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Towards Regenerative Sustainable Urbanism: The Case of Curitiba and Singapore

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

This research received Ethics C clearance from the Human Research Ethics Committee (HREC) at Curtin University, on the basis that this a low-risk research project.

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Abstract

Cities have the capabilities to transform past damage and degeneration into positive, regenerative processes. As global engines of economic growth, cities have traditionally developed by increasing their ecological footprint resulting in the degradation of natural and social systems, and in particular being responsible for the majority of carbon emissions. However, they are also centres of opportunity and can act as forces enabling the world to overcome some of the present problems. The challenge is to shift the way cities are thought about, designed and built. A different approach to urbanism is necessary, one that promotes transformative change to help reverse the negative ecological footprint and turn cities into part of the solution to the planetary challenges. Emerging approaches to design for the built environment integrating social-ecological perspectives are generating promising contributions.

This thesis presents an approach to urban design and planning using the theory and practice of two new ecological design approaches: biophilic urbanism and regenerative development and design, proposing a framework that combines principles of both perspectives. This framework then was applied to two cases, the cities of Curitiba and Singapore, which have implemented successful transformative initiatives related to urban sustainability. They are assessed to see if the framework has potential in leading to urban regenerative sustainability processes in future city development.

It is concluded that regenerative sustainable built environments are those that promote positive contributions to healing and improving urban conditions as a whole, enabling human activities to work with natural systems and produce positive mutual benefits. Both case studies demonstrated that this is possible through a shift in the way cities are currently thought about, designed and built. Regenerative sustainable urbanism is a new field of multidisciplinary dimension requiring a different mindset and methodologies that incorporate a more comprehensive, profoundly integrative and whole systems design approach to respond to the multiple challenges posed by issues such as climate change and increasingly urbanised populations. This is an opportunity as well as an urgency, which compels current and future practitioners to design liveable, healthy, sustainable cities that reverse the negative ecological footprint and turn cities into part of the solution by regenerating social and ecological systems.

Keywords: regenerative sustainable urbanism, transformative change, regenerative development and design, biophilic urbanism.

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Chapter 1

Introduction

1.1 Preface

The 21st century is considered an urban century in much of the literature and sensed in the ongoing lives of most of humanity. Thus, cities are becoming main characters in the modern world. However, as such, what quality of life are they offering to their ever-increasing urban populations and at what cost to the natural systems that underpin human and non-human life? To address these issues, significant shifts are necessary, shifts that include qualitative and subjective aspects as well as the aspiration of living according to personal and collective values that entail understanding and respect for the world as a complex living system.

I have a long-term interest in cities and human settlements in general, focusing on their existing and potential relationship with nature as a means to improve and enrich urban life. This is partly due to my background in architecture and urbanism, as well as to my interest in nature, which led me to take a masters course in landscape architecture. I am particularly attracted to addressing these issues, seeking for ways that can help cities to transform themselves into places that are conducive to life instead of falling into rapidly deteriorating processes as they become increasingly larger and overpopulated. I am interested in cities in general, but have a particular interest in those located in the Global South, where social-ecological approaches to urbanism could make a significant difference.

This interest guided me to Curitiba, in southern Brazil, where an innovative urban transformation was taking place within a process that linked urban planning and politics. It was a rare coincidence and an opportunity in Brazil a city having an architect-urbanist Mayor leading a team of planners to place Curitiba on a pathway of transformative change toward sustainability. It was inspiring to see how it was possible to achieve transformative change at low cost and in a short time, as well as how citizens rapidly accepted and supported the initiatives notwithstanding citizen participation was almost nothing. I lived and worked in this city from 1996 to 2001, a period of urban innovation and international recognition. My experience in this city started as a freelance architect, working on residential and commercial projects, and later on as a team member for the Green Plan projects of IPPUC (Research and Planning Institute of Curitiba) in the late 1990s. I also worked as a researcher in the gearing team for the international conference Forum Mercosul, on sustainable urban development (in 1999) returning to the city many times to follow the process of urban transformation. Working in Curitiba was a meaningful professional experience that promoted a different vision for the practice of architectural and urban design within a context that prioritised social and environmental issues. It provided me with many insights about how cities could be thought about, designed and built in ways that allow positive contributions to society and the environment.

A few years later, before coming to Australia, I was involved in an interesting and challenging project on the coast of Santa Catarina state, 300km south of Curitiba. The project aimed to revitalise local fishing villages affected by the decay of artisanal fisheries, with the peculiarity of being located within an area of environmental protection. The idea was to implement some lessons learned in Curitiba, at a small scale in this case, starting with one of the villages and seeking for replication in the others. After some time and difficulties, it was evident the lack of theoretical foundation related to social-ecological approaches to human settlements to support the development and achievement of the project's objectives.

The need of specific knowledge on sustainability matters to provide firm foundations for my work motivated this thesis. In Perth, I had the opportunity to know the relevant work on sustainability studies developed by Professor Peter Newman and his team at Curtin University Sustainability Policy (CUSP) Institute. I was impressed by the scope and quality of projects and presentations, and decided to start a Ph.D, firstly inspired by the emerging field of biophilic urbanism. Urban greening seemed to be an appropriate pathway to make cities more liveable, not only in the physical aspect, but in the psychological side as well, promoting health and wellness for the residents, through creating biophilic environments and the opportunity of performing aesthetical experiences. This idea was highly strengthened by a seminar on biophilic urbanism presented by Professor Timothy Beatley at CUSP. The information delivered at the seminar provided many insights through the varied and enriching examples of biophilic cities around the world, especially Singapore, and drew me back to my experiences in Brazil. Definitively, biophilic urbanism and design became a touchstone in my research.

Another relevant discovery occurred along the process of literature review. I came across an emerging movement in design called regenerative development and design, led by the Regenesis Collaborative Development Group, a collective of professionals in design, land use planning and development that created a methodology for regenerative development and design, based in the United States. The ideas and design works pertaining to this perspective foster an alternative understanding of sustainability seeking to promote conditions that are conducive to life, helping living systems to recover their capacities of reorganizing and regenerating themselves. To this purpose, the knowledge produced through the specific methodology and its application to the design process leads to life-boosting social-ecological built environments, ensuring regenerative outcomes. Consequently, regenerative development and design was the other touchstone of this research.

The focus of this thesis is on Regenerative Sustainable Urbanism, a new integrated approach to urban design and planning within the regenerative sustainability paradigm (du Plessis, 2012) that combines shared principles of regenerative development and design and biophilic urbanism. It aims to contribute to the design and planning of future and existing cities, promoting transformative change from their buildings to their regional context.

I see it as a promising perspective for the transformation of cities as part of the solution to the challenges of the modern world. I acknowledge that this is a vast process involving many significant shifts in current thinking and behaviours, and it will take time to become mainstream. Nevertheless, the results achieved in Curitiba and Singapore seem to provide promising motivation. Probably, it is not common to have the opportunity to transform a whole city, unless visionary leaders take the occasion, as was the case in these two cities. It would be better, if empowered communities assume the task, but in the early days of these ideas, perhaps it needed more top down leadership. There are emerging cases of smaller scale developments, like neighbourhoods and precincts that seem to be on their pathway to regenerative sustainability, which are driven by community leaders (du Plessis, Beatley).

The process of making this thesis was my own regenerative journey as well, opening my mind to a broad field of possibilities, not foreseen before, to expand the knowledge acquired with the aim to apply it in future opportunities of work, seeking to make positive contributions to a regenerating urban world.

1.2 Background to regenerative sustainability

Cities play a leading role handling three-quarters of economic activity and being home to more than half of the world population. 54% of world population was residing in urban areas in 2014, and current predictions estimate that this figure will attain 66% by 2050 (WUP, 2014).

Urban centres are responsible for the majority of carbon emissions because it is in them that most of the fossil fuels are burnt, mainly in transportation since most cities are auto-dependent producing a high negative ecological footprint (Newman and Kenworthy, 1999; Newman and Jennings, 2008). On the other hand, they are centres of opportunity and can eventually act as a force enabling the world to overcome some of the present and future challenges (UN, 2015). In The Urban Opportunity report, the Thematic Group on Sustainable Development (SDSN, 2013) argue that cities have "characteristics that make them particularly effective as platforms for transformative and sustainable development:

- Cities concentrate and can accelerate economic activity,
- Urban infrastructure investment can enable growth, employment, and poverty reduction,

- Urban areas are sites for social transformation,
- Local governments are nimble,
- Cities are sites of innovation,
- Cities are interconnected with rural areas,
- Cities are interconnected with natural environment,
- Cities have the potential to minimise environmental footprint, and
- Cities are suited for systems-based approaches" (Thematic Group on Sustainable Development, SDSN, 2013, p. 9-12).

Therefore, cities need to be thought about and designed in a way that they can address and develop these opportunities to improve social and environmental conditions in an urbanised world. Cities need to be part of the solution, not the problem.

The urban issue and the challenges of the Anthropocene

Historically, cities have been destinations for migrants seeking for opportunities for better quality of life, and the trend has intensified in current times, making them progressively congested and more complex. For centuries, urban growth has increased its ecological footprint and consequently, the degradation of natural ecosystems as the basis of its wealth and social opportunities. This fact reflects the overwhelming impact of human activities on earth's ecosystems that defines a new era, the Anthropocene, described by Crutzen and Stoermer (2000). This impact has produced destructive effects on the planet, as is the case of human-induced climate change. This subject is expanded in Chapter 3.

In this scenario, many questions arise about pathways toward improved living conditions for humanity while preserving a safe operating space for the planet. Is it possible to reverse the negative footprint of cities on the environment by making them part of the solution? How can cities become drivers for regeneration within their boundaries and beyond, over their bioregions? What are the necessary capabilities of cities leading to this transformation? What kind of urban design and planning would better fit the challenge? What kind of alternatives to the megacities would prove more efficient in providing work of dignity and meaningful lives to the present and future generations? Is there any hope for the future of humanity and a healthy planet?

Before investigating possible solutions, it is necessary to understand the causes that provoked this state of concern in the modern urbanised world.

The legacy of modernism

The mechanistic worldview has underpinned the world economy over the past three centuries. Despite being the basis of huge economic growth with significant reductions in extreme poverty, it has led to many of the problems cited above (Buchanan, 2012). One of the main causes of its negative legacy is the fragmentation of the relationship between humans and nature that Buchanan (2012) describes as the betrayal of modernism because it destroyed our essential humanity across this disconnection. In his words, “This egotistical sense of hubristic disconnection, of humans prevailing over nature, has consistently underscored the modern era” (Buchanan, 2012, p. 4). In Buchanan view, modernism is unsustainable at its core for its denial of human dependency on nature, and the lack of acknowledgment of nature’s cycles and regenerative capacities.

The abundance of cheap fossil fuels (a fundamental basis of modernism) is another cause of the radical shift, revealed in ways of production and consumption, transport, land use and urban form. Cities sprawled very quickly, supported by inexpensive and plentiful fossil fuels, which provided energy to feed lighting, heating and cooling to buildings that could have enjoyed daylight and natural ventilation if any restriction to the energy sources had limited its consumption, or if responsible planning and design had been implemented (Buchanan, 2012).

The modernist city aimed at accomplishing social and environmental improvements through rational planning, in response to the crowded, unhealthy, polluted and undesirable mix of uses that characterised the urban conditions derived from the Industrial Revolution (Dunnett, 2000; Almeida, 2013; Buchanan, 2012). It failed. It reiterated fragmentation, in land use, separating urban space into zones of similar functions; in circulation, disconnecting motor traffic from pedestrians and social activities; in abandoning the concept of the street as the element that articulates urban life (Jacobs, 1961; Newman and Kenworthy, 2015).

Fragmentation seems to be a core issue in Modernity. Disconnection from nature led to over-exploitation of natural resources, infinite economic growth, pollution and contamination of soils and water bodies, even desertification in some cases. Cheap and abundant fossil fuels led to automobile dependence and disconnection of urban spaces (Newman and Kenworthy, 1999), easing the way toward current unsustainability.

Many scholars and thinkers echo this view and advocate for the reunion of humans and nature as the only way to achieve true sustainability (Kellert, 2008; Salingaros, 2010; Salingaros and Mehaffy, 2011; Buchanan, 2012; Mang and Reed, 2012; Beatley, 2011). Hes and du Plessis (2015, p. 25) clearly highlight that the biggest challenge is “escaping the trap of the mechanistic worldview”, if we aim to leave a world of abundance to future generations. The Great Transition advocated by scientists (Rockström, 2015; Steffen et al, 2015) has provided a quantitative basis for the necessity of the ecological worldview and a regenerative sustainability paradigm.

The need for a qualitative shift

The desired change requires a new mindset as the first step, a complex and necessary step. According to Einstein, "We cannot solve our problems with the same thinking we used when we created them" (Einstein, 1916). The ecological worldview and the regenerative sustainability paradigm (du Plessis and Cole, 2011; du Plessis, 2012; du Plessis and Brandon, 2014) provide the theoretical framework for this new vision (expanded in Chapter 3). It embeds the whole and living systems thinking approach (Capra, 1995; Alexander et al., 1977; Reed, 2007) and considers pattern literacy (Orr, 1992) as an essential skill within the new paradigm for design practitioners.

In his essay *The Big Rethinking Part 11: Urban Design* (2013), Buchanan reflects on the need of redefining purposes in order to resolve a wide scope of dangerous pressing issues inherited from Modernity, e.g. the myth of unlimited economic growth that led to human-induced climate change. Moreover, he states that this endeavour would require counterbalancing the modernist full focus on the objective and quantitative aspects, and directing attention to the subjective and qualitative, allowing for the desire to live according to personal values and aspirations (Buchanan, 2013). This view is shared by Hes and du Plessis (2015) who discuss the mechanistic reductionist view as a hindrance to attaining effective solutions to the problems related to living systems. In a recent article, du Plessis and Brandon (2014) recognise the value of knowledge built by the mechanistic paradigm for practical engineering approaches, but advocate for the ecological world vision drawn from quantum physics, ecology, life sciences and neuroscience that has proved to be more appropriate and effective, particularly in the realm of design and development encompassing living systems. The redefinition of purposes involves design for the built environment as a whole, which was profoundly affected by the modernist vision in its mission of providing better and healthier lifestyles, but without the organic links to nature that had characterised centuries of urban growth. Modernism has failed to deliver all its promises, and now there is a need for a fundamental rethink.

The ecological worldview is fundamental to stop the vicious circle (Birkeland, 2008) and to underpin a holistic approach that enables reversal of the fragmentation of modernity, particularly the reunion of humans and nature. Among the first voices expressing this goal, it is important to highlight two influential female thinkers in the early 1960s who have strongly shaped the sustainability discourse since then promoting awareness of the importance of human habitats, both in nature and in cities (Rowe, 2015). In 1961, Jane Jacobs published her seminal book *The Death and Life of Great American Cities* where she discussed the need to develop and adopt a new concept for cities. She demonstrated how modernist urban planning produced harmful impacts on urban inhabitants. In 1962, another seminal book, *Silent Spring* by Rachel Carson, brought alertness of the effect of human actions on natural environments, resonating so powerfully around the world that it was instrumental in launching the environmental movement.

Jacobs (1961) argues that the key issue in city planning is the need to understand what kind of problem cities are. Building on Dr Warren Weaver's findings of the stages of development of scientific thought, she ranked cities as problems of organised complexity. As in the life sciences, cities present problems in which several variables are interacting simultaneously "in subtle, interconnected ways (…) interrelated into an organic whole" (p.433). Jacobs contends that urban design and planning only can progress if city problems are understood as the kind of problem at issue. She notes that the tactics for understanding the problems posed by cities and the life sciences are similar in that both types of problems have to be analysed in detail (Jacobs, 1961).

In Jacobs' views, the most appropriate methods to understand cities are:

- Thinking about processes,
- Working inductively, reasoning from particulars to the general, rather than the reverse,
- Seeking for "non-average" clues involving tiny quantities, which reveal the way larger and "average" quantities are operating (Jacobs, 1961, p.440).

This approach to urban design and planning has been influential and further broadened by thinkers and theorists in whole systems thinking approaches, such as Capra, Alexander, Orr, Salingaros, Mehaffy, and others.

1.3 Shifting worldviews

Worldviews are ways of thinking about and lenses to look at the world; they organise visions and systems of beliefs and guide the interpretation of the various phenomena that shape the space we inhabit. They define the paradigms or subsystems that arrange the ideas or basic assumptions to study the phenomena, allowing for the design of appropriate strategies and promoting a common language among thinkers, researchers, practitioners, stakeholders and people involved. As Hes and du Plessis (2015) clearly put it, "a consciously held worldview can shape new practices and transform the way we engage with the built environment" (p. 112).

