has figured amongst the priorities of urban planners for over a century, the underlying motives and objectives for doing so have changed significantly over time. As early as 1902, the concept of the 'Garden City' saw green areas neatly arranged between residential blocks, and a green belt surrounding urban settlements to provide space for recreation and to reconnect communities to nature (Scott et al., 2016). Later in Europe, Le Corbusier's idea of a 'Functional City' saw nature as mere decoration, to be controlled and fought by technology, and located amongst high-density residential developments (Scott et al., 2016). In the 1980s, the New Urbanism movement began promoting the idea of a 'compact city', with mixed-use mid-to-high density urban centers, which were seen as the modern solution to sustainable urbanization (Scott et al., 2016). This model was thought to counteract urban sprawl and promote the conservation of nature outside the urban boundaries, while urban density and short distances eliminated the need for cars, therefore reducing costs and promoting a healthier lifestyle (Scott et al., 2016). However it wasn't until the early 2000s, with the emergence of Eco-Urbanism, that cities started being framed as complex systems with competing interests and needs (Sharifi, 2016). The Eco-Urbanism framework, which in practice has taken the form of eco-towns, eco-cities, green cities and resilient cities, integrates and emulates natural elements and processes to reduce reliance on grey infrastructure. Environmental features include green and blue infrastructure, permeable surfaces, artificial wetlands, and bioswales (Haase et al., 2014). Technology, on the other hand, is used to produce energy from renewable resources, manage waste efficiently, and achieve net-zero emissions (Sharifi, 2016).

With this shift towards an ecological focus in urban design, attention has focused on how green spaces are integrated into urban development. Inclusion of green spaces, restoration of ecosystems and biodiversity conservation measures need to be considered at the start of the design processes of urban redevelopment projects, to maximise the benefits of ecosystem functions and to avoid greening strategies that are less effective or tokenistic, market-driven exercise (Kirk et al., 2021). Urban green space design should consider local needs, and respond to local conditions. For example, protocols such as Biodiversity Sensitive Urban Design (BSUD) have been created to support developers and decision makers to regenerate urban green spaces that simultaneously enhance natural habitats and ecosystems, allowing for the provision of ecosystem functions, and increasing liveability for people (Kirk et al., 2021).

Arguably, 'nature-based cities' characterise key new directions for the future of sustainable and liveable cities, with the inclusion of nature in city design, development and renewal. With sustainability and climate change challenges, as well as an increasingly urbanised human population, integrating nature-based solutions into city development and operation is critical. Nature-based cities actively identify opportunities for integration of nature-based solutions into the urban fabric, into infrastructure systems, and into the urban places that people love and care for. The next section highlights the benefits for urbanites of greening cities.

3. Urban green spaces and benefits of urban nature

More than 15 years ago, research highlighted the contribution of urban parks for sustainable cities (Chiesura, 2004). Since then, research on urban parks and urban greening has significantly expanded to focus on the functions, contributions and roles of urban nature. Frameworks include ecosystem services, green infrastructure, nature-based solutions and nature's contributions (nature for nature, for society and for culture). 'Nature for nature' encapsulates the provision of habitat for biodiversity and emphasises the intrinsic value of nature (Oke et al., 2021). 'Nature for society' represents the utilitarian values of nature, including provision of drainage, temperature mitigation, climate resilience, air and water quality functions (Oke et al., 2021). 'Nature for culture' acknowledges the importance of people's connections with nature, and the benefits of social cohesion, community connection, educational, and spiritual benefits (Oke et al., 2021). These "non-material benefits that individuals receive from nature" (Taylor et al., 2020) are particularly relevant in urban contexts, where people's preferences and needs can influence the direction of policy making. The following sections present research findings that demonstrate these important environmental, social, health, economic and cultural benefits realised by healthy urban green spaces.

3.1. Environmental sustainability benefits

Healthy ecosystems, with biodiverse plant and animal species, healthy soils and active ecological processes generate multiple functions and benefits, and indeed underpin environmental sustainability and ecosystem functions on which all our lives depend. Conserving a city's network of green spaces is vital to supporting healthy ecosystems that can maintain this biodiversity, and preserve the biophysical functions of healthy soil (Haase et al., 2014). Urbanisation negatively impacts the number of different flora and fauna species present in a given landscape (species richness), as well as their relative abundance in that same environment (species evenness); these are important metrics that describe an ecosystem's stability and ability to generate ecosystem services (Gotelli and Colwell, 2001). Sustaining and actively managing a connected network of diverse green spaces and environments supports the delivery of ecosystem functions (Ahern, 2013, Benedict and McMahon, 2006).

Neighbourhood parks, street trees, and other green spaces also act as regulators of microclimates: they effectively lower air temperatures, filter air pollution, absorb rainfall and solar radiation, contributing to increased liveability (Mell, 2009). These functions are particularly important in areas prone to heat-island effect, pollution and flooding, either due to their geographic location or to extensive presence of impermeable and heat-absorbing building materials (Feyisa et al., 2014). Australian cities are increasingly exposed to the impacts of urban heat, with the urban heat island effect adding several degrees of warming to urban areas, and climate change further amplifying the severity, frequency and duration of heatwaves (Duncan et al., 2019). Vegetation is one of the most effective mitigators of urban heat stress (Hatvani-Kovacs et al., 2018), which can prove deadly, so inclusion of green spaces, street trees and well-watered urban vegetation is an increasing focus for Australian cities (Norton et al., 2015, Ossola and Lin, 2021). Research has highlighted the importance of planning urban landscapes and selecting species that can cope with increasing urban temperatures and changes to water availability (Ossola and Lin, 2021).

As fundamental components of wider ecological networks that sustain biodiversity, urban green spaces also ensure the continuation of ecological processes that provide humans with essential life services (Beaujean et al., 2021). Vegetation, and in particular broad-leaf trees, filter the air removing toxic pollutants and particulate matter in and around cities (Kessler, 2013). This process, called phytoremediation, also occurs below ground, where contaminated soil and water are processed and removed by biological plant processes (Peng et al., 2012). A healthy, connected urban forest also acts as a carbon sink by sequestering carbon dioxide, much of it having been released by human activities taking place in cities. The urban forest can therefore play a role in climate change mitigation (Endreny et al., 2017, Hausmann et al., 2016).

Both vegetation species diversity and structural composition are important for habitat provision. Key attributes that drive habitat quality include the density of large native trees, the volume of understorey vegetation and the percentage of native vegetation: increasing the habitat value of urban green spaces can be supported with use of locally indigenous (native) species and increasing vegetation complexity (trees, shrubs and understorey) (Threlfall et al., 2017). Some studies globally have found that vegetation structural attributes can be as important, or more important than plant species composition, as a predictor of biodiversity and habitat value for certain faunal taxa, with increased habitat value with greater structural complexity (multiple vegetation strata) (Threlfall et al., 2016). On the other hand, research in Australia on urban biodiversity and habitat provision has found that the use of indigenous species in parks and private gardens can increase species richness and abundance of native wildlife, thereby improving the biodiversity of the local area (Shaw et al., 2017). While mown lawn provides minimal habitat (Davern et al., 2017), decreasing the frequency and altering the timing of mowing can increase invertebrate diversity (Parris et al., 2018). As well as providing significant biodiversity habitat, indigenous species can also connect with the local area's unique 'sense of place' and cultural heritage (Cumpston, 2020), aspects which are considered further in Section 3.4.

To effectively contribute to environmental sustainability, it is important that urban planners strive to design green spaces that combine recreational and aesthetic uses with biodiversity conservation outcomes (Beaujean et al., 2021). For urban green spaces to continue to provide the range of benefits and functions that humans enjoy, and on which their survival and quality of life depends, it is necessary to ensure urban ecosystems are healthy and thriving, enabled by biodiversity and ecosystem services.

3.2. Health and wellbeing benefits

The relationship between cities and human health has been recognised and promoted by global organisations and frameworks including the World Health Organisation and the UN's Sustainable Development Goals, with associated frameworks and policy guidance documents to contribute to sustainable urban development (Douglas et al., 2017). A great proportion of the most common chronic health conditions can be attributed to modern lifestyles: people live in densely populated urban centres, spend increasingly longer periods of time indoors, often using technological devices as a substitute for in-person interactions, while time spent outside has steadily decreased (Frumkin et al., 2017). Modern life "irritants" such as crowded places, elevated urban temperatures, noise pollution and particulate matter have been linked to compromised ability to self-regulate emotions and responses to external stimuli (Wolf, 2017). These, in turn, have been linked to higher chances of aggression and violence (Bratman et al., 2012). Increasing attention has therefore been directed at strategically redeveloping urban environments that generate a cascade of health benefits that are accrued over an entire lifetime, from birth, throughout a child's early development, and until old age (Douglas et al., 2017, Syrbe et al., 2021, Wolf, 2017).

Urban green spaces have been linked to improved mental and physical health through direct contact with different types of biodiversity and habitats, and decreased exposure to pollutants, UV radiation, and extreme heat (Wolf et al., 2020). Evidence also shows that 'good' bacteria living on urban plants can protect humans from harmful diseases (Haase et al., 2014). Other more indirect pathways include the promotion of outdoor activities like social gatherings, physical exercise, mindfulness practices, family events and weekend hobbies (Douglas et al., 2017, Kondo et al., 2015). Positive correlation has been found between exposure to greenery and cognitive function, making nature-based therapy a strong tool to help individuals suffering from ADD and ADHD (Frumkin et al., 2017). Direct contact with nature also reduces anxiety, stress and depression (Frumkin et al., 2017, Kondo et al., 2015, Wolf et al., 2020), and may be a predictor of higher academic performance (Wolf et al., 2015). Research also found correlation between living in proximity to green spaces and tree canopy with lower odds of developing conditions like diabetes, hypertension, cardiovascular disease, stroke and arteriosclerosis (Astell-Burt and Feng, 2019, Syrbe et al., 2021). Time spent outdoors correlates with lower obesity rates, one of the leading causes of premature death worldwide (Wolf et al., 2020). Residing and spending time near large trees with high canopy was found to reduce sleep disorders (Syrbe et al., 2021). Studies on Alzheimer found higher and increasing recurrence of aggressive assaults amongst patients in facilities without open green spaces, and the creation of gardens had a positive effect on reducing such episodes (Kuo and Sullivan, 2001).

The issues of proximity and accessibility to nature has become particularly evident during the Covid-19 pandemic, and especially during the lockdowns established around the world to counteract the spread of the virus. Surveys in nations severely hit by the pandemic revealed that individuals living further from parks were less likely to (or in some cases restricted from being able to) cover the extra distance to exercise and spend time in urban green spaces (Ugolini et al., 2020). These people therefore missed out on the health and well-being benefits provided by regular exposure to urban nature, potentially intensifying the detrimental effects of social and physical isolation (Priess et al., 2021, Ugolini et al., 2020).

Failure to ensure adequate access to urban nature has the power to deprive people of life-enriching experiences, resulting in increased current and future health costs (Chiesura, 2004). Residents of economically disadvantaged areas are more likely to be exposed to environmental hazards, which negatively impact on health (Douglas et al., 2017, Kondo et al., 2015). Prolonged exposure to unhealthy environments triggers the release of stress hormones that can lead to poor health outcomes related to inflammatory conditions (Kondo et al., 2015). Inflammatory changes in cardiovascular, neurological, and endocrine systems have recently become the object of extensive research as potential culprits behind a host of psychological and physical conditions, associated with accelerated ageing and disease (Bird et al., 2018).

3.3. Social benefits

Beautification and co-management of green spaces encourage social cohesion and increase trust levels amongst members of the community or neighbourhood (Alaimo et al., 2010). In turn, researchers have suggested that social cohesion may be an important determinant of behaviour and lifestyle choices: individuals who feel connected to their community are more likely to engage in environmental and sustainable practices and less likely to smoke, use drugs, and become involved in organised crime (Kondo et al., 2015, Prévot et al., 2018, Wolf, 2017). Urban green spaces provide dedicated places for people to meet, exercise, and socialise, effectively counteracting the impacts of infrequent social interactions and loneliness, which are associated with a range of human health concerns (Holt-Lunstad et al., 2015). This is especially true for the elderly, as spending time outdoors strengthens their social connections, lowers early mortality, suicide rates, and fear of crime, all the while improving their physical health (Holt-Lunstad et al., 2015, Syrbe et al., 2021, Wolf, 2017). Even small green spaces can provide social benefits: a study conducted in three cities in Australia and New Zealand revealed that green wedges and nature strips can be used as extensions of people's homes for small gatherings and events, creating a sense of community among neighbours (Taylor et al., 2020).