The importance of working within worldviews and paradigms is that they provide a broad comprehension of reality. Du Plessis and Brandon (2014) explain the essence of a worldview in these terms:

> It describes the structure, function and nature of the world, and provides guidance on the general principles by which we should organise our actions within this world: how we would act and create, and how we can influence and transform the world. As such it not only engages with our scientific understanding of the world, but also with our value systems and ideologies, as well as our ideas about sense-making, problem-solving, decision-making and correct action based on how we evaluate reality and the possible futures to which these actions may lead. It is therefore far more than a scientific explanation of the physical universe (du Plessis and Brandon, 2014, p.2).

The emerging ecological worldview and its regenerative sustainability paradigm (du Plessis, 2012) support a significant evolution in the sustainability field. The concept of regenerative sustainability is founded on the principle that the threats to sustainability only could be addressed in a positive manner if "humans and their activities are rewoven into mutually beneficial, harmonious relationships within the larger web of life, thus restoring the inherent regenerative capacity of natural and social living systems" (Benne and Mang, 2015, p. 8-9).

Hes and du Plessis (2015) argue that the ecological worldview embeds two aspects, one tangible or external related to the biophysical sphere or perceptible realm, as well as the social structures, e.g. economic or legislative systems; the internal aspect entails the mental, intangible, invisible realms, related to the field of thoughts, feelings, values and human interactions. Both together form the systems in which human life and activities take place.

In regards to the built environment, the regenerative sustainability paradigm considers the city as a "phenomenon originating from and created by both mental social and technological-natural processes" (du Plessis and Brandon, 2014, p.6). This means that systemic planning and design processes must involve both the interior aspect comprising individual and collective values systems, and the biophysical or exterior side. This appreciation is based on St Isidore of Seville's definition of a city as formed by two indivisible parts: the *urbs* or physical aspect and the *civitas* or mental part including the emotions, rituals and rules (quoted in du Plessis and Brandon, 2014).

1.4 Incorporating social-ecological approaches to urban design and planning

Besides introducing restorative environmental practices, cities need to actively contribute to the aspirations of their citizens, not only in their physical but also in their psychological aspects. This approach introduces the concept of biophilic urbanism and the work of its main theorists starting with Crafoord Prize winning American biologist E. O. Wilson. As defined by Wilson (1984), biophilia is an innate affiliation of human beings with all kinds of life; hence, the proximity and contact between people and nature should be prioritised in urban design and planning. According to recent research, the benefit from this contact is crucial for human health and wellbeing, but it depends on repeated experience because to be functional it has to be nurtured and developed (Salingaros 2010; Kellert, 2008; Kellert and Calabrese, 2015). Beatley (2011, p.154) calls this "daily dose of nature". He explains that the application of biophilic urbanism provides opportunities for fulfilling experiences of nature, creating abundant green urban spaces for easy and frequent access to nature for urban residents, consequently bolstering the reconnection city-nature. Besides promoting human health and wellbeing, biophilic urbanism can contribute to urban and regional regeneration of ecosystems and biodiversity by restoring damaged areas and creating new habitats for natural systems. Beatley (2011) states that urban populations can be powerful allies in the conservation of nature, not only within urban boundaries but also elsewhere. He sees in this a major source of volunteer work that needs to be remembered and harnessed. Moreover, Beatley studies the biophilic benefits implemented at diverse scales, and argues that many places around the world show positive outcomes derived from small projects that facilitated relationships of people with nature. This is beginning to demonstrate that existing high-density precincts can be regenerated, and new ones can be designed as quality living environments that can regenerate social-ecological systems, as is the case in Curitiba and Singapore (see Chapters 6 and 7).

Biophilic urbanism and regenerative development and design approaches to urban design seem to be appropriate means for the regeneration of built environments and communities that begin to address the innate connection to nature largely neglected by modernism.

Biophilic urbanism and regenerative development and design share many principles: both are integral strategies to the regenerative sustainability paradigm and involve a new way of understanding the built environment, enhancing the value of nature and resetting people back as part of it. It is also important to see that this vision of the built environment as a social-ecological system enhances the value of cities, by incorporating natural ecosystem services into the urban regenerative design process across scales while pursuing multiple benefits simultaneously (Perdersen Zari, 2012; Mang and Reed, 2012; Bene and Mang, 2015; Hes and du Plessis, 2015).

1.5 Framing the problem: The need for this research

Cities are wonderful human-made inventions, cradles for social relationships and interactions that enable the creation and development of knowledge and innovation, culture, work and leisure. However, as mentioned before, they have been growing for centuries based on cumulative ecological footprints and degradation of natural and social systems. As the world is becoming increasingly urbanised, cities should be enabled to be part of the solution to current and future challenges (Lerner, 2003; Sassen, 2009).

But how to transform cities into places that are conducive to life, cities and urban precincts that place life -human and non-human- at the forefront? This study poses the hypothesis that implementing integrated planning initiatives founded in social-ecological approaches to urbanism can lead to sustainable regenerative processes in cities. This thesis will develop the concept of Regenerative Sustainable Urbanism as a positive approach to social-ecological urbanism as a foundational and practice-oriented concept for the vision of future cities. The study will set out how the approach could make cities for people and nature, together. It aims to help reverse the polarity of impacts by turning negative ones into net-positive interventions. It is about going beyond reducing urban ecological impact by restoring and helping rebuild past impacts ensuring ecosystems services and wellbeing to the inhabitants. Embedding nature into the cities may help not only in increasing resilience and in mitigating the effects of climate change; it integrates into a holistic approach the benefits from biophilic urbanism and regenerative development, allowing cities to be part of the regional solution rather than a barrier. This is demonstrated in Curitiba, "Brazil's sustainable city", and in Singapore, "the city in a garden", which have developed successful strategies that encompass design concepts toward regeneration of urban and regional social-ecological systems based on the multiple benefits from a new way of thinking about cities (see Chapters 6, 7 and 8).

It should be noted that this approach incorporates not only natural ecosystems, it considers society and culture and, as is the case of cities, it includes design as a cultural ecosystem service. Landscape architecture theorist Elizabeth Meyer (2008) argues that designed landscapes and biophilic elements have the essential ability to create memorable places where human activities and ecological processes coexist. This aesthetic experience can promote awareness and restorative sensations in our psyche that, in turn, can inculcate environmental values and lead to the appropriation and care of place (Meyer, 2008). The paper I wrote (see Appendix A), also generates a further perspective on this approach, arguing that within the ecological worldview, the concept of beauty shifts from its historical conception to a new understanding that conceives it as an essential strength toward sustainability and regeneration (Zingoni de Baro, 2014).

Instead of seeing the increase of urbanization as a threat to the future of the planet and humankind, it is possible to begin to imagine a future where cities can be seen as potential contributors to the health, nourishment and regeneration of a world in which all communities can thrive and flourish.

This may seem somehow naïve. However, when scientific evidence is showing that the only planet we have to live in is starting to operate in a risky zone and the world we know will not be the same in a relatively short time, a sense of urgency impels to take action. The research process allowed me to observe that the sentence 'the world that we know' has diverse interpretations: some may understand it as the safe place to be, ignoring the effects of increased global heat (more than 2 degrees). Others may see in it the opportunity for change that frees the world from the causes of its current state and challenges. This second position embeds a new energy that can lead to transformative change and hope (Reed, 2007; Newman and Jennings, 2008; McLennan and Reed, 2013; Salingaros, 2010, Salingaros and Mehaffy, 2011; Hes and du Plessis, 2015).

1.6 Research questions and objectives

Reflecting on the opportunity for transformative change, cities are to be transformed into forces for regeneration where human activities and ecological processes can coexist and co-evolve. Hence, the new approach to urban design and planning integrating strategies founded in social-ecological approaches to urbanism is deemed to be a pathway toward regenerative sustainability processes in cities.

This is done through the development of an integrated framework for regenerative sustainable urbanism, and applied to two case studies.

It has international application, opening the study to urban precincts and cities around the world, both in industrialised and developing countries, with the necessary consideration of the uniqueness of each place.

The core question this thesis asks is:

> Can a framework be developed to give meaningful direction to the application of the concept of regenerative sustainable urbanism as a foundational and practice-oriented concept for the vision of future cities?

Objectives

- To create an integrated framework to enable practitioners and communities to design liveable, healthy, resilient cities that provide transformative change to help transform the negative ecological footprint and turn cities into part of the solution to the planetary challenges.

- To assess the framework through two case studies on Curitiba and Singapore.
- To analyse the principles of regenerative sustainable urbanism and reflect on how this approach affects the way future professionals and their practices are currently formed.

1.7 Research design and methodology

In order to achieve the objectives, this research sought to determine ways of transposing the urban ecological footprint into a positive one transforming cities into forces for regeneration of both socio-cultural and ecological systems, using the case study methodology as the overall approach that most effectively elicits the data required to address the research questions. Yin (2009) describes "case study" as a method comprising a "twofold technical definition. The first part begins with the scope of a case study:

1. A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.
2. The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis" (Yin, 2009, p.18).

Yin also depicts case study as a comprehensive research strategy encompassing a logic of design, multiple data collection techniques and distinct approaches to analysis. Stake (1995) describes case study as a process of examining the particularity and complexity of a case, which results in a deep understanding of both the activity and circumstances. Therefore, for this research, the use of a case study approach provided the researcher with a methodology to examine urban issues as problems of organised complexity. The strength of the case study strategy is its ability to provide in-depth descriptions of the phenomena that are presented in their real-life context. Stake (1995) classifies cases into three categories: intrinsic, instrumental and collective, and these vary according to the reason for the study. An intrinsic study provides in-depth understanding of the case in itself, whereas an instrumental case study offers insight into an issue with the purpose of extending theory or generalising across cases, and a collective case study examines multiple cases attempting to understand specific phenomena. Grandy (2010) agrees and adds that a case study can be both intrinsic and instrumental in nature, fitting cases that present multiple research interests because the opportunity to learn is the core issue in both.

This qualitative, two-case replication instrumental case study approach to research is set in the constructivist tradition. According to Stake (1995), the purpose of a case study is to understand rather than to explain, and knowledge is constructed rather than discovered. This perspective provides researchers with the opportunity to understand and interpret what they are observing. The foundation of case studies is to describe what is likely to be in a determined site. Therefore, rich descriptions and interpretations of events and circumstances are their key traits. In this sense, case studies line up with the interpretive description theory described by Thorne (2008).

Instrumental case studies offer the opportunity for the use of thick description of particular sites, individuals, groups, design processes. Cases must be carefully chosen, in which the focus is known in advance and designed around established theory or methods (Grandy, 2010). Thick description is an interpretive approach used in qualitative research, which pays attention to contextual detail when observing and interpreting social meaning of an event or phenomenon. In case study research, thick description is an essential part of the process of determining what are the particular issues, dynamics, and patterns that make the case distinctive (Dawson, 2010).

Fig. 1-1 outlines the two-case approach. The cases selected for the study are the cities of Curitiba, in Brazil, and Singapore, the city-state. These cities were chosen according to their particular patterns regarding urban sustainability. Thus, Curitiba is used to examine the Regenerative Development and Design strategy, looking at various elements of planning practice, and Singapore to study the Biophilic

Urbanism strategy with a similar array of elements in planning practice. The intention of this research is to look at how the implementation of two social-ecological approaches to urban design can be conducive to regenerative sustainable processes in the built environment, not only in the biophysical aspect but also in the psychosocial side as well, and how the thesis questions can be answered.

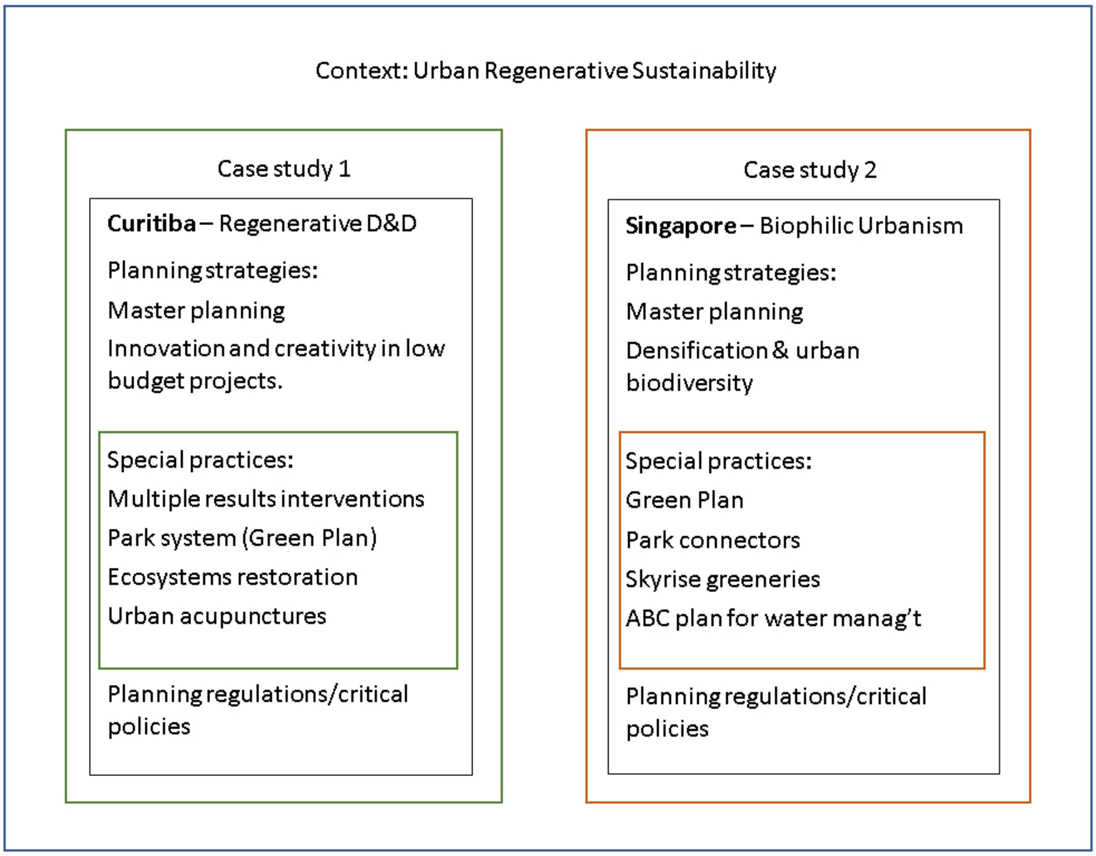


Figure 1-1: Two-case study research design.

Source: Author

For this purpose, I used grounded theory methodology, an inductive process founded on the idea of generating theory from systematically gathered data, to build a framework drawing from an in-depth analysis of the theory of biophilic design and regenerative development and design, plus the data collected for the case studies. Glaser and Strauss (1967) developed grounded theory as a methodological position for qualitative data, which started to be used to support research in the social sciences. Further, it was described by Strauss and Corbin (1994, p. 273) as a "methodology for developing theory that is grounded in data systematically gathered and analysed". The research adopted the concept of theory defined by Strauss and Corbin (1994, p. 277) as “plausible relationships proposed among concepts and sets of concepts” having in mind the two principal foci, discovering patterns and identifying processes, embedded in this concept, and following the method of constant comparisons for data collection and analysis (Case and Light, 2011). In this method, data collection and analysis are closely entwined and comprise several stages. The first, called ‘open coding’, determines initial categories or themes by grouping similar events together. Each event or incident must be thoroughly compared with others previously coded in the same category. The second stage or ‘axial coding’ involves the refinement of the categories and their properties by revising and testing all events coded in a category with the properties of that category. Then, categories are also compared for overlap and examined for possible relationships among them. The process ends when theoretical saturation is reached, which occurs when additional data collection and analysis do not change the findings substantially (Case and Light, 2011).

The resultant framework for the practice of regenerative sustainable urbanism was used as a lens to analyse both case studies and test its validity and applicability. I developed a matrix comprising the theoretical principles, and the practices and policies observed in both cities, which was used as an analytic tool and applied through a replication approach to both cases. The two-case replication approach was designed and conducted following Schramm’s definition: “The essence of a case study, the central tendency among all types of case study is that it tries to illuminate a decision or a set of decisions, why they were taken, how they were implemented, and with what results” (Schramm, 1971, cited by Yin, 2009, p.17).

The process of gathering the relevant data was organised to comply with the purpose of the case studies, having in mind the guiding questions. It followed the procedures designed by Yin (2009) that include three principles of data collection: a) using multiple sources of evidence; b) creating a case study database, and c) maintaining a chain of evidence.

Primary data collection was done through observation. This included direct observation of: physical setting and social and cultural context, and patterns in each city; infrastructure and services; fit between physical setting and cultural patterns; urban quality and success of policies and plans.