The presence of trees and vegetation has been associated with both the existence and prevention of crime, reflecting people's complicated relationships with the place of nature in cities. While clearing of vegetation along roads and in public thoroughfares, to increase visibility and eliminate hiding spots, has been practiced to deter crime, research has shown that the presence of vegetation is not a predictor for increased criminal activity (Kuo and Sullivan, 2001). On the contrary, widely spaced tall trees and gardens may actually hinder crime (Kuo and Sullivan, 2001, Wolf, 2017). This might be because well-maintained green areas are perceived as 'territorial markers' that indicate the presence of a vigilant, meticulous and tight-knit community (Kuo and Sullivan, 2001). The increased surveillance, real or perceived, acts as a deterrent for vandals and criminals, who avoid the areas out of fear of being caught (Wolf, 2017). Other possible mechanisms by which urban green spaces can reduce crime are by mitigating some of the psychological precursors to violence, and alleviating mental fatigue (which is characterised by symptoms such as irritability, inattentiveness and decreased impulse control, all of which are known to lead to aggression) (Kuo and Sullivan, 2001). Finally, by appealing to parents and guardians as well as children, parks also record higher levels of adult supervision compared to concrete playgrounds, reducing incidence of aggression towards minors (Kuo and Sullivan, 2001). While it is acknowledged that a range of other potential confounding factors might be at play, analysis has isolated the effects of such factors, and determined that presence of parks with tall trees was the main predictor of lowered crime rates (Kuo and Sullivan, 2001).

3.4. Sense of place and cultural heritage benefits

Plants and nature are often important elements in creating a 'sense of place' (Bush et al., 2020). 'Sense of place' emerges through our interactions with our biophysical environment (Masterson et al., 2017). 'Sense of place' includes the meanings and attachment that individuals or groups hold for a place (Tuan, 1977). Place *meanings* are the descriptive narratives and symbolic understandings, while place *attachment* is the evaluative emotional bond with the environment (Frantzeskaki et al., 2018, Masterson et al., 2017, Stedman, 2016). 'Sense of place' provides a window into understanding how we connect with our local environments and the emotional meanings that we associate with places. It is often the natural elements of place that provide the strongest building blocks for the stories and connections to place; the natural elements, the sounds and smells as well as the sights, can underpin our memories of favourite places and provide evocative links to memory and identity (Bush et al., 2020).

The contribution to sense of place is also a strong argument for the use of native plants (Dagenais et al., 2018), particularly those native to the local area. Locally native (indigenous) plants connect directly and uniquely with the ecological and cultural heritage of place; in Australia, indigenous plants hold "cultural stories and great cultural and ecological importance for many Aboriginal and Torres Strait Islander people in Australia" (Cumpston, 2020). Aboriginal People's knowledge of their local plants includes "medicinal, nutritional and technological use of plants (such as traps, nets and weapons) developed over many, many millennia" (Cumpston, 2020). As such, using indigenous plants in parks and gardens provides "ongoing opportunity to learn on Country: gardeners and visitors will be able to interact with plants, smell, touch and taste, whilst they learn. This is an Indigenous way of knowing and learning, it is experiential learning: learning through doing, smelling, tasting, seeing, feeling, sharing and talking" (Cumpston, 2020). Indigenous plants "tell stories about the cultural belonging of Indigenous peoples and allow a portal into the rich cultural and ecological knowledges held by Indigenous peoples … they illuminate the specific identity and history of landscapes" (Cumpston, 2020).

Using indigenous plants in designed, curated and managed landscapes may contribute to building ecological literacy and shifting aesthetic appreciation towards the forms, colours, sizes, shapes, textures and scents of the flora that is unique and specific to the local area.

3.5. Economic benefits

Urban green spaces can generate substantial economic benefits. There is a complicated relationship between the costs and benefits of green spaces, and the recipients and beneficiaries of these. The economic perspectives raise questions of the distribution of green spaces throughout urban areas and associated equity of access, highlighting the importance of integrating a diverse, connected network of green spaces throughout the city. This section considers a range of economic aspects associated with urban green space provision.

In many cities, property prices have been found to be higher near urban parks and green space, reflecting the increased value that many attach to living close to parklands and green space (Engström and Gren, 2017, Kim et al., 2018). Much of the research that examines the relationship between house prices and proximity to parkland adopts 'hedonic pricing' analysis, which aims to capture a consumer's willingness to pay for specific characteristics that add or detract from the intrinsic value of an asset or property (Engström and Gren, 2017). However while the relationship between increased property prices and proximity to green space is well established in many cities, further analysis has indicated that different features or characteristics of the open space can impact this relationship, including population density, distance to, and the type of, urban nature (Bockarjova et al., 2020). In urban Australia, Breunig et al. (2019) found that nearby playgrounds add to property prices. Czembrowski et al. (2019) reinforced multifunctionality of green spaces as well-recognized and highly valued by real estate buyers: the higher the number of characteristics an urban green space has, the stronger its impact on property prices in their study in Stockholm.

The tensions between property development objectives for capitalizing on land value with urban planning objectives for equitable park access are also highlighted in much of the research on this topic (Schwarz et al., 2021). The "positive feedbacks between certain forms of urban greening and property prices" has been associated with processes of gentrification: "the establishment of parks has long been used to raise the price and profile of surrounding neighbourhoods" (Cooke et al., 2020, 174).

However, the interaction of parks, housing prices and gentrification processes should be considered in the wider context of the operation of real estate markets. In an urban renewal project in Leipzig, Ali et al. (2020) found that the creation of a park had indeed "operated as a trigger for structural, social, and symbolic upgrades in the growing city of Leipzig, but only in combination with real estate market developments, which are the main drivers of change".

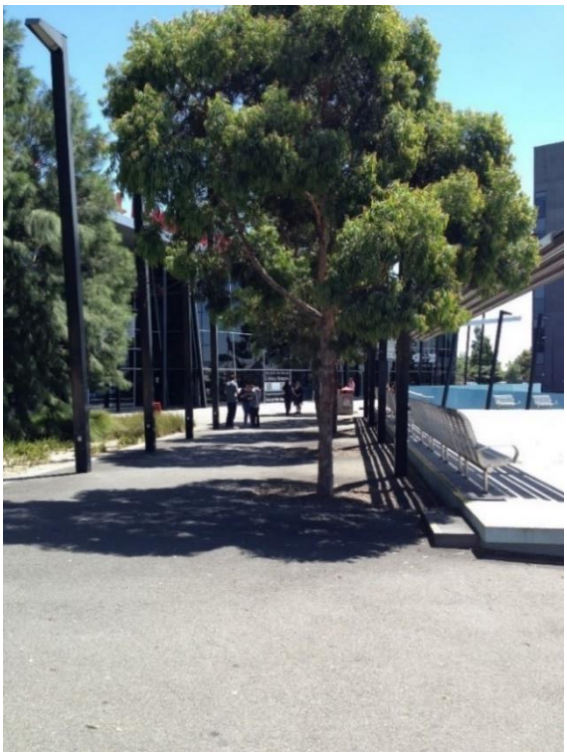
Gentrification processes are critiqued for displacing existing residents and for exacerbating inequities in access to parks and other facilities (Bockarjova et al., 2020, Cooke et al., 2020). In response, urban planning and housing policies may adopt measures that seek to ensure equitable distribution of green spaces across cities, and to counter displacement processes associated with gentrification and unaffordability, including through engaging public agencies, advocates, and developers to achieve equitable greening outcomes (Gibbons et al., 2020). From a property development perspective, the potential for increased property prices in proximity to parklands could act as an incentive for private developers to incorporate additional green spaces above mandated minimum requirements, as the additional land allocated for parks could be compensated via higher prices for stock sold.