Critical observation (based on reflection) of natural and built environments looked at efficiency of planning, land use, transportation connection, sustainability and liveability, fit of urban spaces and human behaviour, use of public spaces, and quality of design. Other methods used were:

- Photography
- Immersion in living in Curitiba (1996-2001), and fieldwork in Singapore (one week)
- Engagement in architectural and landscape architectural work in Curitiba
- International conference attendance and presentation in Singapore, including technical visits to the main biophilic projects.

The Singapore fieldwork was conducted in 2013 including a conference presentation. I presented the poster "Regenerating Cities through Living Architecture Collaboration" (see Appendix B) at the 2nd International Skyrise Greeneries Conference, where I had the opportunity to meet and talk with international practitioners and professionals from government authorities (Urban Redevelopment Authority, Housing Development Board and National Parks Board) who provided useful information on their work approaches and networking. This information was relevant to collate with the data collected during the Planning Institute of Australia seminars, in Perth (see below).

The fieldwork involved:

- Technical visits to residential developments, educational and health buildings
- Main biophilic projects, including parks, Botanic Gardens, park connectors
- examples of skyrise greeneries such as green roofs and green walls
- ABC plan for water management, the Bishan Ang Mo Kio park, and
- Conversations with design practitioners.

Secondary data collection included:

- Literature review: extensive consultation of books, theses and dissertations, academic journal articles, previous case studies, institutional reports, institutional websites and others, including online databases.
- Document analysis
- Archival records
- Landscape architecture and architectural projects analysis
- Attendance at the Planning Institute of Australia (PIA) seminars over the last three years, as they enabled me to relate to professionals involved in practice
- Online courses on themes directly related to the main research topic.

As urban design and sustainability are multidisciplinary fields, many other disciplines and areas of knowledge can provide valuable contributions to the research aim. The focus of this research is on urban regenerative sustainability and, within this approach, on the role of two ecological approaches to urban design, biophilic urbanism and regenerative development and design (Kellert et al., 2008; Beatley, 2011; Mang and Reed, 2012; Cole, 2012a,b; Cole et al., 2013; Hes and du Plessis, 2015; Benne and Mang, 2015). This approach is discussed in Chapter 4.

The literature review process was extensive and permeates the whole research, exploring themes in the fields of urban design and planning, landscape architecture, urban ecology and sustainability, green urbanism, biophilic design and urbanism, and regenerative development and design, looking for historical and recent theory and practice in these disciplines. The search resulted in rich information gathered from seminal books, articles, analysis of projects at different scales, and remarkable documentaries that added vivid information and images to the main topics and moved forward my process of understanding theories and approaches to urban issues. Literature review provided the context for this research and established a basis for analysis; it provided background to set the study within the regenerative sustainability paradigm, supporting the formulation of research questions and objectives, and the chosen strategies for achieving urban regenerative sustainability. It also endorsed the development of my theoretical framework, a novel approach to urban design that builds on the recent findings on design for the built environment, and aims to contribute to the future of cities, acknowledging that cities are problems of organised complexity, requiring adaptation to the uniqueness of each case.

Archive records, document and project analysis, local press articles (online access), local publications, helped in attaining deeper understanding of the processes both cities went through, and for further triangulation.

PIA seminars were helpful for tracking the latest practices in Australia, and for meaningful informal conversations and networking with different practitioners, national and international, that provided information about their work methodologies and approaches that influenced the selection of methods for data collection, and some findings. These discussions particularly influenced the answering of the question about applying the new design paradigm to professional practice.

I studied two online courses that promoted many insights and reflection, fostering awareness about the challenges that cities are currently facing. The first course, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, organised by the Word Bank, presented state-of-the -art scientific evidence on climate change, and some of the opportunities for urgent action. The second course, *The Age of Sustainable Development*, on the Sustainable Development Goals (to be launched by the United Nations later this year) was created and delivered by Professor Jeffrey Sachs, University of Columbia. It was crucial to understand the need for limits to economic growth and the situation of world cities, particularly those in developing countries where it is critical not to repeat the errors of the industrialised world in terms of urbanisation, transport, land use and carbon emissions, among other social and health concerns.

The database organises the data collected for both cases (Chapters 6 and 7). It encompasses field notes registering observations, conversations, reflections and details from document analysis, as well as features and comments about projects. There are also annotations regarding documents and archival records from the IPPUC (Portuguese acronym for Research and Urban Planning Institute of Curitiba), Urban Redevelopment Authority, Housing Development Board and National Parks Board and other presentations at the conference held in Singapore (November, 2013).

The case studies

In this research, the cases selected for the two-case replication study are the cities of Curitiba, in Brazil, and Singapore, the city-state. Both cities were chosen according to their particular patterns regarding urban transformation toward sustainability, and they share a number of similarities in their developments. As urban planning had an influential role in both Curitiba's and Singapore's processes, I used STS –Science and Technological Studies method of analysis, a constructivist perspective considering urban planning as a form of technology, and studies cities as whole systems or sociotechnical artefacts including human systems, rather than looking at their constituent parts. STS investigates how and why particular technologies appear in determined places at determined times in history (Moore, 2007). Aibar and Bijker (1997) used this method to study Cerda's plan for the extension of Barcelona in the late nineteenth century, considering urban planning as a technology and examining rival explanations to construct the three technological frames involved to analyse the case. It demonstrated appropriate ways to study the effects of technology on the urban form. After this substantial study, this method of analysis has been increasingly applied to holistic urban studies (Moore, 2007).

Thus, building on Aibar and Bijker's (1997) approach, I describe how and why both cities started their processes. Moreover, how urban planning itself evolved during the process, adopting new methodologies and promoting new understandings of the essence of the city and its systems, both biophysical and social.

In each city, I sought data related to urban planning history, theories and practices available in both cases, their evolution through time, and innovations. I was interested in seeing why and how these cities enhanced the role of green infrastructure in their planning since as early as the 1970s, what was the influence of this in producing regenerative processes, and what crucial policies made them competitive cities.

As Curitiba and Singapore are believed to be literal replications, data collection and further analysis are part of a two-case replication approach. The process of gathering the relevant data was designed upon understanding the purpose of the case studies, based on the hypothesis -*'implementing integrated planning initiatives founded in social-ecological approaches to urbanism can lead to regenerative sustainability in cities'*- and having in mind the guiding questions (see below). It followed the procedures determined by Yin (2009) that include three principles of data collection: a) using multiple sources of evidence (as described above); b) creating a case study database (Chapter 6 presents data collected in Curitiba, and Chapter 7 data collected in Singapore); and c) maintaining a chain of evidence (see Fig. 1-2).

Case study guiding questions:

- Why did this specific process of urban transformation occur in those cities and not in any other city in the country or region?
- How did it happen and how was it conducted?
- What kind of evidence is being sought?
- What would constitute supportive or contrary evidence?
- What variations can be anticipated?
- What kind of findings could be considered as evidence of regenerative sustainability or leading to it?
- Can Curitiba and Singapore be considered as precedents of regenerative sustainable urbanism?

The analytic strategy is based on a theoretical proposition, uses thick description and cross-case synthesis. To test the hypothesis, the analysis was organised into three phases. First, the consideration of the effect of the local urban planning technology incorporating ecological approaches on the urban form. Second, the application of the theoretical framework to each case, using a matrix as an analytical tool, developed from the integrated framework for regenerative sustainable urbanism described in Chapter 5. Each case has its own matrix including the practices and policies found in each city and the theoretical principles, showing the matchings between them. Third, the cross-case synthesis looking for analytic generalisation, was conducted according to Yin(2009), having in mind that conclusions from each case provide information needing replication by other individual cases. Finally, the conclusions.

The maintenance of the chain of evidence has been a constant concern during the data collection process. To ensure the links between research questions, data collection, analysis and conclusions are brought together in the final chapters (6, 7 and 8) the process followed to construct case studies validity and reliability is set out in Fig. 1-2, below,

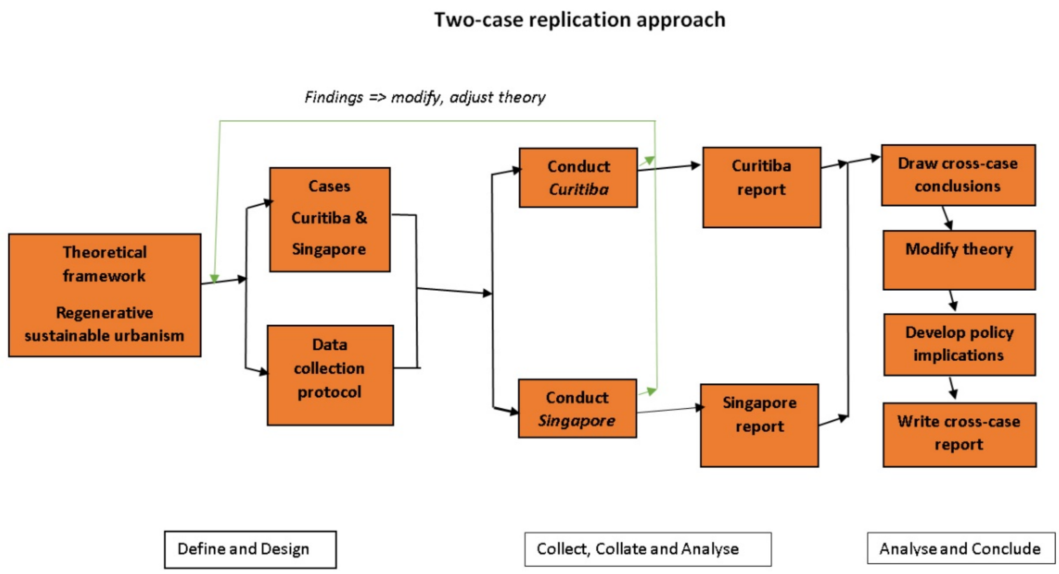


Figure 1-2: Two-case replication approach.

Source: Author, adapted from Yin (2009)

Ethics

This research received Ethics C clearance from the Human Research Ethics Committee (HREC) at Curtin University, on the basis that this is a low-risk research project.

1.8 Research scope and limitations

The overall scope of this research is international, opening the study to urban precincts and cities around the world. It is applicable both in industrialised and developing countries, with the necessary consideration of the uniqueness of each place, as regenerative and development design and biophilic urbanism are site-specific technologies.

Although the focus is on urbanism, urban design and planning is a broad field of multi-disciplinary scope. Therefore, the research narrowed down to an emphasis on ways of thinking and doing cities that are founded on the ecological worldview and incorporate social-ecological strategies to urban design and planning methodologies to adjust to the research objectives.

Additionally, the study limited the approach to two cities because they are examples of what can be achieved when the process of urban transformation involves regenerative sustainability principles, demonstrating that both social-ecological technologies, biophilic urbanism and regenerative development and design, are applicable to the urban scale. This research does not address an in-depth study of the recently designed tools to support regenerative practices, such as REGEN and LENSES, or the Living Building Challenge, but it acknowledges it is a necessary future work to investigate their possible application to urban studies.

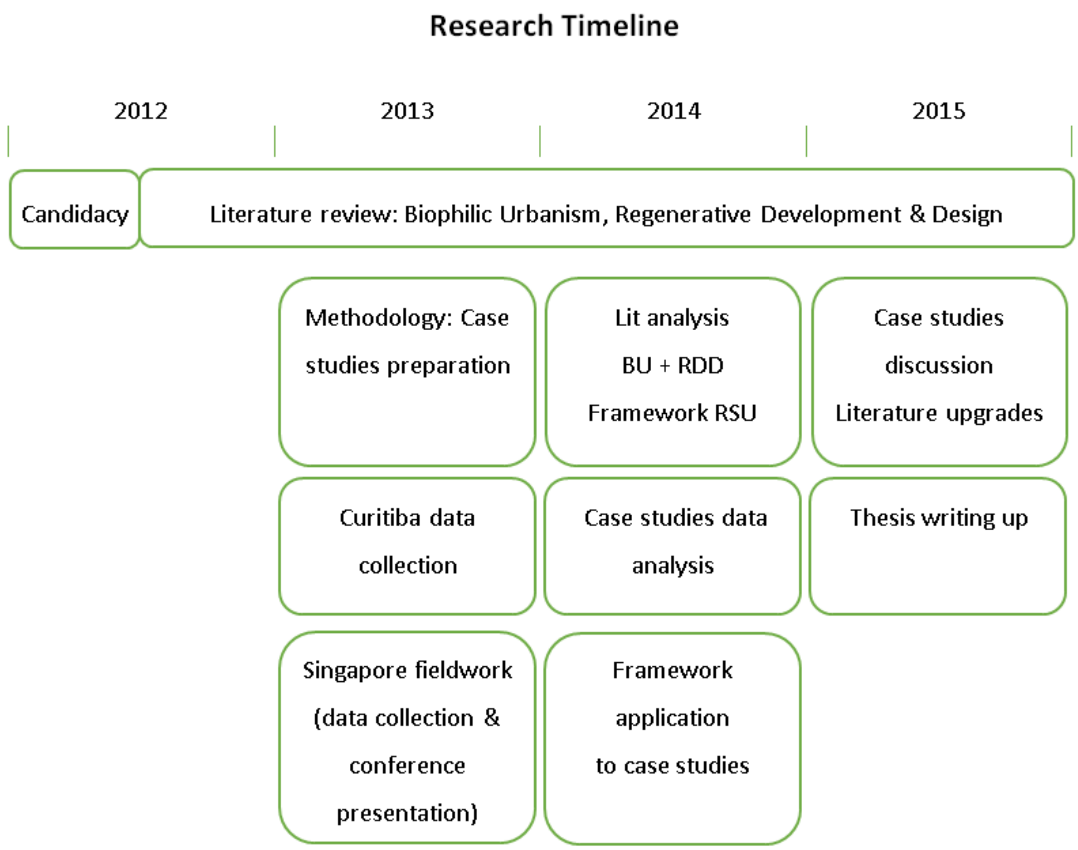


Figure 1-3: Research Timeline

Source: Author

1.9 Thesis structure

This thesis consists of nine chapters positioning the current research within the related literature to the topic of regenerative sustainability, and organising the discussion on how cities can be part of the solution to the challenges the urbanised world is facing.

To provide a background to the enquiry, Chapter 2 reviews existing knowledge about the challenges posed by the Anthropocene to the highly urbanised world, and undertakes a review of the current state of cities as a corollary of Modernity. This includes the revision of the historical context and processes that caused the current state of the world, and the critique of the urban utopias of the last century, particularly the critique of modernist urbanism. It identified the mechanistic paradigm underlying the phenomenon of global change that promoted an overwhelming economic activity that ignores natural cycles and the regenerative capacity of nature, arguing for the need to shift the ways the world and the future of humanity are currently comprehended.

In search for solutions to the fragmentation of Modernity, Chapter 3 explores the importance of worldviews and acknowledges the ecological worldview as the foundation for this research. This vision advocates for the reconnection of humans and nature, sustaining a new mindset leading to a way to understand the world that incorporates the findings of the new sciences and seeks for solutions to the challenges of the Anthropocene. It embeds the regenerative sustainability paradigm that presents an alternative concept of sustainability looking for strategies to achieve it. It influences the understanding of the built environment as a social-ecological system, exploring this concept and discussing the possibility of harmonic coexistence of urban ecology with social-cultural systems.

Chapter 4 discusses two social-ecological design approaches embedded in the regenerative sustainability paradigm leading toward urban regenerative sustainability: biophilic urbanism and regenerative development and design. From the comparative analysis of the theoretical principles and applications of both perspectives, I looked for convergence and overlapping of tenets that could lead to the formulation of a framework for a social-ecological approach to the built environment.

This integrated framework for a new approach to urban design and planning called Regenerative Sustainable Urbanism is developed and explained in Chapter 5, which also considers the potential of the framework for application to practice. It aims to contribute to the design and planning of existing and future cities from their buildings, neighbourhoods, precincts and regional context, opening the study to cities around the world, both in industrialised and developing countries, with the necessary consideration of the uniqueness of each place.

To test the validity and applicability of the integrated framework, I developed a two-case replication approach case study, involving the cities of Curitiba, Brazil, and the city-state of Singapore, using a matrix comprising the theoretical principles, and the practices and policies observed in both cities as an analytic tool. Chapter 6 presents data collected in Curitiba, and Chapter 7 organises data collected in Singapore. Case study design and data collection in both cases was conducted according to the methods described in the Methodology section in this Introductory Chapter, including case study context, theoretical and instrumental procedures used to collect, present and analyse data.

Chapter 8 analyses the application of the integrated framework to both cities concerning current practices and policies developed and implemented in each city and relating them to the theoretical principles. From the analysis of results and discussion on the key findings, several conclusions and recommendations were drawn in terms of urban planning thinking and methodologies, and regarding the new design approach named Regenerative Sustainable Urbanism.