Other enviro-economic perspectives

A healthy urban tree network can reduce the costs associated with heating, cooling, and stormwater processing (Endreny et al., 2017, Hausmann et al., 2016). As exemplified by the case studies presented in this report, some of the most successful global examples of sustainable urban regeneration include greening strategies that have transformed them into well-known tourist attractions. This exemplifies how urban nature can become a source of revenue when it attracts tourism (Bateman et al., 2013). The economic benefits associated with urban green spaces also include increased economic activity associated with attractive urban landscapes and streetscapes (BOP Consulting, 2013, Rogers et al., 2012). In terms of cost savings, researchers have estimated the potential value of the health, well-being, and public safety benefits of urban nature to be between $2.7 and $6.8 billion (USD) per year for USA (Wolf et al., 2015). While the authors acknowledged some limitations of their approach, they do however point out that the results represent an underestimation of actual cost savings enabled by urban greening, as only a subset of benefits was used for their calculations.

Carbon footprint assessments have calculated that built environments, including the construction and maintenance of buildings, are responsible for a considerable share of global greenhouse gas emissions (IEA and UNEP, 2018). The property sector is also particularly susceptible to the impacts of climate change, including physical impacts such as sea level rise, extreme weather events and extreme temperatures, or economic impacts on property prices, and cost and availability of insurance cover (Warren-Myers et al., 2021). This has led to private property developers being identified

as key stakeholders in cities to contribute to addressing climate change and environmental degradation. In Australia, discussions around the concept of climate risk have been increasingly permeating the property sector, despite the country lacking a coordinated and proactive policy approach to climate adaptation (Warren-Myers et al., 2018). A range of climate change 'frontrunners' have emerged in the Australian property sector, who, through the creation of dedicated sustainability teams, are accounting for the impacts of future climate scenarios on their planned activity (Warren-Myers et al., 2021).



Property sector 'frontrunners' have the potential to demonstrate significant leadership through 'best practice' examples of climate change action (Warren-Myers et al., 2021), and through inclusion of urban green spaces for healthy, vibrant and liveable cities (Bush et al., 2021). Demonstrating frontrunner and leadership approaches to urban development, through a focus on sustainable urban design, contributes towards meeting corporate social responsibility objectives and as well as pushing 'thought leadership' perspectives for environmentally and socially sustainable housing and challenging the status quo of established housing markets (Doyon and Moore, 2019, Moore and Doyon, 2018).

4. Multifunctionality: sharing green space for multiple uses

In cities, where land is at a premium, and with competition between different types of land use, multifunctionality of urban green spaces is an important consideration. As discussed in the previous sections, research has found that green spaces provide multiple functions and benefits for both human and non-human urban residents. To successfully deliver the range of functions and ensure healthy and thriving cities, design and management of green spaces must embrace both multifunctionality and interdisciplinarity. This section discusses these considerations and presents a framework, informed by research, for design of thriving multifunctional urban green spaces for nature-based cities.

Research has provided considerable evidence of how healthy green space networks contribute to urban environment and climate, and to people's health and wellbeing. The realisation of these benefits through greening strategies requires effective collaboration across disciplines to achieve a balance between environmental, social, cultural and economic gains. To overcome the complexity of interdisciplinarity, a plethora of initiatives have been launched by agencies such as the European Commission to facilitate the exchange of knowledge and experiences between researchers, practitioners, policy-makers, and private developers (Lafortezza and Sanesi, 2019). People use urban green spaces for a variety of purposes, highlighting the responsibility of city-makers to cater for multiple user groups (Douglas et al., 2017). In research focused on cities in Australia and New Zealand, park visitors were found to value both the presence of nature and biodiversity, as well as park facilities such as playgrounds and exercise equipment; "many interactions were also serendipitous …. due to proximity of urban parks near residential areas, businesses and transport hubs, or as extensions of their homes" (Taylor et al., 2020). In a study of Twitter posts associated with green spaces in Melbourne, researchers found that "all parks generate positive sentiments, [and] they evoke different levels of emotions based on the types of activities that take place in each park" (Lim et al., 2019, 97). They found that popular activities in larger parks often involved food, drinks, and events (Lim et al., 2019).

Urban design must therefore be intentional: stakeholder engagement practices must be adopted during the design phase to ensure parks foster positive connections between communities, address local needs and boost liveability (Madureira and Andresen, 2014, Mell, 2009, Wolf, 2017). This requires the understandings of specific motivations of local users (utilising both qualitative and quantitative indicators and data), and might result in the re-assessment of size, location, and distribution of parks across a defined landscape (Ugolini et al., 2021). Several studies have identified patterns of uses and preferences that correlate with age and cultural background. For example, in Europe, older people are interested in meeting at parks and gardens to experience nature (or even wilderness), enjoy tranquillity, and spend time in beautiful surroundings, while younger age groups use parks to exercise and use sports facilities, placing more importance on size, availability, and location of frequently used green areas (Palliwoda and Priess, 2021, Priess et al., 2021). In China, on the other hand, individuals over 60 frequent parks to exercise and socialise, suggesting cultural differences in motives for park visits and ecosystem service use between countries (Priess et al., 2021). For these reasons, transferring design ideas across geographic locations should first carefully account for local social and environmental variabilities, and explore the potential synergies, conflicts and trade-offs among different functions (Chiesura, 2004, Madureira and Andresen, 2014, Priess et al., 2021).

The multifunctionality of urban greenery extends beyond its uses by humans. Cities are important sites for nature conservation and biodiversity. Australian cities provide habitat for threatened species (Ives et al., 2016), and some threatened species are found only in cities (Soanes and Lentini, 2019). Even small nature reserves can make important contributions to biodiversity conservation (Kendal et al., 2017). For example, small patches of green space on school grounds provide stepping stones for species dispersal (Iojă et al., 2014). Research has also found that golf courses can have exceptionally high ecological value, holding the potential to promote pollination and the natural control of exotic species (Colding and Folke, 2009, Threlfall et al., 2016).