Finally, Chapter 9 contains the conclusions of this research on both urban planning thinking and methodologies, and regenerative sustainable urbanism. In addition, it presents considerations about the limitations to generalising the findings to other cities in the world, which needs further replications. There is also a reflection on the study with recommendations and suggestions for future research agendas.

1.10 Use of terms

It is important to note the use of some terms in this research:

- “Urbanism” is interchangeable with “urban design and planning”
- When referring to urban design and planning, regenerative development and design, biophilic urbanism or biophilic design, the terms “strategy (ies)” or “technology (ies)” apply in the same way, according to the definitions and use of terms by influential authors for this research: Aibar and Bijker (1997) contemplated urban planning as a technology in their study on Barcelona. Mang and Reed (2012b, p.2) define regenerative development and design as systems of technologies and strategies. Moreover, Hes and du Plessis (2015) considered them as design strategies within the regenerative sustainability paradigm. Thus, this research uses the terms accordingly.

Chapter 2

The Anthropocene and the urbanising world

2.1 The challenges of the Anthropocene

Planet Earth and humanity are living the Anthropocene era. The term coined by Crutzen and Stoermer (2000) depicts a world predominantly affected by human action that is causing unprecedented impacts on the planet to an extent that made the Earth lose the stable conditions of the Holocene, its natural geological epoch (Crutzen & Steffen, 2003; Steffen et al., 2007; Rockström et al., 2009). The planet is becoming warmer, has lost much of its forests and biological diversity, and is exposed to severe climatic issues. Ten years ago, the Millennium Ecosystem Assessment (2005) estimated that two-thirds of the world's ecosystems were at risk due to human activities and technologies. This damage is particularly due to unsustainable ways of natural resources consumption, land use, urban sprawl, and contamination of water bodies and soils, among the main causes. Moreover, excessive GHG emissions into the atmosphere are producing climatic deviations that are threatening living conditions for many species, including humans.

2.1.1 The anthropogenic world and the planetary boundaries

In a recent article, Rockström (2015) discusses the need for limiting economic development as it has been taking place thus far (business as usual) in order to preclude irreversible change to the planet's operating systems. He advocates for a great transition towards sustainable development that can lead to abundance within the planetary boundaries. In other words, development is possible while preserving the continuity and resilience of the Earth's systems. In order to study and assess the effects of human pressure on the planet, and provide awareness and orientation towards the necessary shift in the way economic development is occurs, scientists created the Planetary Boundaries paradigm that aims to keep world development within a safe operating space. It comprises two strategies: the first is to change the obsolete development framework (mechanistic); the second is to foster the shift to awareness, and support values and institutions that integrate people and planet with equity (Rockström, 2015).

Nine planetary boundaries delimit the planet's safe operating space: climate change, biosphere integrity, novel entities, stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, biochemical flows, freshwater use and land-system change. The first assessment of the integrity of the nine planetary boundaries was held in 2009 and disclosed that three of them had already been transgressed: biodiversity loss, climate change and nitrogen loading. In January 2015, a second assessment including refined metrics was published. It revealed four planetary boundaries already trespassed, two in the high-risk zone: biosphere integrity (former biodiversity loss) and interference in the phosphorus and nitrogen cycles; and the other two occurred in the danger zone: climate change and land use change (Rockström, 2015).

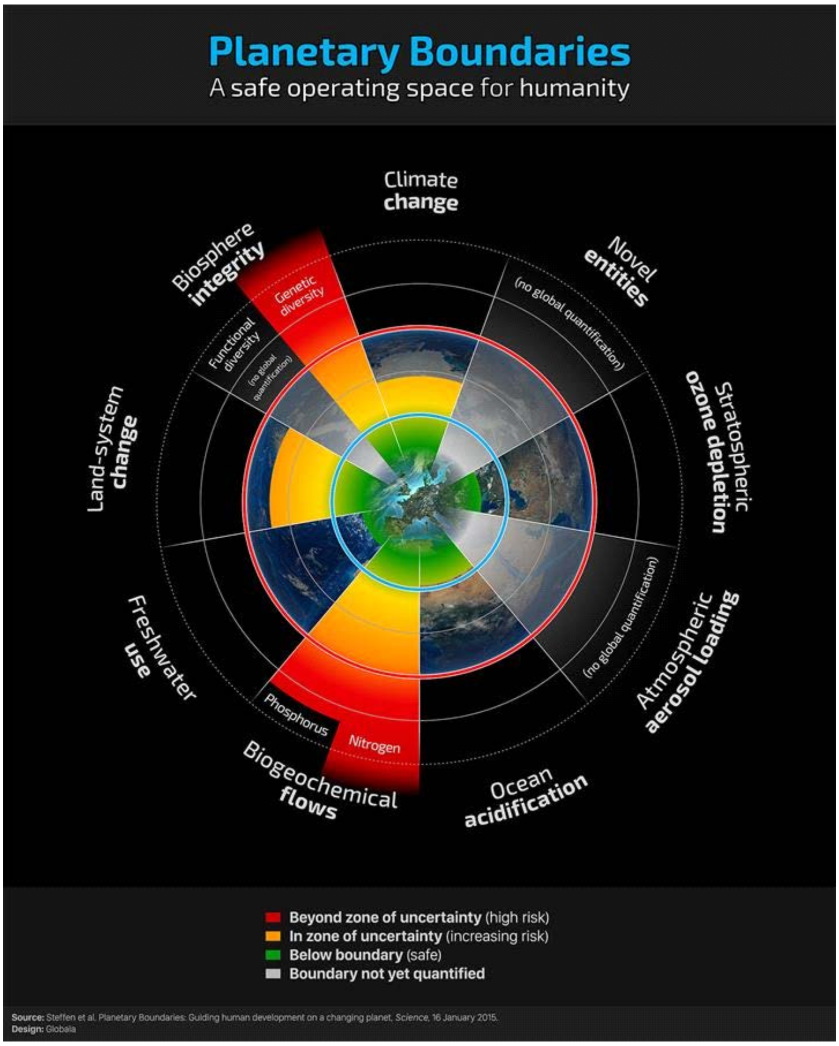


Figure 2-1: The 2015 update on planetary boundaries.

Source: Rockström, 2015

Hence, the latest findings in Earth systems science are demonstrating the significance of maintaining planetary conditions that are supportive of all kinds of life, and the understanding of the Earth's capacity for resilience and the potential tipping points. Therefore, a shift in the current relationship of humans and the planet is essential to a safe living space for all kinds of life. In Rockström's words, "We need an integrated paradigm in which economy is seen as a means to achieving social goals and generating prosperity within the limits of the Earth, not as an end in itself" (2015, p.2). This task is a collective challenge requiring the commitment of all nations and the inclusion of its principles in policymaking at all levels (Rockström, 2015).

2.1.2 The Great Acceleration

The current state of the world derives from a historically recent process that Steffen et al. (2007) defined as the Great Acceleration, a period of fast economic growth that triggered the phenomenon of global change. Since its early days on Earth, humanity has been nurtured by and evolved in close relationship with nature, as an inherent part of it. The Great Acceleration promoted a profound change in the relationship between humans and nature, shifting from an intimate connection to a critical dichotomy. These authors recognise different stages in the great acceleration process: the first is the Industrial Era (ca. 1800-1945) characterised by the expansion of industrialization based on the use of fossil fuels, first coal, then oil and gas. Since then, humanity relies on the energy produced from these sources, "a massive energy subsidy from the deep past to modern society, upon which a great deal of our modern wealth depends" (Steffen et al., 2007, p. 616). The second stage starts after World War II (1945-2015); it is called Great Acceleration because it is most significant in terms of global change. After World War II, there was a sudden spurt in many aspects. Global population doubled in 50 years passing from three billion to over six billion by the end of the 20th century; global economy grew by more than 15-fold and oil consumption increased by a factor of 3.5 since 1960; the number of motor vehicles had an extraordinary increase from 40 million in 1945 to 700 million in 1996. Another dramatic shift occurred in the second half of the 20th century, when the world's urban population grew from 30 to 50%, and the trend strongly continues. The urbanisation process triggered the interconnectedness of cultures, supported by the explosion in electronic communication, international travel and the globalization of economies (Steffen et al., 2007). The cost of this acceleration is extremely high and concerning. The human enterprise has impacted the global ecosystems faster than any other period of human history. The Earth is now in its sixth great extinction event, losing species at fast rates in both terrestrial and marine ecosystems. Global temperatures are rising rapidly due to increasing atmospheric concentrations of greenhouse gases, and the nitrogen cycle is modified by fertilizer production and fossil fuel combustion (Steffen et al., 2007). The massive industrialization and use of fossil fuels fostered the expansion of transport networks across the planet (as seen in Fig. 2-2) that mainly contributed to the exponential rise of GHG concentration in the atmosphere, producing negative effects like global warming. All these vast transformations are producing alterations in the planet's systems and its safe operating space.

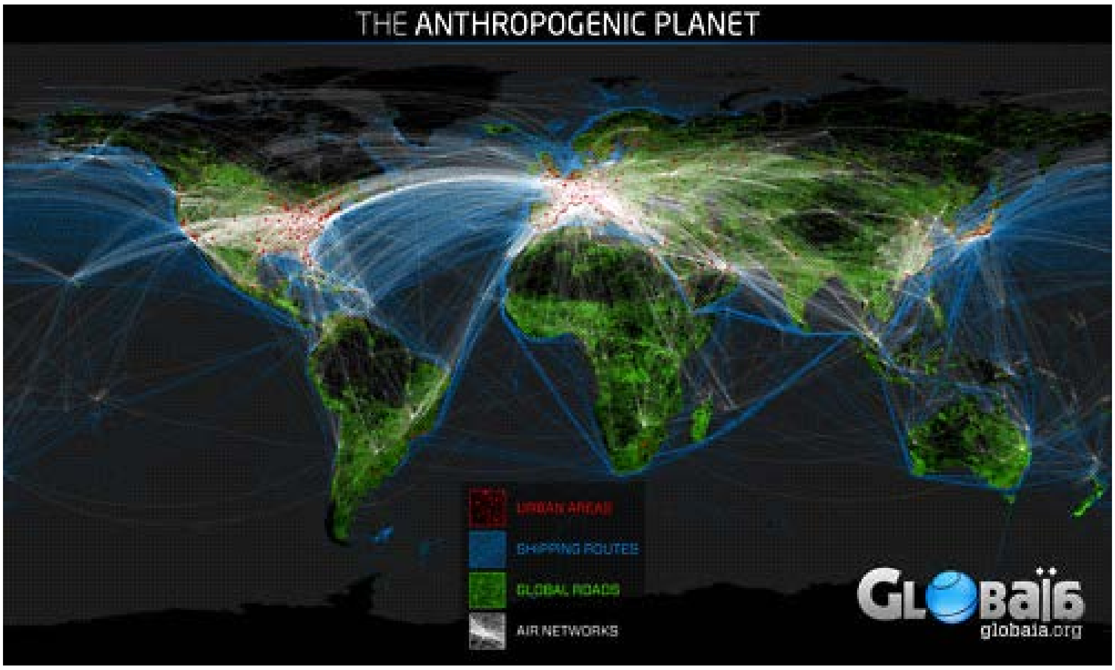


Figure 2-2: The anthropogenic planet: global transportation network.

Source: Globaia.org

The third stage is called Stewards of the Earth in hope that humanity is able to meet the challenge posed by human-induced stresses on Earth's life support systems (Steffen et al., 2007). Scientists are calling for a profound and quick commitment to action towards ensuring the sustainability of the planet, comprised in the Great Transition, a necessary strategy expected to be universally accepted at all levels, from global and local governance institutions, to the private sector and communities (Rockström, 2015).

In Rockström's view (2015), the Great Transition could lead to the restoration of the Holocene's conditions, a balanced relationship of world development that reconciles respect for limits with principles of social justice. This process of transformative change will require transformations in various aspects: energy systems, food production and distribution systems, urban development and use of materials, institutional changes in economic arrangements, financial systems and world trade; and importantly, a profound shift in values, governance structures and globally defined sustainability criteria.

2.1.3 The planetary boundaries paradigm

Given the risk of irreversible change if more planetary boundaries are transgressed due to maintaining the business as usual status, there is great concern about the economic development of the emerging economies. To address this issue, the Planetary Boundaries paradigm recommends a strategy comprehending a two-track approach to achieve sustainable development, including the Global South. The fast track targets the current paradigm through a series of global policy measures, aiming to increase protection from the immediate risks. The critical transformations required are decarbonising the world's economy by 2050 to 2070; feeding the world through sustainable agriculture by 2050; improving resource-use efficiency and accelerating progress towards an economy of cyclic material flows (Rockström, 2015).

The longer track encompasses a profound mindset shift focused on universal values that reconnect world development with the planet's resilience, social justice and less materialistic lifestyles.

2.2 Cities in the Anthropocene

To the vulnerability observed in the ecosphere, another critical issue has to be added: humanity has become an increasingly urban species. Cities historically have been destinations of migrants looking for opportunities for better quality of life, and the trend has intensified in current times, as demonstrated by the rapid urbanisation registered in China and Africa (WUP, 2014), making cities progressively complex, transforming them into drivers of economic growth, hubs of trade, industrial production, knowledge, and innovation. The Great Acceleration affected cities extraordinarily, shaping not only their spatial structure but also the social and cultural aspects of urban lifestyles.

The industrial revolution generated strong migrations from the fields to the cities. Cities grew rapidly and new towns were created to house increasing populations.

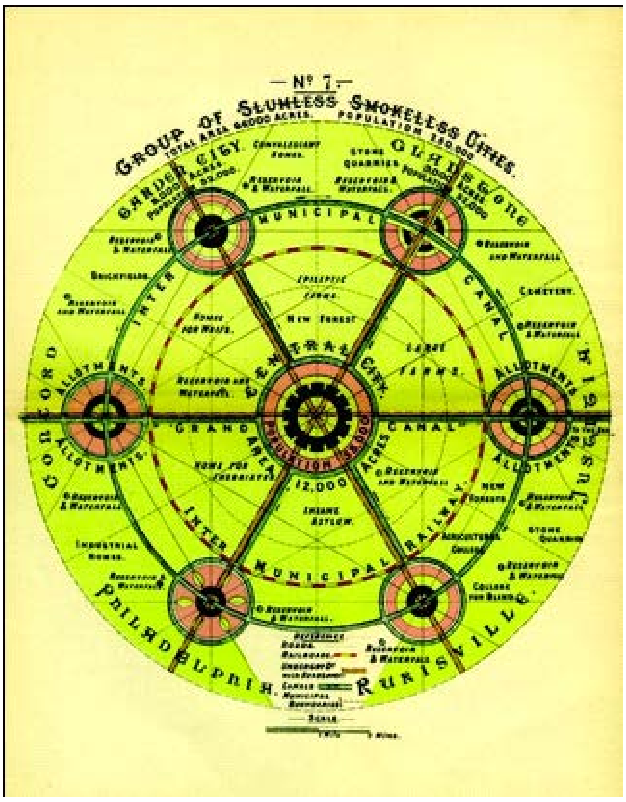
However, urban life did not offer better conditions for the working class. Moreover, many farmers and artisans who lived healthy lives with their families in the fields or small villages saw their lifestyles seriously deteriorate in urban working class precincts. Housing conditions were the worst, in overcrowded units without water supplies or sanitation, lack of ventilation and terrible conditions of hygiene and exposure to pollution and many epidemics of waterborne diseases. The need to solve the unhealthy and unfair social conditions of the industrial city inspired the emergence of various urban design utopias.

2.2.1 Urban utopias of the Great Acceleration

The Garden City

By the end of the eighteenth century, Ebenezer Howard proposed the Garden City as an alternative to improve living conditions in urban precincts, based on creating small garden cities with populations up to 32,000 people in the countryside, interlinked by canals and transit along a permanent greenbelt. Howard's idea was to provide "a group of slum less, smokeless cities" (Fig.2-3) with vast open space offering the residents the best of both town and country living. Howard summarised his vision of the Garden City in the "Three Magnets" concept representing the three lifestyle alternatives, Town, Country and Town-Country. He believed that the Town-Country lifestyle concentrated the "energetic and active town life" plus the "beauty and delight of the country" in a perfect combination, while being free of the disadvantages of each (Howard, 1902, p. 15).

He envisioned stopping London's growth and repopulating the countryside by replacing the declining villages by healthy living towns. In 1898, he first published his ideas in a book titled *To-morrow: A Peaceful Path to Real Reform*. Howard's ideas were successful in attracting attention and financial support to start building the first town planned according to these principles, Letchworth Garden City in Hertfordshire, England. However, the aim to make this a mass movement did not seem to become a reality in a short time. Then, Howard modified the title of his treatise and published a second edition in 1902 as *Garden Cities of To-morrow*, which helped to sustain the movement and influenced urban planning until these days. The ring and radial pattern materialised as a permanent belt of open and agricultural space around the towns and, linked to the central city by radial railways, highly influenced British planning. The Plan for Greater London of 1944 implemented and included it as a planning feature in the *New Towns Act* of 1946, which created a ring of new towns beyond the London Greenbelt. After World War I, a second town was built in 1920: Welwyn Garden City, also in Hertfordshire, designated as one of the first new towns in 1948. Both towns exemplify Howard’s physical, social and cultural planning ideals that expanded to other cities in Europe and around the world, including Canberra, the Australian capital (Reps, n.d; “en.wikipedia.org/wiki/Garden_city_movement”).



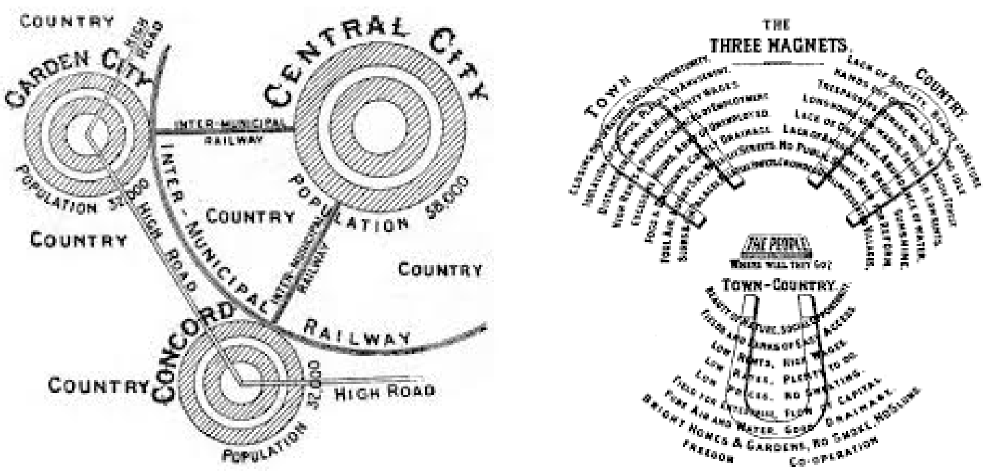


Figure 2-3: The Garden City.

Source: Howard, 1902

The influence of Howard's ideals currently can be seen in many places around the world, as in satellite towns built in Europe, mainly England and Sweden, after World War II, based on the Garden City principles. Moreover, the attraction of this approach continues, upgraded to the needs of this time, in implementations at different scales. It can be seen as a precedent to what Kellert and Beatley named biophilic design and urbanism that is gaining recognition and support in the design of green spaces and infrastructure in urban precincts, cities and regions.

It is interesting to appreciate two ongoing initiatives. One is Copenhagen's Green Structure Plan, also known as Copenhagen Finger Plan (Ministry of the Environment, 2015) that aims to ensure people have easy and permanent access to open space, parks and undeveloped natural areas on a regional scale. The plan attempts to intertwine new "green elements" into the existing urban precincts according to a number of principles reminiscent of Howard's ones:

- "Urbanization will develop in slender fingers
- Green wedges of undeveloped land will remain between fingers
- Finger development will follow public transport (esp. railways)
- Suburbs will develop like pearls on a string
- Inhabitants will live in close proximity to green spaces

The guiding principles of the Green Structure apply both to recreational possibilities as well as to the greater environmental context of the city. In developing their strategy, planners took into account cultural-historical and ecological concerns" (Cahasan & Clark, n.d, p.1). Figure 2-4 below shows the balance between built and green areas in Copenhagen.

URBAN	**GREEN**
City centre	Green wedges
Connective radial transit system	Bicycle paths, harbour-side promenades
Reclaiming parking for plazas and open space	Well-distributed network of urban parks
Dense mixed development with transit nodes	Undeveloped areas / nature reserves

Figure 2-4: Copenhagen's Green Structure Plan.

Source: https://www.google.com.au/search?q=copenhagen+green+fingers+plan&newwindow

The other current case of application of Howard's ideas is the Spanish city of Vitoria Gasteiz, capital of the Basque country. The city implemented a green belt that effectively contributes to improving air quality and liveability. Vitoria Gasteiz was awarded the European Green City of 2012, a result of its successful strategies for sustainable development such as cleaner energy sources, a public transport system and the green belt of parks and other natural areas surrounding the city centre that has greatly contributed to increased biological diversity and higher air quality.

Walkability is another relevant feature that reinforces this initiative. The pedestrianisation of the city centre and public places enabled half of all journeys in the city to be done on foot, compared to 37 percent by car. A broad network of footpaths, cycle routes, bus lanes, and light rail is given precedence over automobile traffic, which is also limited by other measures such as parking restrictions.

Vitoria Gasteiz' Green Belt was first conceived in the 1900s, then resumed and updated in the 1990s. It encompasses a ring of varying green spaces – parks and various natural areas – surrounding the city, ensuring the distance from residential or commercial areas to green open spaces does not exceed 300 metres, and this applies to the whole urban population of approximately 300,000 inhabitants. The city is completing its ambitious plan to make the green belt entirely comprehensive by recovering degraded areas. This is also part of the city's efforts to improve biodiversity through the monitoring of species distribution and the reduction of fragmentation and air pollution (http://wwf.panda.org/?204590/Vitoria-Gasteiz-greening).

Figure 2-5: Vitoria Gasteiz green belt.

Source: http://www.vitoria-gasteiz.org/we001/was/we001

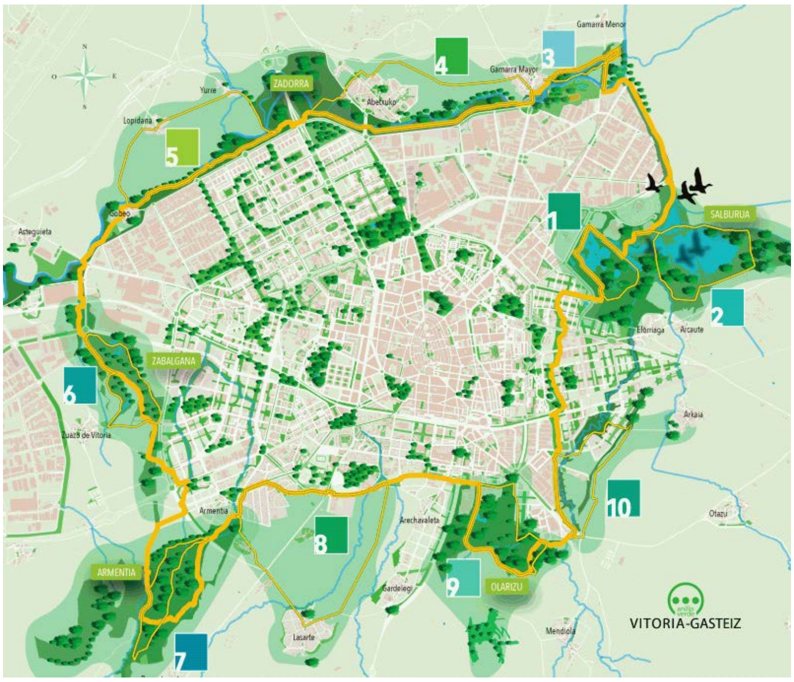


Figure 2-6: Vitoria-Gasteiz green belt plan.

Source: https://www.google.com.au/search?q=Vitoria+Gasteiz+green+plan&newwindow

Critiques of the Garden City

Jane Jacobs, the urban thinker, writer, and activist, was a passionate advocate for cities, particularly big cities. In her seminal book *The Death and Life of Great American Cities*, 1961, she points out "the heart of my argument in defence of the city is that the aim of urban planning should be to catalyse and nourish the close-grained diversity of uses and working relationships that support each other mutually and constantly, both economically and socially". In addition, she remarks: "if there are urban areas that are not lively and vibrant, it is due to the failure in their planning, in not achieving healthy close-grained relationships" (Jacobs, 1961, p.14).

She argues that within urban utopias like the Garden City and others, the consistently planned urban form required tight monitoring by the Public Authority to avoid unwanted development. It is important to notice that in the Garden City, population growth, density, and land use had limitations, which needed permanent control to keep compliance within the planning objectives. In Jacobs' opinion, this issue has a negative effect on the lives of the inhabitants, who have not the right to have plans of their own; this significant right was only reserved for the utopia's planner. Therefore, in her view, residents of utopian cities would have dull, simplistic lives. Moreover, she states that Howard envisioned not only the physical environment and social life of the Garden City, but also "a paternalistic political and economic society" (Jacobs, 1961, p. 18).

According to Jacobs (1961), Howard's ideas were reductionist and destructive of the essence of the city, because he did not consider it as a whole, but instead he was interested in picking those simple functions that could be relatively self-contained and served his utopia. Analysing the strategies of thought supporting Howard's planning theory, Jacobs states that he developed his theory of the garden cities as self-contained towns based on a simple two-variable relationships system, seemingly not enough for a theory that aimed to redistribute the population of cities in a region, and looked towards regional planning. Howard just considered the quantity of wholesome housing required and the number of jobs as the two variables of the system. The entire town was treated in the same manner, as a simple system of order, a two-variable system where the town is one of them and the greenbelt the other. Considering each variable as a relatively closed system, as is the case of the wholesome housing, and putting aside commerce, the complex cultural aspects of cities, their governance issues among others, renders planning "a series of static acts, […] paternalistic if not authoritarian". In addition, she says, "Howard made sense in his terms but none in terms of city planning" (Jacobs, 1961, p.19).

Nevertheless, Howard's ideas strongly influenced American planning, converging on the city from both the town and regional planners' and the architects' sides. On the planners' side, Patrick Geddes saw urban planning as part of a bigger scale, or regional planning, which would benefit from the implementation of garden cities rationally distributed and integrated to natural resources in large territories, where they could contribute to counterbalance agriculture and woodland. From the architects' side, the Garden City principles were useful in supporting housing projects and housing finance, given the enthusiastic support that these ideas had in professional circles and community (Jacobs, 1961).

This influence is still alive on concepts that underlie orthodox American urban planning. It reflects on important principles, e.g. the replacement of the street as the organising element of urban form and life by the concept of the block or, even better, the super-block. The streets lost their social importance to such an extent that it became preferable to open the houses to sheltered green spaces rather than towards the street, and it was considered a waste to devote urban space to the construction of frequent streets. Commerce was also affected by the segregation from residences and greens, and its reduction to the appropriate minimum size to serve households. From this perspective, urban design was intended to create neighbourhoods as self-contained units, resisting change and sticking to the design from the start, and promoting the "illusion of isolation and suburban privacy" (Jacobs, 1961, p.20).

The Modernist City

Le Corbusier, the Swiss-French architect and urbanist, developed a number of conceptual plans for urban form since the early 1920s, based on the principles of rationality, orderliness, and social improvement. His theories aimed to create a scientifically rational solution for urban issues and incorporated the emerging ideals of mass production. Like Howard, he was concerned with the pollution and chaotic conditions of the industrial cities; however, his proposals were rather different to those of the garden city. The Corbusian vision saw urban residents living in designed high-rise precincts settled in the middle of green open areas that would promote democracy and quality of life (Almeida, 2013), ideas that had a profound and lasting influence in urban planning over the 20th century. His 'superblocks' extended across Europe, the Americas and many other countries in the world. Notwithstanding, his conceptual urban form designs have also been strongly criticised since their early days.

Le Corbusier believed that mathematical order in the design of urban environments was a solution for social ills (Almeida, 2013). In his own words: "We strive for order, which can be achieved only by appealing to what is the fundamental basis on which our minds can work: geometry" (Le Corbusier, 1982, p.95). This rationale is reflected in the urban structure of his planning, ruled by orthogonal designs and segregation of uses by strict zoning. Even though the urban form concepts had variations, Le Corbusier was committed to achieving green cities, landscaped cities that offered sun, space and greeneries to their inhabitants the three elements he thought essential to health and wellbeing while ensuring adequate circulation of transport within the urban space. Nevertheless, Corbusian solutions involved the progressive elimination of the street as the dominant organising element of the urban form (Dunnett, 2000).

Le Corbusier developed three urban form concepts that evolved over the first half of the 20th century:

1. The City of Three Million of 1922 is an ambitious proposal for an entire capital city, and referred to Paris. It comprises a high-density administrative core surrounded by a green belt, and beyond it a wide sector of low-density residential suburbs.

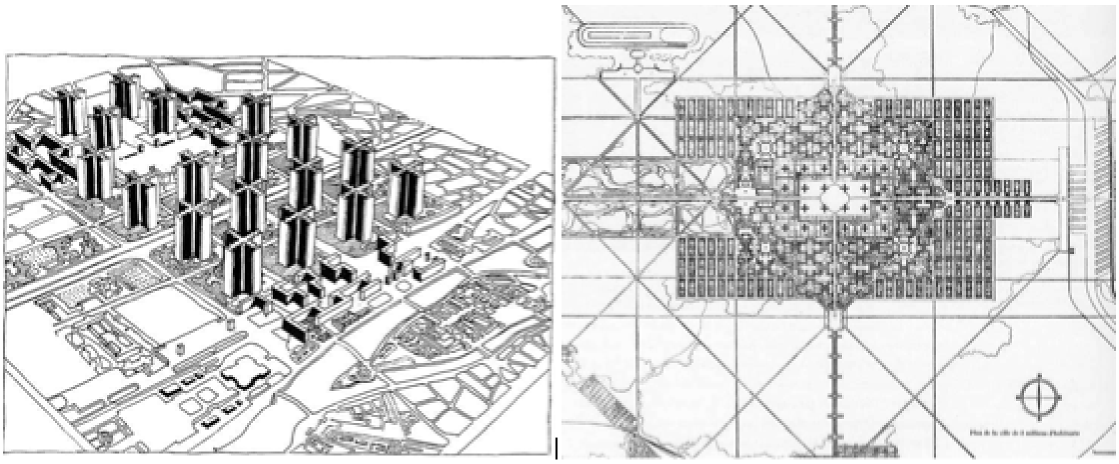


Figure 2-7: The Three Million City.

Source: https://www.google.com.au/search?q=city+of+three+million+inhabitants+corbusier

2. The Radiant City (La Ville Radieuse), conceived in 1932 and referring Moscow, is perhaps the most famous proposal and the one that received most criticism. In this model, the entire population would reside only in high-rise developments consisting of detached towers settled in extensive green areas.

Figure 2-8: The Radiant City, general plan and detail of sports sectors.

Source: *https://www.google.com.au/search?q=La+ville+radieuse*

Residential areas included continuous apartment blocks, 15 storeys high and arranged in serpentine formats. They were provided with elevated roads, and the ground levels were dedicated to sports and green areas to promote the idea of horizontal continuity of the urban realm (Fig. 2-8). Le Corbusier called this pattern 'The Vertical Garden City' (Dunnett, 2000).

The Radiant City had no streets; residential areas had a pattern independent of the road layout.

Figure 2-9: The Radiant City, colour sketch by Le Corbusier.

The residential area in the forefront and the seventy-storey office skyscrapers at the back. Source: http://thecharnelhouse.org

3. The third Corbusian model of urban form is the Linear Industrial City of 1941-1942. Le Corbusier believed that industrial activities and the population of workers should "be dispersed into loose linear cities linking compact radial-concentric cities of exchange" (Dunnett, 2000, p.56). This model was associated with compact residential blocks, or *Unités d'habitation,* consisting of 20-storey slab self-sufficient buildings providing not only the residential apartments but also the essential sources of domestic supply. This made the streets unnecessary for trade and other services, and consequently for human interactions, promoting the end of the traditional continuity of urban form.

The Radiant City influenced many urban designs around the world, among which it is interesting to look at the examples of Chandigarh in India, designed by Le Corbusier, and Brasilia, the new capital city of Brazil, designed by Lucio Costa. Both cities were designed and built from scratch in the 1950s, and founded on the modernist ideals to celebrate democracy and hope in their nations.

Chandigarh

Chandigarh was the dream city of the first Indian Prime Minister Jawahar Nehru to commemorate India's independence in 1947. He hired Le Corbusier to develop the former plan of Albert Mayer and Mathew Novicki for Chandigarh. Le Corbusier's Master Plan modified the shape of the city plan and the curving road network into an orthogonal shape with a grid pattern for the fast traffic roads. For economic motives the definitive plan had its area reduced, and embraced other modifications for cultural reasons, living habits of local people, and socio-economic conditions that ruled out vertical and high-rise buildings. The plan incorporated Le Corbusier's principles of light, space and greenery and the metaphor of a human being. The head contained the administrative core, the heart the commercial centre, and the arms, which were perpendicular to the main axis, comprised the academic and leisure facilities (City of Chandigarh).