5. Designing parks and urban green spaces

This report has highlighted the substantial research demonstrating the benefits of urban green spaces, and the wide range of functions and contributions that nature makes towards creating liveable and sustainable cities. It is increasingly apparent that in the design and development of urban areas, as well as in urban renewal processes, there needs to be significant focus on inclusion of well-designed urban green spaces. To support this process, we identify from research the key elements that should be considered and incorporated into urban green space design. The framework brings together research on *nature's contributions* with research on *designing parks for health and well-being across a life course* (Chiesura, 2004, Douglas et al., 2017). 'Nature's contributions' (Díaz et al., 2015, Oke et al., 2021) are conceptualised across three categories:

- 'Nature for nature': nature's intrinsic value, biodiversity and habitat; nature for nature ensures ecosystems are healthy and thriving and therefore able to provide the associated contributions to society and culture;
- 'Nature for society': nature's utilitarian values, climate resilience, air & water quality, urban heat mitigation;
- 'Nature for culture': community cohesion, physical & mental health & wellbeing; connection with nature.

Urban parks and green spaces play essential roles in providing 'nature's contributions' to urban residents. "Besides many environmental and ecological services, urban nature provides important social and psychological benefits to human societies, which enrich human life with meanings and emotions … results confirm that the experience of nature in urban environment is source of positive feelings and beneficial services, which fulfill important immaterial and non-consumptive human needs" (Chiesura, 2004). Across human life stages, green spaces provide a range of different functions and benefits, with "health and well-being benefits accruing from green space from prenatal development through childhood, adolescence, adulthood and old age" (Douglas et al., 2017). Importantly, "different green space configurations afford different activities and promote different physical and psychological responses for different age groups" (Douglas et al., 2017). Therefore, to effectively meet the range of needs across the human life course, urban green spaces need to include a range of different spaces, elements and features that can support different activities and experiences: active; social; adventure; nature connection and visitor facilities. Furthermore, with competition for space in cities, particularly in denser urban areas, green spaces need to be multifunctional and designed effectively to maximise these functions and benefits.

These conceptualisations can be brought together into a combined framework (Table 1) that can be used to both assist in planning urban green spaces, as well as to analyse and assess the effectiveness of proposed precinct designs that incorporate urban green spaces. Best practice urban green space design should seek to incorporate as many different elements as possible from the framework.

Table 1 Designing urban green spaces for nature-based cities

Nature's contributions	Key functions	Design elements
Nature for nature	Biodiversity habitat	Indigenous species Vegetation structural complexity Diverse, connected network Nature connection for people
Nature for society	Climate regulation, cooling Water management, runoff Air quality Carbon sequestration Urban agriculture, food production	Tree canopy Well-watered vegetation Pervious surfaces
Nature for culture	Community connections Social cohesion Health and wellbeing Economic activity	Active Social Adventure Nature connection Visitor facilities (including commercial facilities)

6. Case studies

To complement and illustrate the findings from the research review presented in the previous sections, seven international case studies of sustainable urban renewal are presented to highlight the range of environmental, economic, social and cultural benefits of integrating green-blue infrastructure and nature-based solutions in areas of urban renewal.

The case studies have been selected based on three criteria: they are mixed use, multifunctional projects; they include green urban spaces as one of their land-use types; they illustrate a range of uses and functions, funding sources, and motives for redevelopment.

The case studies are grouped based on their geographic region:

- Asia Pacific
    - Barangaroo, Sydney (Australia)
- North America
    - Red Hook, New York (USA)
- Scandinavia
    - Hammarby Lake City, Stockholm (Sweden)
    - Bo01, Malmö (Sweden)
- Western Europe
    - Passeig De Sant Joan, Barcelona (Spain)
    - Westerpark, Amsterdam (the Netherlands)
    - Zorrotzaurre, Bilbao (Spain)

Data for the case studies has been drawn from peer-reviewed academic research as well as other sources including government websites, city reports and industry papers.

6.1. Case Study 1 Barangaroo, Sydney (Australia)

Overview

Barangaroo waterfront development is located at East Darling Harbour in Sydney. The area operated as container terminal throughout the 20th century. In 2003, the New South Wales government rezoned the area to transform it into a mixed-use public and private community. The 22-hectare project comprises three precincts: Barangaroo South, Barangaroo Central, and Barangaroo Reserve.

Environmental benefits

The project has ambitious environmental and sustainability goals. To achieve the vision of being "carbon neutral, water positive, to create zero waste emissions and contribute to community well-being" (Barangaroo Development Authority, 2017c), the project initially involved the remediation of contaminated land. A combination of green and grey infrastructure was built to mitigate the impacts of climate change and reduce reliance on natural resources (Barangaroo Development Authority, 2017a). A sea wall provides a barrier from future sea level rise, buildings use non-reflective thermal efficient materials to reduce heat-island effect, and incorporate shade and cooling elements like vertical gardens, green roofs and awnings to reduce ventilation needs (Lehmann, 2019). Energy for the site is produced from solar and co-generation systems (Lehmann, 2014), and rainwater capture and grey water recycling systems were installed which contribute to the goal of water positivity (Lehmann, 2019). Barangaroo is also the first urban redevelopment in Sydney to use 100% Australian carbon credits to achieve carbon neutral certification (Lehmann, 2014). The site includes a nature reserve that was revegetated with 75,000 native trees, plants and shrub belonging to over 80 species indigenous to the Sydney region (Leake and Bryce, 2019). The parkland also includes gardens, lookouts, walking and bike trails, and tidal rock pools (Barangaroo Development Authority, 2017b). Open public spaces cover almost half of the site, with a continuous 30-metre-wide public foreshore walk (Lehmann, 2014, Lehmann, 2019).

Social and economic benefits

While the project has a marked focus on sustainability and reducing the site's ecological footprint, the two precincts of Barangaroo South and Barangaroo Central were designed to revitalise the local economy and link the area to Sydney's central business district.

Barangaroo South and Central include residential apartments for 3,500 new residents, commercial and retail spaces, tourism and cultural buildings, and a network of green and open spaces, all of which are expected to contribute two billion dollars a year to the New South Wales economy (Lehmann, 2019). The project includes features that promote a greater involvement with Sydney's Aboriginal history (Barangaroo Development Authority, 2017a). For example the Wulugul Walk, completed at the end of 2020, runs along Sydney Harbour waterfront and joins the 14 km walk from Glebe to Woolloomooloo (Barangaroo Development Authority, 2017a).