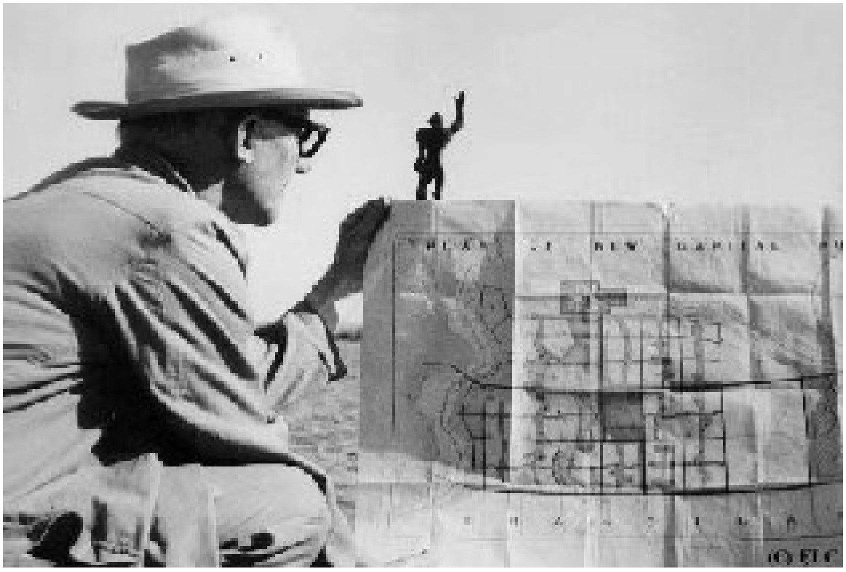


Figure 2-10: Le Corbusier, the Modulor, and Chandigarh's plan.
Source: https://www.google.com.au/search?q=Chandigarh+Le+Corbusier

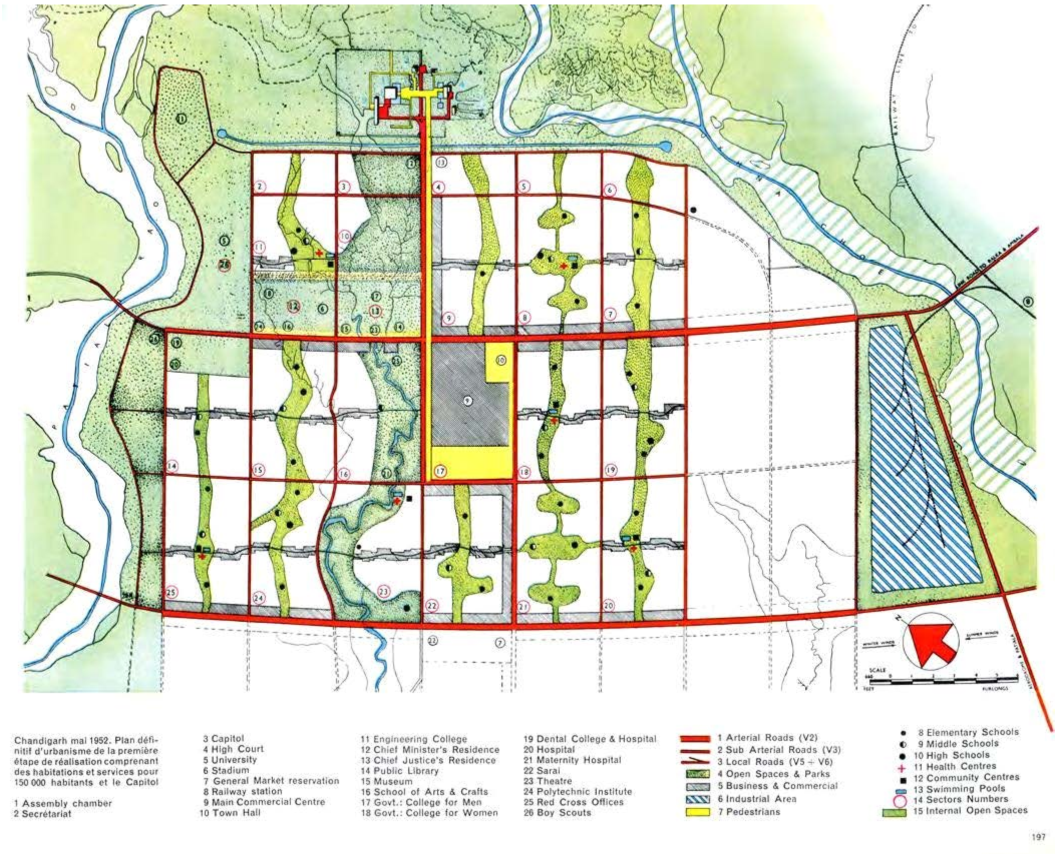


Figure 2-11: Chandigarh, plan.

Source: https://www.google.com.au/search?q=Chandigarh+Le+Corbusier

As per the Radiant City concept, Chandigarh was zoned into different sectors. The primary module of the city's design is the Sector, a neighbourhood unit measuring 800 metres x 1200 metres. It is a self-sufficient unit containing shops, school, health centres and places of recreation and worship. The population of a sector varies between 3,000 and 20,000 people depending upon the sizes of plots and the topography of the area. In this case, each neighbourhood unit is quite similar to the traditional Indian mohalla, covering 250 acres of land. Each sector contains a strip of greenery running north to south, which is intersected by commercial roads running east to west (in red on the map). The roads were organized according to the Seven Circulation Ways or 7Vs (corresponding to the French Les Sept Voies de Circulation), a traffic concept idealised by Le Corbusier that prioritised the automobile, that he considered the central factor of modern town planning. So, the streets in Chandigarh were ordered in a diminishing hierarchy from V1 through V8; V1: arterial roads that interconnect cities, V2: urban city roads, V3: vehicular road surrounding a sector, V 4: shopping street of a sector, V5: distribution road meandering through a sector, V6: residential road, V7: pedestrian path, V8: cycle track. V2 or V3 roads surrounded each sector, with no buildings opening on to them, and were meant to be self-sufficient, with shopping and community facilities within reasonable walking distance (City of Chandigarh).

Chandigarh was Le Corbusier's opportunity to accomplish his ideas on urbanism; however, he was unable to execute his full concept of the Radiant City in India. Contrary to the Master Plan, the residential sector of the city was not what he had envisioned. He would have preferred his 'superblocks' or Dwelling Units (Unités d'habitation), models of integrated vertical living solutions, to be designed to emphasize their relationship with the sun and the sky and their freedom from the ground. However, these typologies did not suit the climate, culture and living habits of local people. Le Corbusier designed the main government buildings in the Capital Complex, such as the Secretariat, the Palace of Assembly and other public buildings that characterise the city, besides a number of sculptures and artworks (City of Chandigarh).

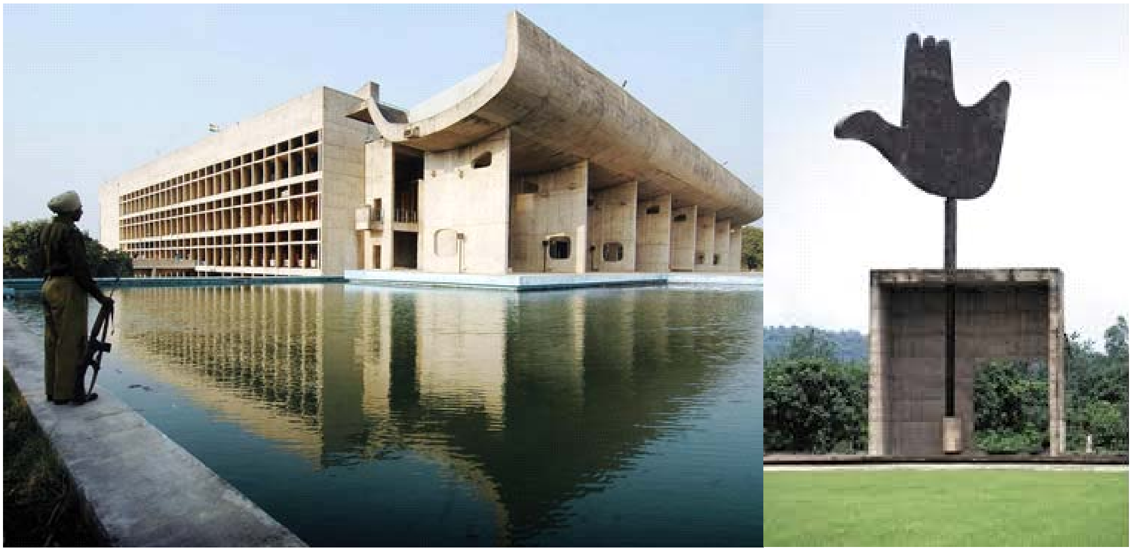


Figure 2-12: Palace of Assembly & Symbol of Chandigarh

Source: https://www.google.com.au

Brasilia

Brazil was going through a period of economic development and democratic institutions in the 1950s. In 1956, the former president Juscelino Kubitschek was determined to achieve a two-centuries-old dream of scattering the country's population into the hinterland of Brazil, to promote a national modernization project. To this purpose, he committed his government to the erection of a new federal capital in the central-western part of the country as a symbol of his policy to upgrade the image of the entire country, to expand industry, and to undertake major construction projects. In 1957, a national competition was launched for the urban design of the new capital. An international jury declared the winner the entry by Lucio Costa (1902—1998) called the Brasilia Pilot Plan (UNESCO World Heritage; Matoso Macedo and Ficher, n.d.).

The proposal reflected the modernist principles and clearly defined the two different functions of a capital city, the administrative or *civitas* and the ordinary urban fabric or *urbs,* which translated into the plan in differentiated forms and spatiality. As Costa described it, the Pilot Plan symbolised the initial gesture of someone designating a place and taking possession of it: a cross formed by two bars intersecting. This image is represented in the plan by the intersection of the monumental and thoroughfare axes, "which stands as the determining factor of the city's urban scheme and underscores the representative character of Three Powers Square" (UNESCO World Heritage).

The *civitas* structures along a monumental axis oriented east to west are reinforced by a sequence of public buildings designed by the internationally renowned Brazilian architect Oscar Niemeyer (1907—2012) and his team. It incorporates the Ministries Esplanade, the Cathedral, the National Theatre, and National Museum, converging on the civic centre or the Three Powers Square, lining the Planalto Palace (seat of the executive power), the Parliament Palace and the Supreme Court Palace.

The *urbs* is materialised as an arch-shaped area spreading north to south, adapted to the topography and the natural slope of the ground. The curved shape of the north-south axis improves its orientation and traces the layout of the wide transportation artery. The city's traffic concept prioritises the automobile and road specialization. *Urbs* encompasses the residential areas, commerce, services and educational and health facilities (UNESCO World Heritage). The six-storey apartment blocks, mainly composed of functional units, are grouped in the 'superquadras' or superblocks, so-called due to their extension five times bigger than a common urban block (Fig. 2-15). The buildings are supported on pylons, which allow the landscape to flow beneath and around them.

Civitas Brasilia underwent a fast construction process, three and a half years, and was inaugurated in April 1960, with the "completion of the most prominent civic structures to create an emblematic vision of the nation's new capital" (Matoso Macedo and Ficher, n.d.).

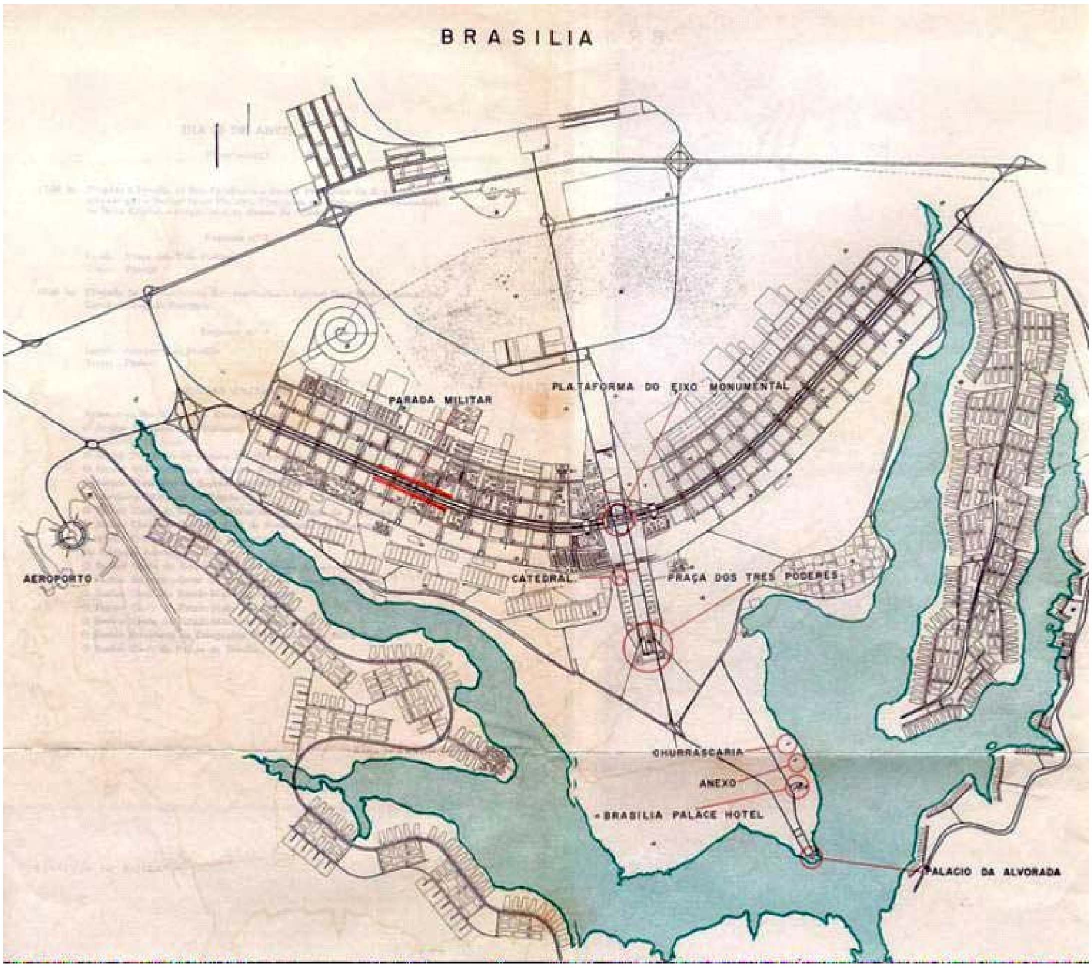


Figure 2-13: Brasilia's Pilot Plan by Lucio Costa.

Source: https://www.google.com.au/search?q=Brasilia+planning

Figure 2-14: Brasilia, the Monumental Axis, with the Parliament Palace at the back.

Source: *http://www.en.wikipedia.org*

Figure 2-15: Brasilia's 'superquadras'.

Source: *http://www.en.wikipedia.org*

In December 1987, the city was awarded UNESCO's World Heritage Site title for Costa's Pilot Plan and Niemeyer's main buildings. The criterion (iv) specifies that

> Brasilia is a unique example of urban planning brought to fruition in the 20th century, an expression of the urban principles of the Modernist Movement as set out in the 1943 Athens Charter, in Le Corbusier's 1946 treatise How to Conceive Urbanism, and in the architectural designs of Oscar Niemeyer, including the buildings of the three powers (Presidential Palace, Supreme Court and Congress with its twin high-rise buildings flanked by the cupola of the Senate building and by the inverted one of the House of Representatives), and the Cathedral with its 16 paraboloids 40 metres in height, the Pantheon of Juscelino Kubitschek and the National Theatre (UNESCO World Heritage).

Planalto Palace

Parliament

Supreme Court

Cathedral

Juscelino Kubitschek Memorial National Theatre

Figure 2-16: Niemeyer's main buildings.

Source: *https://www.google.com.au/search?q=praca+dos+tres+poderes+brasilia*

Today, Brasilia is the fourth largest metropolis in Brazil and the home of more than two and a half million inhabitants (World Population Review). However, less than 10 percent of the total reside in the Pilot Plan area, which accommodates mainly the upper middle classes. The greater portion of the population, covering a wider social range, lives in the twenty-seven satellite towns of the Federal District. These towns have merged into an extensive multi-centred conurbation sprawling from the Pilot Plan. This populated area suffers from dispersion, low densities, an inadequate mass transportation system, segregation and neglected public spaces. These rather common issues in metropolitan areas are intensified in Brasilia by unwise urban policies and need urgent revision (Matoso Macedo and Fecher, n.d.).

Chandigarh and Brasilia, former symbols of modernist hope, today suffer from similar inadequacies, many of them derived from the modernist approach which failed to provide opportunities for social improvement. Insufficient affordable housing, traffic congestion, lack of efficient public transport system mono-functional zoning that aggravates automobile dependence, and urban sprawl surrounding them seem to be the legacy of this urban utopia.

Critiques of the Modernist City

The Modern Movement's conceptions of urban design and planning have been criticised from various fields. Critiques point out the failures in accomplishing objectives meant to be achieved through rationalist planning, like social improvement and development, environmental and sustainability aspects, and in the strategies of thought behind the modernist planning theories. The views of Jane Jacobs and Peter Buchanan are significant for the scope of this study.

Jane Jacobs (1961) mainly addresses the strategies of thought underlying Le Corbusier's Radiant City, and acknowledges its utopian features, directly derived from the Garden City. Its creator called it Vertical Garden City. The 'city of towers in a park' replaced the low-rise housing of the Garden City with skyscrapers and high densities. Jacobs argues that Howard's Garden City supporters never accepted the Radiant City but, ironically, they helped to popularise its main concepts among architects, students and housing reformers, given the success that the Garden City achieved among them. Concepts such as super-blocks, project neighbourhood, unchangeable plan, and the diffusion of lawns and greeneries became widely accepted. Moreover, Jacobs says, "What is more, they were successfully establishing such attributes as the hallmarks of humane, socially responsible, functional, high-minded planning" (Jacobs, 1961, p.22).

Jacobs opposes the functionalist, mechanistic, and consequently reductionist conception of the modernist city. She advocates for diversity and intertwined complementary relationships in the urban realm, concepts that strongly contest the modernist principles of mono-functional object buildings, mono-use zoning, and fragmented urban fabric. She posited sound arguments against the destruction of the roots of urban life proposed by the modernist city. In her opinion, its most controversial issue was the progressive abandonment of the street as the essential organising element of the urban form and life. She based her argument on the emerging science of complexity and urged the planners first to understand "what kind of problem a city is" (Jacobs, 1961, p.428). This relevant inquiry is also the title of the inspiring last chapter of *The Death and Life of Great American Cities.*

For Jacobs, the Radiant City is the result of thinking of urban issues as problems in disorganised complexity, as “a collection of separate file drawers” (Jacobs, 1961, p.436). She argues that the conception of the Radiant City also encompasses the two-variable thinking system of the Garden City, and incorporates some elements of “the statistical reordering of a system of disorganised complexity, solvable mathematically; his towers in the park were a celebration, in art, of the potency of statistics and the triumph of the mathematical average” (Jacobs, 1961, p.436). This critique resonates in Dunnett’s (2000) review of Le Corbusier’s ideas on urbanism and the consequent critiques from two different schools of thought: the Cambridge school based on mathematical grounds, and the New York school, founded on the writings of Jane Jacobs and Rem Koolhaas in the 1960s-1970s.

According to Dunnett (2000), the Cambridge school of thought under the leadership of Professor Leslie Martin used objective criteria of assessment. They made a mathematical analysis of the Radiant City focused on land use, transportation, and open space. The results indicated high efficiency in land use; very low contribution of the automobile in compared to the importance given to it in the design, which abandoned the traditional urban street pattern to accommodate the car inside the city; and compactness of the relationship between the extremely high residential density attained by combining housing, offices and manufacturing and the remaining open space. For Dunnett, the New York school of thought, where Jacobs was the main exponent, based the criticism on subjective appreciations. Both Jacobs and Koolhaas claim the loss of the soul of the city and its sense of excitement is due to abolishing the street and opening of the urban space.

Summarising, Dunnett’s conclusions consider that the key issue in the criticism of both schools of thought is the open space: for Cambridge, it is land use criteria, and for New York, the sterility of Corbusian urbanism (Dunnett, 2000).

Jacobs concludes that the Garden City and the Radiant City are two powerful visions of ideological vacuum, including the mix of both, which gave place to more sophisticated versions that paradoxically became points of reference for American orthodox planning (Jacobs, 1961).

“Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody” Jane Jacobs (1961, p. 238).

Peter Buchanan (2012; 2013) founds his critique of Le Corbusier’s ideas about urbanism on the unsustainability of the modernist approach to both urban design and architecture. He argues that modernism is unsustainable at its core because it betrayed our essential humanity in disconnecting humans from nature, echoing and advocating for their reunion as the only way to achieve true sustainability (Buchanan, 2012). In his words, “This egotistical sense of hubristic disconnection, of humans prevailing over nature, has consistently underscored the modern era” (Buchanan, 2012, p. 4).

Buchanan argues that cheap and abundant fossil fuels facilitated the profound shift in sensitivity and forms in architecture. This was only possible due to the industrialization of oil derivatives that promoted a number or new products and materials, which enabled new shapes in buildings, like flat roofs and slabs, ensuring waterproof and thermal insulation. The same occurred in cities that sprawled very easily, also supported by inexpensive and plentiful fossil fuels which provided energy to feed cars and to lighting, heating and cooling buildings that could have enjoyed daylight and natural ventilation if any restriction to the energy sources had limited its consumption, or if responsible planning and design had been implemented. In his view, the modernist denial of human dependency on nature, and the lack of acknowledgment of nature’s cycles and regenerative capacities, reflects in this “petrochemical architecture and planning, that is axiomatically unsustainable” (Buchanan, 2012, p. 5).

Buchanan founds his critique on the premise that the fundamental purpose of urban design is the provision of a framework that guides the development of the citizens (Buchanan, 2013). In his critical view, he makes a relevant analysis of modernist planning and its by-product, the functionalist city shaped by rational, objective matters, defined in the Athens Charter. This approach to planning establishes rigid mono-functional zoning, allocating requisite facilities according to a mathematical ratio: one playground for every determined number of dwellings and one primary school per multiple of that number of dwellings, and so on. The different settlements like work places, housing and recreation spaces are connected by circulation-only transport corridors; freestanding mono-functional object buildings are erected in residential areas. In Buchanan's words, "This is human life reduced to a mere productive economic unit, its pointlessness to be compensated for by the addictive distractions of consumerism and entertainment. Indeed, the underlying ethos of such planning was a weird mixture of socialism and consumerism […]" (Buchanan, 2013, p.8).

The functionalist city is a fragmented city; its disjointed urban fabric affects civic life and the psyche of its residents in Buchanan's view. Thus, the cultural and social aspects of urban life are reduced, blocked by the dispersed locations of human activities and roles: a place to live in, a place to work, a place to play and so on. A city of isolation that discourages encounters. As Buchanan describes it:

> In such a city, nobody is known in their entirety, the reductionist and mechanistic conception of the layout resulting in the avoidance of community entanglements and chance encounters, with their complexities and contradictions that provoke self-reflection, so leading to self-knowledge and psychological maturation. Certainly, the city is a place of trade and manufacture, residence and recreation, education and welfare. But the quintessential and most elevated purpose of the city is as the crucible in which culture, creativity and consciousness continually evolve (Buchanan, 2013, p. 9).

2.3 Conclusions

This chapter discussed the challenges of the Anthropocene to the highly urbanised world threatened by the effects of overwhelming economic activity that ignores natural cycles and the regenerative capacity of nature.

It pondered on the causes of the current state of the world identifying the mechanistic paradigm underlying the phenomenon of global change initiated with the Industrial revolution that promoted a profound fracture in the relationship between humans and nature leading to human dominance on nature. This is an essential issue, responsible for what humanity and the planet are facing.

It contemplated the Earth scientists' call for an urgent action to limit economic growth, one of the core issues derived from Modernity, which is provoking irreversible change in the safe operating space of the planet and the global ecosystem. They advocate for a different understanding of development that embeds social justice and preserves the continuity and resilience of Earth's systems.

It also considered the effects of the Great Acceleration and modernist planning on the built environment that influenced urban spatial structure and the social and cultural aspects of urban lifestyles. In addition, it analysed the urban utopias that emerged aiming to improve unhealthy living conditions and promote social progress, but failed. Critiques of both utopias were also contemplated, focusing on the fragmentation of the urban fabric and the progressive elimination of the street as generator of urban form and life, with psychological effects on the inhabitants.

In search for solutions to the fragmentation of Modernity, Chapter 3 discusses the ecological worldview and a new understanding of sustainability, named regenerative sustainability.

Chapter 3

A shifting paradigm for an urbanised world

As seen in Chapter 2, the need for a new vision to guide our thoughts and actions is crucial given the legacy of Modernity, a doomed scenario where cities are playing a leading role handling three-quarters of economic activity and being home to more than half of the world population (SDSN, 2013). This achievement was made possible at a high cost, as cities have been growing for centuries based on increasing ecological footprint and overwhelming impact of human activities on earth's ecosystems. Is it possible to transpose this negative impact by making cities part of the solution? Can they become a force for regeneration within their boundaries and further, over their bioregions?

For this purpose, an increasing number of scholars, urban thinkers, and practitioners agree on the need for a new approach to urbanism. In the early 1960s, Jane Jacobs raised this matter in her seminal book *The Death and Life of Great American Cities* (1961). She argued that the key issue in city planning was the necessity to change the way of thinking about cities to understand what kind of problem cities are. Building on Dr Warren Weaver's findings of the stages of development of scientific thought, she ranked cities as problems of "organised complexity" (p.429). As in the life sciences, cities pose problems in which a number of variables are interacting simultaneously "in subtle, interconnected ways (…) interrelated into an organic whole" (p.433). Jacobs argues that urban planning only can progress if the problems are not seen as only relating to cities. She suggests that urban problems can be studied using strategies and tactics from life sciences, because both fields require detailed analysis that allows holistic understanding of the issues presented by cities and living organisms.

In Jacobs's opinion, the most appropriate methods to understand cities are:

- Thinking about processes,
- Working inductively, reasoning from particulars to the general, rather than the opposite,
- Seeking for "non average" clues involving very small quantities, which reveal the way larger and more "average" quantities are operating (Jacobs, 1961, p.440).

This approach to urban design and planning has been broadened by thinkers and theorists in whole systems thinking approaches, such as Capra, Alexander, Orr, Salingaros, Mehaffy and others.

This chapter describes the theoretical framework for the new vision, the ecological worldview, and its regenerative sustainability paradigm (du Plessis, 2011, 2012; Hes and du Plessis, 2015).

3.1 The importance of worldviews and paradigms

Worldviews are ways of thinking and lenses to look at the world; they organise visions and systems of beliefs guiding the interpretation of the various phenomena that shape the space we inhabit. They are relevant in building and structuring new knowledge, defining values and ethical behaviour, and guiding actions. In the words of Hes and du Plessis (2015, p.23),

> A worldview can be described as the stories we tell ourselves about how the world is created, what it is made of, how it is structured and it functions. These stories in turn allow us to construct a value system that informs our ideas of what is good and true, what constitutes ethical action, and how we define concepts such as happiness and success. It also defines the paradigms we use to discover and structure knowledge.

Paradigms organise ideas or basic assumptions to study the phenomena from a specific worldview, enabling the design of appropriate strategies and promoting a common language among thinkers, researchers, practitioners, stakeholders and people involved. As Hes and du Plessis (2015) clearly put it, "a consciously held worldview can shape new practices and transform the way we engage with the built environment" (p. 112). It is important to note that worldviews evolve by building on the knowledge produced by the previous ones, and provide different perspectives and types of knowledge that are valued if applied within the appropriate context of analysis and field of validity (du Plessis and Brandon, 2014).

Paradigms provide the tools or practices to study the phenomena. Citing Wilber (2000), du Plessis and Brandon describe paradigm as follows:

> It is the paradigm that discloses a particular type of data and in a way thus determines what data get disclosed, and therefore the type of knowledge that could be articulated in a given world space (the perceivable phenomena) or worldview (du Plessis and Brandon, 2014, p.3).

3.2 The shifting worldview and paradigms

Mechanistic and ecological worldviews and paradigms have essentially different and sometimes contradictory principles as well as divergent understandings of sustainability. Nevertheless, they made valuable contributions, each in its field. The former produced knowledge and laws of great value in the fields of engineering and technology. However, it was demonstrated that the mechanistic worldview in same aspects was limited, e.g. in dealing with agricultural processes, and the design and development of environments that include living systems, and in other aspects was overwhelming as in regards to the over exploitation of natural resources and intensive use of fossil fuels, practices that led to dangerous and destructive outcomes resulting in challenging phenomena such as the anthropogenic induced climate change. The ecological paradigm adds new knowledge drawn from quantum physics, ecology, life sciences and neuroscience that have proved to be more appropriate and effective particularly in the realm of design and development encompassing living systems (du Plessis and Brandon, 2014). This vision strongly resonates with the Earth scientists call for a radical shift in the way we think, live and produce goods and cities, as seen in Chapter 2.

3.2.1 The mechanistic worldview

The mechanistic worldview, based on the metaphor of the machine, comprehends the universe as a whole composed of material parts – living organisms included – that function like mechanical systems governed by universal laws. It generated the technological sustainability paradigm, focused on the belief that the power of science and technology can solve social-ecological challenges, considered as complicated technological problems. In this view, universal laws rule both mechanistic and closed systems and living or open systems that can be handled using the same methods. The technological sustainability paradigm defines sustainability as "achieving and then maintaining an optimal triple-bottom-line steady state" (Benne and Mang, 2015, p.8). This static view of sustainability as a change of states with an end (Hes, 2013) has been criticized by many scholars (Alberti et al., 2003; Moffat and Kohler, 2008; du Plessis 2012; Cole et al., 2013). The strategies designed to achieve this state attempt to optimise the efficiency of each component of the system by identifying distinct performance requirements, establishing specific measurable goals and targets, and obeying assigned formulas, rules and criteria. In this way, the sustainable performance of the whole is ensured by aggregating the solutions for each part. Regarding project and development processes, designs and measurements are elaborated outside of context, without consideration of or relationships with the wider environment, except when site conditions are considered directly relevant. These approaches separate humans from nature, built and natural environments; they are technocratic, generic and top-down, applicable to any place in the world, with adjustments for regional distinctions or cultural differences only if strictly necessary. Strategies conceived by this paradigm for designing a sustainable entity are predominantly quantitative and efficiency-focused, encouraged by numerous rating tools, e.g. eco-efficient design, green buildings, resource-efficient built environment, to mention a few (Benne and Mang, 2015; Hes, 2013). It is important to recognise that the application of these strategies has achieved some results contributing to less harm, but they still maintain issues that hinder full outcomes because they are still dependent on earth's carrying capacity, show disconnection between design and performance, and also decouple from their immediate environment and social context. This individualist approach is contradictory in itself, because if it seeks efficiency on the one hand, on the other it ignores opportunities of social and environmental collaboration (e.g., water treatment, tri-generation systems) for creating a thriving urban system (Hes, 2013).

The mechanistic worldview has underpinned the world economy over the past three centuries. It has led to a production and consumption model based on resource consumption and infinite development with economic growth resulting in resource depletion and ecosystem services reduction, so grave that in many cases, the Earth planetary boundaries have been already crossed (Rockström, 2015).

Thus, if we aspire to leave a healthy world of richness and diversity to future generations, humanity's only choice is to overcome the biggest challenge, "escaping the trap of the mechanistic worldview" (Hes and du Plessis 2015, p.25).

3.2.2 The ecological worldview

Conversely, the ecological worldview sees the world through the metaphor of the ecosystem; it considers the universe as a complex web of self-organising living systems, where everything is integrated and interconnected, forming an interdependent and multi-levelled net of structures of multi-faceted living systems (Capra, 1996; Mang and Reed, 2012, Benne and Mang, 2015). The notion of ecosystem has been influential in shaping the ecological and regenerative comprehension of the world, and particularly the role of humans as part of nature. This furthered systematic efforts to relate sustainability and development, incorporating living systems thinking to understand things systemically, that is considering "relationships within the context of a larger whole" (Benne and Mang, 2015, p.6), which opposes mechanistic reductionism. The vision of the world, where cities are designed and built, is then of a place in constant state of flux and change including both biophysical and social systems.

The ecological or regenerative sustainability paradigm sees the integration of humans and their activities with the other forms of life in a harmonious and mutually beneficial manner as the main principle to reduce menaces to sustainability and as a leading pathway to “restoring the inherent regenerative capacity of natural and social living systems” (Benne and Mang, 2015, p.8-9). Contrasting the mechanistic definition, sustainability is understood as “the capacity of a living system, in a continually changing environment, to maintain its core purpose and integrity in reciprocal relationship to the larger system(s) in which it is nested. Sustainability is an emergent property arising from the interaction of social, economic and ecological solutions” (du Plessis, 2012, cited in Benne and Mang, 2015, p.9). Strategies for a sustainable built environment in this paradigm are mainly qualitative; their purpose is to create conditions that enable and sustain all kinds of life in a specific place, allowing their co-evolution along time. The concept of ‘ecosystem’ influences how we define the built environment, the role of buildings, precincts and cities, as well as the role of design practitioners and the thinking, technologies, and standards of ecological performance that support their practices. The uniqueness and particular flows of life in a place determine the concepts, design and processes on which the strategies rely, steering the potential of the contribution that the proposed building or development can offer to the site. Regenerative solutions are site-specific and entail the comprehension of relationships between local human and ecological systems to support and enhance life. In this way, humans and nature are co-creative partners and participants in their mutual evolution (Mang and Reed, 2012; Cole, 2012a,b; Hes and du Plessis, 2015; Benne and Mang, 2015).