Key lessons and success factors

Barangaroo is one of Australia's largest urban renewal projects, with a strong focus on climate adaptation and ambitious goals to have a small ecological footprint on the environment (Lehmann 2019). The developers transformed a concrete-heavy industrial area into a vibrant and eclectic mixed-use precinct. The project was however at the centre of an extended debate around the state government's decision to favour private commercial activities, like the much-criticised Crown Resorts Casino, instead of re-zoning the area for public use.

6.2. Case Study 2 Red Hook, New York (USA)

Overview

The suburb of Red Hook is located in the Borough of Brooklyn, New York. Once a successful industrial port, its landscape is characterised by a high density of low-rise brick warehouses (Simon, 2010). Red Hook's slow decline had already begun by the beginning of the 20th century due to a delocalisation of productive activities (Daly, 2015, Simon, 2010): buildings were slowly abandoned, organised crime became established in the area, and homelessness rates increased. Red Hook today is still characterised by degraded socio-economic conditions. More than two thirds of its residents live below the federal poverty line, and over 50% live in social housing complexes (García Sánchez et al., 2018). The neighbourhood was also severely impacted by Hurricane Sandy in 2012. It is estimated that 78% of its surface and 66% of its buildings were damaged, highlighting the urgent need to redevelop the area integrating nature-based solutions and green infrastructure to increase its resilience to future climate change-related events (Garcia Sanchez et al, 2018). Further, due to its low-lying position and geographic location, Red Hook is at risk from sea-level rising, flooding, and extreme weather events like hurricanes and heat waves (Garcia Sanchez et al, 2018). The NY Rising Community Reconstruction Program is a publicly funded project with the double aim of reducing flood risk and increasing community preparedness to emergency management (NYRCR, 2014).

Environmental benefits

One of the main strategies of the Program is the creation of an interconnected network of green urban spaces, especially along the waterfront, to create a coastal protection system as an effective climate change adaptation tool (Garcia Sanchez et al, 2018). Parks and gardens moderate the impacts of the urban heat-island effect, making the neighbourhood healthier and more liveable (Garcia Sanchez et al, 2018). Larger and higher-elevation green areas achieve the additional function of providing space to set up post-disaster aid and emergency services (NYRCR 2014), while a vegetated roof provides access to additional green space connected to nearby parks (KPF Architects, 2021). Other complementary strategies, such as Red Hook's Integrated Flood Protection System, combine green infrastructure such as landscaped berms and vegetation, with more traditional grey infrastructure including storm surge barriers (Aerts et al., 2013). Other elements of the redevelopment include improvements to the sewage network, the installation of photovoltaic panels, and establishment of a micro-grid to ensure Red Hook's access to electricity in case of emergency (NYRCR, 2014).

Social and economic benefits

The project generates important social benefits for the local community, including the strengthening of cohesion between residents and local entrepreneurs, and enhanced resilience associated with the establishment of a network of relief centres throughout the neighbourhood (NYRCR, 2014). These provide both physical and informational resources during periods of crisis, as well as aid for post-disaster recovery. The developers of Red Hook Houses, one of the new residential areas included as part of the redevelopment, required input from the community to bring local knowledge into all phases of the design (KPF Architects, 2021). The increased preparedness and resilience that the Red Hook redevelopment achieves will generate significant future economic savings for both the public and government.

Key lessons and success factors

The strategies for the redevelopment of Red Hook provide examples of innovative adaptation strategies that use green spaces in urban renewal precincts to achieve greater urban resilience (Garcia Sanchez et al, 2018).

6.3. Case Study 3 Bo01, Malmö (Sweden)

Overview

Bo01 is located in Malmö's Western Harbour precinct, previously an industrial estate and port left derelict after a recession in shipbuilding in the 1970s (Naturvation, 2018b). It is a 30-hectare sustainable residential district, initially built for the European Housing Expo in 2001 and branded as 'the City of Tomorrow'. Bo01 is part of a mixed-use urban development precinct that includes a commercial section which employs ~17,000 people, as well as education facilities such as schools, pre-schools and a University (Flurin, 2017).

Environmental benefits

From an environmental perspective, Bo01 includes a network of green and blue spaces that provide habitat and breeding grounds for species including seabirds, insects, bats, salamanders, frogs, fish, shellfish and crustaceans (Kruuse, 2011). Each residential garden is home to at least fifty varieties of plants, while green roofs and walls reduce the need for grey infrastructure for stormwater processing (CABE, 2005). The precinct is also strongly focussed on resource efficiency: rainwater is harvested and recycled, and 100% of energy requirements are met from renewable sources (Naturvation, 2018b). An experienced ecologist was hired to give advice on design elements of the project and conduct annual biodiversity surveys to estimate population numbers and trends (Austin, 2013, Kruuse, 2011). Bo01 is considered the first generation eco district (Flurin, 2017). Amongst its most unique elements figures the concept of Green Space Codes: based on a system of points, for each lot architects and developers could choose from a list of green measures to reach a minimum score (CABE). This fostered innovation and diversity, and resulted in the creation of natural areas with distinct functions and identities (CABE, 2005).

Social benefits

The eco-district has been extremely successful both in regard to its appeal to new occupants, as well as in terms of its impacts on people's perceptions of nature. In fact, a survey found that people's value of yards and parks increased after the redevelopment was completed (Kruuse, 2011). Bo01 has become a popular place in Malmö for sports and recreation, and some of its design features such as the green courtyards provide spaces for residents, workers and students to meet and play (Naturvation, 2018b).

Economic benefits

The level of innovation and focus on sustainability introduced in Bo01 resulted in the value of residential properties to double over a period of just six year (Flurin, 2017). While this achieved the objective to revitalise the area, it also attracted criticisms for creating an exclusive community for wealthier people, rather than a model of 'sustainable living' for everybody to partake in (Flurin, 2017).

Key lessons and success factors

Completion of the project required a high degree of technical innovation to achieve its ambitious sustainability goals, however it did rely on public consultations to make it less technocratic and more inclusive (Flurin, 2017). The result is a highly successful example of ecosystem design, used intensively by residents and visitors, where green and blue spaces are integrated with other more traditional grey infrastructure elements (Delshammar et al., 2015).

6.4. Case Study 4 Hammarby-Sjöstad, Stockholm (Sweden)

Overview

Hammarby Sjöstad, literally Hammarby Lake City, is located in Stockholm's inner city on the shores of Lake Hammarby Sjo. Previously an industrial area for the Luma Factory, a modernist lamp factory built in the 1930s (Jauhiainen, 2007), it was intended to become the Olympic Village for the 2004 Olympics. The city lost the bid to Athens, however the regeneration projects went ahead (Mahzouni, 2015). The 200-hectare precinct includes 12 sub-neighbourhoods, which on the whole comprise a residential precinct for 20,000 people, commercial activities, and a network of open and green areas for recreation and urban nature conservation (Baltic Urban Lab, 2018). The developers defined Hammarby's goal as being a sustainable community that would be twice as efficient as a standard one, and for 80% of residents to commute to work by public transport, walking or biking (Baltic Urban Lab, 2018).

Environmental Benefits

Hammarby's natural environment includes a 19-hectare network of structural and functional urban green areas, designed for transport and recreation as well as urban biodiversity conservation (Vall, 2018). Parks and green corridors are connected to green wedges at the boundaries of the precinct, as well as to nature reserves and forests outside these boundaries (GlashusEtt, 2007). An eco-duct, or a planted viaduct over the highway, was also created. "Natural areas of particular value were protected from development. Development of previously undeveloped green public spaces was compensated for by creating biotopes that benefit biological diversity in the immediate area" (GlashusEtt, 2007). Bo01 in Malmö was used as inspiration for Hammarby's regeneration model, which was taken to an even further level. In fact, to achieve the project's ambitious sustainability goal, the developers devised the so-called Hammarby Model (Crewe and Forsyth, 2011). This includes the design and installation of a centralised stationary vacuum system for waste management called Envac (which was later exported to other similar sites abroad), generating power from 100% renewables (solar, waste, and water), and a stormwater remediation system including green roofs and walls (Crewe and Forsyth, 2011).

Social benefits

The project also achieves high levels of social inclusion and cohesion through its family-friendly features and focus on environmental education (Crewe and Forsyth, 2011). The green corridors are pedestrian friendly and encourage people to spend time outdoors in nature, while frequent connections with buses encourage low-carbon transport alternatives. An Open Space Standard was also developed whereby all common and social areas have a minimum of 4-5 hours of sunlight exposure each day to promote people's health, and all apartments have a courtyard (GlasHusEtt, 2007). The redevelopment is also designed to foster people's connection with water through features like waterside lawns, and water-facing residential buildings (Vall 2018). The precinct also involved the opening of GlashusEtt, an environmental education centre that provides information to residents and visitors on sustainable urban planning (Crewe and Forsyth, 2011).

Economic benefits

Like Malmo, the creation of the Hammarby 'eco-town' triggered a quick rise in property value, turning the area from a declining industrial district into a world-famous mixed-use infrastructure model to be replicated in other cities (Crewe and Forsyth, 2011). The quick rise in real estate value attracted criticisms related to affordability and social inclusion.

Key lessons and success factors

The success of Hammarby Sjöstad can be mostly attributed to the innovative integrated system of the Hammarby Model. This inspired the design of several other urban regeneration projects from North America to Asia (Moore, 2016).

6.5. Case Study 5 Boulevard of Passeig de Sant Joan, Barcelona (Spain)

Overview

Despite being located within Barcelona's tourist area and one of the city's main avenues, until recently Passeig de Sant Joan was a concrete-dominated street, with high levels of car traffic and little vegetation. These factors, together with the lack of public space infrastructure, contributed to high temperatures in summer, and to the environmental and social degradation of the area (Oppla, 2021). Between 2009 and 2015 the city council completed the redevelopment of the Passeig, transforming it into Barcelona's first green corridor (Naturvation, 2018a, Oppla, 2021). The project had three goals: to increase the ecological connectivity of the boulevard to the city's network of parks and green corridors, to increase access to functional green space while creating a 'slow-living' atmosphere for local residents and visitors, and to rejuvenate the local economy by creating the conditions to attract better business for local entrepreneurs (Kotsila et al., 2020).

Environmental benefits

Several of the design attributes of this project make it quite remarkable in the sphere of green urban regeneration. It is one of the earliest examples of green infrastructure that aims to achieve the three main pillars of sustainability: economy, environment, people. The masterplan achieves this by introducing multifunctional design elements that provide a multitude of benefits to its users. For example, the enlarged 17-metre-wide footpaths includes 6 metres for pedestrian circulation, and 11 for vegetation, kids' playgrounds, bar terraces and resting areas (Kotsila et al., 2020). The semi-permeable pavement, which alternates tiles and grass, helps to absorb rainwater reducing the risk of localised flash floods (Naturvation, 2018a). Another remarkable feature of this project is the complexity in the variety and landscaping of trees, plants, shrubs and grasses introduced. Unlike many boulevards that are lined with a single species, plant composition includes different species and stratified positioning, providing functional habitat for a rich urban biodiversity (Kotsila et al., 2020).

Social and economic benefits

Vegetation also increases the availability of green open spaces for residents, provides health benefits by reducing acoustic and air pollution, and effectively reduces the urban heat-island effect, by providing shade and absorbing solar radiation (Rojas-Cortorreal et al., 2017). This variety of benefits positively contributes to the boulevard's liveability for existing users, while making it more appealing to potential new residents and business owners. The bi-directional bike lane located between the two car lanes promotes a healthy lifestyle and low carbon means of transportation. Moreover, a high proportion of green and rest areas were placed in correspondence of the many cafes, restaurants and shops found along the boulevard (Naturvation, 2018a). This was done to strengthen social ties, and to create a safe and healthy place for all stakeholders to enjoy.

Key lessons and success factors

The green corridor on Passeig de Sant Joan is considered a highly successful example of productive green infrastructure, its completion being spurred by Barcelona city council's ambitious plans for green urban renewal (Kotsila et al., 2020). In addition, the complexity of the project pushed for institutional change, and created an opportunity for businesses to innovate to respond to new needs and demands. While successful at enhancing the area's liveability and increasing the value of real estate, however the project attracted some criticisms. These are, for example, the disproportionate level of influence of local business owners over the masterplan's design, insufficient engagement of foreign residents (Kotsila et al., 2020), and the effects the project had on rental prices resulting in the displacement of existing residents (Kronenberg et al., 2021).

6.6. Case Study 6 Westerpark District, Amsterdam (The Netherlands)

Overview

Westerpark District is located north-west of Amsterdam. Previously an industrial area including a gas factory, it was left derelict and highly contaminated for decades after being decommissioned in the 1960s (GP-B, 2017). In order to respond to both housing and sustainability needs, the local council embarked on a public-private partnership to reclaim the brownfields, and transform the area into a vibrant cultural hub (GP-B, 2017). The project worked towards the creation of three themes within a multifunctional precinct: a new park, spaces for cultural events, and business opportunities for cultural enterprises (Richards, 2001).

Environmental benefits

In terms of design, the Masterplan created a free-flowing natural landscape in the west that blends into a more formal urban layout in the east (Jing et al., 2020). All existing buildings were maintained and repurposed: the variety of shapes and sizes of building allowed for an array of events to be held in the precinct, from music festivals to fashion shows and street markets (Bonink and Hitters, 2001). The grounds were decontaminated from the tar, cyanide, and other mineral oils that were left from the industrial days (Hinshaw, 2004), and made into a 50-hectare park used for events, sports and recreation (Bonink and Hitters, 2001). It includes gardens, trails, a waterfall, and a constructed lake that can be drained when larger events are held (GP-B, 2017). This gave local residents access to urban nature and green spaces that was previously lacking (Bonink and Hitters, 2001).

Social, economic and cultural benefits

The main successes of Westerpark are to be found in its social, economic and cultural achievements. The precinct combines adjacent zones with varying functions and character, including art galleries, restaurant, nightclubs, a music school, and it attracted commercial activities like street markets and a cinema (Bonink and Hitters, 2001). All these features put Westerpark front and centre in Amsterdam's art scene, thanks to an eclectic cultural programming in both park and buildings within the precinct (Bonink and Hitters, 2001). Surveys found that visits increased in Westerpark from 45% in 2008 to 50% in 2013 (Cavallo et al., 2016).

Key lessons and success factors

The success of Westerpark lies in the juxtaposition of multiple uses and functions, which make it attractive to a wide section of Amsterdam's population, both permanent and transient. The ripple effects of the success of the new Westerpark were felt outside the precinct itself: nearby residential lots dating to the industrial days were targeted as the next renovation project to accommodate an additional 36,000 people (City of Amsterdam, 2021). Further contributing to the project's success was the year-long consultation process rolled out by developers to give all stakeholders involved (environmental organisations, parks departments, local residents, arts groups) a voice to increase the precinct's responsiveness to specific local needs and changing urban context (GP-B, 2017).

6.7. Case Study 7 Zorrotzaurre, Bilbao (Spain)

Overview

Zorrotzaurre, also known as La Ribera, used to be an industrial port on both sides of the then-peninsula. With the economic crisis of the 1970s it ceased operation, resulting in the economic and social degradation of the area (García Sánchez et al., 2018). In 2004, a Masterplan to transform the peninsula into "an island for living, working, and pleasure" (Gainza, 2018) was presented to local council by Zaha Hadid architects, to create a mixed-use area where renovated residential buildings coexist alongside new workplaces, art facilities, and a network of public green spaces (García Sánchez et al., 2018). The project aims to rejuvenate the city to achieve several objectives: attracting young people to reverse Spain's trend of an aging population, integrating the island with the rest of Bilbao, providing affordable housing, cultural and social facilities, and increasing the amount of urban nature (Gainza, 2018). Finally, as Bilbao is prone to the urban heat-island effect, fluvial flooding, and sea-level rise (García Sánchez et al., 2018), the project strives to increase the island's resilience to the impacts of climate change.

Environmental benefits

After the opening of the Deusto Canal, the surface of the new island was divided into three zones with different uses and density of development (García Sánchez et al., 2018). Urban green spaces are concentrated along the canal, a linear park of 40,000m^2 is located in the middle of the island, and over 6700 trees have been planted (García Sánchez et al., 2018). Gardens on the 'mainland' are also functionally connected to those on the island through compatible vegetation to support a rich biodiversity (García Sánchez et al., 2018). The redevelopment allows 100% of the population to be within adequate accessibility range of urban green spaces, and provides above the optimum number of trees per capita (García Sánchez et al., 2018). These features are not only effective at promoting the good health and well-being of all users involved, but they also contribute to making Zorrotzaurre more resilient. The coastal parks provide permeable surfaces that decelerate the rising of water in case of fluvial flooding (ZMC, n.d.). The opening of the canal lowered the river water level by 1 metre, reducing estimated flood damages by 67% for the 100-year period (Reil et al., 2016). Finally, the new green spaces have been effective at considerably reducing the urban heat-island effect in the local area (Alvarez et al., 2021).

Social benefits

This redevelopment strived for multifunctionality. This was achieved with the inclusion of a sports centre and marina to encourage residents and visitors to take up recreational activities like rowing, sailing and windsurf (ZMC, n.d.). The recovered industrial warehouses are used for cultural and art events, which boosted Zorrotzaurre's reputation as a creative cultural alternative to Bilbao's more traditional scene (Gainza, 2018).

Economic benefits

The redevelopment aims to boost the local economy in a number of ways. The island is connected to the mainland via frequent and efficient public transport alternatives, and it is now home to the largest private hospital in the Basque country (ZMC, n.d.). Two technology parks for tertiary training and education provide state-of-the-art facilities for students and young professionals in advanced services for industry (ZMC, n.d.).

Key lessons and success factors

While the renewal of Zorrotzaurre is incomplete at the time of writing (September 2021), this project is already often cited as a landmark example of green urban regeneration (IUCN, 2019). This outcome can be related to two main factors: the use of green/grey infrastructure to prepare the island and its residents for future scenarios, and the participatory approach designed and implemented by the developers to integrate the needs and priorities of all stakeholders involved (Ortega Nuere and Bayón, 2015). This allowed for multiple modifications to be made to the original masterplan in order to include local knowledge and meet specific needs.

7. Conclusion

The inclusion of green spaces in cities has been found to provide multiple functions and benefits that significantly contribute to the sustainability and liveability of urban areas. Creating 'nature-based cities', through the integration of nature-based solutions and greening, is arguably the key direction for the design and redevelopment of future cities. This review has highlighted key research findings that point to nature's contributions to people, sustainability and liveability. These research findings have informed the development of a 'framework for designing nature based cities' that highlights 12 features that together support the design of urban green spaces that deliver multiple functions and meet a diversity of needs.

Best practice examples of urban renewal and redevelopment projects from Australia, Scandinavia, Europe and North America highlight the diverse opportunities, as well as the environmental, social and economic benefits that accrue from the integration of greening in these areas. These best practice case studies can provide inspiration for other urban renewal activities, and an increasing focus on the integration of green spaces in cities, that are designed to address the key design elements for nature-based cities, as well as responding to local context and local communities' needs and aspirations.

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