The ecological worldview embeds two aspects, one tangible or external related to the biophysical sphere and the other intangible or internal aspect related to the sphere of thoughts, feelings, values and human interactions. Both together form the systems in which human life and activities take place, focusing on three core themes, *wholeness, relationship* and *change*, which comprise a set of values and guidelines to ensure ethical actions. The regenerative sustainability paradigm provides the guidelines and strategies to answer the questions posed by these key themes (du Plessis and Brandon 2014; Hes and du Plessis, 2015).

The concept of *wholeness* refers to the re-union of human and natural systems, leading to a new attitude toward the understanding of the world, considering the built environment as a social-ecological system. The new attitude involves the change of mindset entailing cognitive, emotional and spiritual reconnection of humans to nature. It incorporates existential knowledge, the indigenous peoples' wisdom and traditions that embed the notion of humans as being part of and having interconnected and intertwined relationships with all kinds of living systems. It also combines human technologies such as ecological design and engineering, construction and building ecology, and knowledge and application of principles of biomimicry (du Plessis and Brandon, 2014).

As mentioned before, the whole systems approach comprises interior and exterior domains of existence. Exterior relates to the biophysical, perceptible realm as well as the social structures, e.g. economic or legislative systems; the internal aspect entails the mental, intangible, invisible realms. Based on St Isidore of Seville's definition of a city as formed by two indivisible parts: the urbs or physical aspect and the civitas or mental part including the emotions, rituals and rules, the regenerative sustainability paradigm considers the city as a "phenomenon originating from and created by both mental-social and technological-natural processes" (du Plessis and Brandon, 2014, p.6). This means that systemic planning and design processes must involve the interior aspect comprising individual and collective values systems, and both interior and exterior change with the pertinent technologies as well.

Related to the second main theme, *Relationship*, below there is an example of how approaches to development and design within the ecological worldview organise their methodologies, whose application also is illustrated in the case studies (Chapters 6, 7 and 8). Mang and Reed (2012a) developed a specific relationship-based methodology for regenerative design. This design approach to the built environment is embedded into the ecological worldview because it combines both the exterior or biophysical aspect and the interior or mental, emotional aspect of existence (Plessis and Brandon, 2014).

Thus, this methodology's critical objective is supporting and enhancing life conditions and evolution in place. It comprises three stages (Story of Place, Co-creation and Co-evolution) to ensure that the project's purpose is enabled in order to achieve regenerative outcomes. The first stage, Story of place, focuses on the understanding of place and its main characteristics (cultural and economic aspects, ecology, geography, and climate) as well as the recognition of the patterns that organise the place and its region aiming to achieve a correct relationship between project and place. Through the making of the story of place, stakeholders can be aware of the uniqueness and opportunities of place and will be able to identify possible mutual beneficial impacts that the project can have on the broader system. Thus, this stage comprises the deep understanding of place and its potential, and the building of adaptive capacities of all parts involved. The second stage, Co-creation, is about designing for harmony, integrating human purposes with the evolution of natural systems on place. It founds on the values system, which comprise respect, mutuality and fellowship between humans and nature, with a special focus on human actions responsibility. The third stage is Co-evolution, reassuring that the created regenerative capacity involving all systems is sustained over time.

The third core theme is C*hange*. It is inherent to all living systems and caused by the interconnected actions of the component parts, which also encompass capabilities of response to surprise, unpredictability and non-linear effects that are intrinsic to complex systems. Therefore, it is necessary to build on adaptive capacities allowing for modification of place to unpredictable changes that may appear in the future (e.g. renewable energy, urban food production, rainwater harvesting).

Importantly, the three core themes of wholeness, relationship and change lead to a system of values, embedded in the ecological worldview.

3.2.3 Understanding the built environment as a social-ecological system

As mentioned earlier, the reconnection of humans and nature is essential to re-establish health and wellbeing within built environments, not only to ensure liveability in dense populated cities but importantly, to create symbiosis between humans and all forms of life. The regenerative sustainability paradigm has the potential to “align human development efforts with the creative efforts of nature” (du Plessis and Brandon, 2014, p.4), presenting appropriate strategies and practices to restore past damage and nurture positive relationships between people and their social and biophysical environments.

This approach echoes in the built environment shifting the ways we think, design and build cities. Cities are now understood as complex social-ecological systems that embed living systems as well as engineering and technological ones. As Newman and Jennings clearly put it, “Cities are the defining ecological phenomenon of the twenty-first century” (2008, p.2).

New research fields are emerging from this perspective aiming to formulate a theoretical context to underpin studies that allow for better understanding of the relationships between natural and built environments (Alberti et al, 2003; Alberti, 2005; Moffatt and Kohler, 2008; Newman and Jennings, 2008; Beatley, 2011; du Plessis and Cole, 2011; du Plessis, 2012; Cole et al. 2013; du Plessis and Brandon, 2014; Bene and Mang, 2015).

Urban ecology is one of the developing fields. Various scholars have proposed ways to investigate the urban phenomenon and the challenges it poses to the ecology of place, particularly to ecosystem functions. Alberti et al. (2003) consider cities as emergent phenomena, arguing that they have to be understood as wholes, instead of being studied by the properties of their component parts. Moreover, they define cities as “complex ecological entities which have their own unique internal rules of behaviour, growth, and evolution, and important global ecological forcing functions” (p.1170) that differentiate them from other ecosystems because of the dominance of the human component. Considering that human activities are modifying the rules that regulate life on the planet, the framework proposed by Alberti et al. (2003) entirely integrates humans in ecosystem studies. The alterations of natural processes are mostly manifest within and around cities, creating a new type of ecology in human-dominated landscapes. In these places human decisions and choices affect ecosystem processes directly, e.g. land use, patterns of development and density of infrastructure, and also indirectly as is the case of air and water, emissions, solid waste, land conversion and extraction of resources (Alberti et al, 2003).

The effect of urbanisation on the functioning of earth's ecosystems is vast. It consumes resources from existing ecosystems in the ecologically productive area surrounding cities that provide what is necessary to support urban populations, and in doing so, it disrupts, fragments, isolates and degrades natural habitats, hydrological and energy flows and nutrient cycles, and appropriates "large shares of earth's carrying capacities" (Alberti, 2005, p. 169). This relationship defines the cities' ecological footprint, which is directly related to the concept of ecosystem services (Costanza et al, 1997; Folke et al, 1997; UN, 2005; Alberti, 2005; Newman and Jennings, 2008; Pedersen Zari, 2012).

The fragmentation of ecological patches directly affects biodiversity, which is key to ecosystem function, and alters the structure and distribution of vegetation and fauna, breaking landscape's connectivity, a critical property for the movement of resources among natural patches (Alberti, 2005). Since human interactions with natural system processes is mediated through patterns of urban development, Alberti (2005) proposes an investigation on the influence that different types of urban patterns have on natural ecosystems, suggesting that "alternative urban patterns have differential influence on ecosystem function" (Alberti, 2005, p.171).

Urban patterns can be defined by the Urban-to-Rural Transect planning model created by new urbanists Andres Duany and Elizabeth Plater-Zyberk and Company (DPZ) to guide the intensity of urban development ranging from untouched natural areas to the urban core zones, classifying it into six categories. This model was adapted by the International Living Future Institute (ILFI) into Living transects for the Living Building Challenge, a program created by ILFI and defined as "a philosophy, certification and advocacy tool for projects to move from beyond merely being less bad to become truly regenerative" (ILFI, 2014, p.4). It is used to evaluate buildings and developments' performance providing "a framework for design, construction and the symbiotic relationship between people and all aspects of the built environment" (ILFI, 2014, p.6).

Ecosystem services and the built environment

The United Nations' Millennium Ecosystem Assessment (2005) described ecosystem services as the benefits that humans draw from natural ecosystems, and classified them into four categories: provisioning services, regulating services, supporting services and cultural services. Provisioning services provide food, biochemicals, raw materials, fuel, fresh water, ornamental resources and genetic information. Regulating services are responsible for pollination and seed dispersal, biological control, climate regulation, prevention of disturbance and the moderation of extremes, decomposition and purification. Supporting services comprise soil, fixation of solar energy, nutrient cycling, habitat provision and species maintenance. Cultural services involve artistic inspiration, education and knowledge, aesthetic value, cultural diversity and history, recreation and tourism, spiritual and religious inspiration, creation of a sense of place, and relaxation and psychological wellbeing. Unfortunately, this immense wealth is being dramatically reduced due to human impact. Ten years ago, the Millennium Ecosystem Assessment (2005) estimated that two-thirds of the world's ecosystems were at risk due to human activities and technologies (UN, 2005). These findings corroborate the previous warnings of scientists and scholars.

Costanza et al. (1997) argued that although ecosystem services are essential to human survival, economic development does not consider the value of these functions in the cost of global production. They called this the *hidden human requirements for ecosystems functions*, and correlated urban growth to ecological sustainability. Folke et al. (1997) raised the problem of the increasing urban ecological footprint, which sometimes is more than 1000 times larger than the urban area itself, in the industrialised countries. These authors contended that city planning and development need to account for the challenge of the decreasing capacity of ecosystems in sustaining urban areas, recommending that urban development should be sensitive to the changing productive capacity of ecosystems, and urban growth limited according to the processes and functions of the ecosystems it relies on. Moreover, they warn that

> One cannot talk about sustainable cities if the ecological resource base on which they depend is excluded from analysis and policy. It is in the self-interest of city inhabitants to make sure that ecosystems continue to produce the biophysical preconditions on which they live (Folke et al. 1997, p. 171).

Newman and Jennings (2008) in their essential CASE (Cities as sustainable ecosystems) approach definitely integrate humans within ecosystems, stating that ecosystem models can help shaping cities by modelling urban processes on ecological principles of form and function. They emphasize that cities need to mimic nature's patterns and processes in their pathways to sustainability. Furthermore, they suggest that if the development of urban strategies incorporates ecosystem qualities of diversity, adaptation, inter-connectedness, resilience, regenerative capacity and symbiosis, urban processes could benefit by increasing their productivity and regeneration ability to improve ecologic, social and economic aspects.

CASE approach to urban design and planning relates the dynamics of cities and urban challenges to the characteristics of natural ecosystems, looking for and mimicking patterns and processes that can provide the foundations for sustainable urban strategies. In Newman and Jennings' words,

> Examining a city as an ecosystem enables flows of energy, materials and information to be studied together along with the interactions between humans and non-human parts of the system (Newman and Jennings, 2008, p. 93).

According to these authors, the new understanding of cities can lead to transforming human actions and processes in urban areas reflecting on urban form and provisioning systems such as energy, water and food, as well as in restoring the functional capacity of bioregional ecosystems.

Moffatt and Kohler (2009) discuss the necessity to formulate a unified theory for the built environment remarking that it is essential to understand it as "a complex social-ecological system where multiple-related metabolisms interact at different scales" (p.249). They claim the need of a historical analysis to see how the relationship between the built environment and the ecosphere has performed over time, moreover, how the concept of built environment is dependent upon historical context. The authors consider that the built environment exists only in relationship to the natural environment, and that this is related to the historically changing opposition between humans and nature. They also argue that the theoretical structure defining the built environment as formed by social and ecological systems "combines flow-based and capital or resource-based models for building and infrastructure stocks", foreseeing a shift in design practices. This includes respect for the regenerative capacity of natural systems, resilience-based models and integration of the "history of nature with the history of human culture" (Moffatt and Kohler, 2008, p.266).

On the same line of thought about the built environment, Pedersen Zari's (2012) research focuses on the analysis of ecosystem services as a key issue for the design of built environments, particularly for urban design and planning. She claims for a rethink on the way of building cities that can contribute to mitigate or even reverse the current negative pressure on ecosystems. In her words,

> Ecosystem services analysis enables ecological regeneration goals for the built environment, but it needs to be used in conjunction with other aspects of regenerative design that focus on the development of relationships between humans, the built environment and wider ecosystems (Pedersen Zari, 2012, p. 57).

According to Pedersen Zari, ecosystem services analysis can be used as a basis for design, specifically for regenerative design. One of regenerative design goals is to address the degradation of ecosystem services by creating environments that promote their return or evolution to a state of health where they can thrive without human intervention (Reed, 2007).

Regarding design, ecosystems can guide practitioners to think projects as living systems, showing how life can organise functions in a given place. Design strategies based on mimicking ecosystems and their processes can also promote insights for the design of green infrastructure and urban design, as described by Newman and Jennings (2008) in their CASE approach, and as a "systematic transfer of ecological knowledge into a built environment context" (Pedersen Zari, 2012, p.56).

Pedersen Zari (2012) identified six ecosystem services as most suitable for regenerative design for the built environment, which could help in demonstrating the limits of regenerative design and making interventions measurable:

Supporting services	Regulation services	Provisioning services
Habitat provision Nutrient cycling	Purification Climate regulation	Fuel/energy for human consumption Fresh water

Table 3-1: Ecosystem services related to the built environment

Source: Author

Applying this concept to design, buildings or urban developments could help incorporating functions matching those of an ecosystem, such as

- providing habitat for non-human species (e.g. biophilic features such as green roofs and green walls)
- contributing to soil formation and fertility (e.g. recycling biodegradable wastes, composting)
- Purifying air, water and soil (e.g. living machines – natural filters using plants; green roofs and green walls, urban canopies and forests)
- Producing renewable energy
- Regulating climate through mitigating greenhouse gas emissions or possibly sequestering carbon (e.g. biophilic features and interventions, passive design)
- Collecting water (e.g. rainwater harvest, pervious exterior paving).

Pedersen Zari observes that application of regenerative design to the built environment from an ecosystem services analysis perspective requires interdisciplinary approaches and, essentially, a new mindset and goals to promote the needed transformative change.

Socio-cultural and ecological systems co-evolution

The concept of co-evolution between socio-cultural (human) and ecological (natural) systems, core principle of regenerative development and design is addressed by Cole et al (2013) settling it as a distinctive characteristic of the new vision of the built environment as a social-ecological system.

Building on Mang and Reed's (2012a,b) definition of co-evolution,

> "[…] Regenerative development and design means the reconnection of human aspirations and activities with the evolution of natural systems – essentially co-evolution (Mang and Reed, 2012a, p.26).

Cole et al. describe its unique significance as "a partnered relationship between socio-cultural and ecological systems rather than a managerial one" (p. 238), suggesting that it builds social and natural capitals. These authors remark an important property of the social part of the system. Conversely, to the ecological systems that regenerate by self-healing and self-organising their attributes, the built environment does not regenerate itself. Cole et al. explain that rather it is

> "the act of building and inhabiting a system consisting of buildings, [their] inhabitants and the biophysical and socio-cultural context is regenerative and provides a catalyst for positive change within the unique 'place' it is situated" (Cole et al., 2013, p.238).

In addition, it is expected that through time the system – built form, infrastructure and all stakeholders – can provide positive outcomes, enhancing life in all its forms, socially and environmentally (Cole et al, 2013). This is similar to the processes all living and complex systems undergo through their lifetimes, including traditional human settlements.

As seen in the aforementioned discussion, the current state of the built environment is untenable, incapable of supporting sustainable living standards; then, it must be consciously transformed into one that allows survival and evolution (Newman and Jennings, 2008; Cole et al, 2013). This is a complex process of learning and adaptation involving firstly a new mindset, to undertake transformative action understanding how to work within complex, uncertain and unpredictable situations. It implies acquisition of knowledge, and learning how to cope with change and uncertainty. Secondly, involvement of all parts, including institutional frameworks and social networks that help in creating awareness and responsible stewardship (Cole et al, 2013; McLennan &Reed, 2013). Thirdly, understanding the nature of social-ecological systems as something that is not the inclusion of humans in ecological systems nor ecosystems included in social systems, but a different entity, although with recognisable component parts. (Walker et al, 2006).

Synthesizing these ideas, Peter Buchanan brilliantly described the city as follows:

> A city is a cultural artefact, consciously and wilfully shaped by humankind, yet also a living organism unconsciously shaped by its own metabolic forces. (Buchanan, 2013, n/p.).

3.3 Conclusions

This chapter discussed the ecological worldview, a vision guiding to reunite the whole that modernity fragmented, and sustain a new mindset leading toward a way of understanding the world that incorporates the findings of the new sciences and seeks for solutions to the challenges of the Anthropocene.

It explained the importance of worldviews and paradigms in the study of phenomena and in organising ideas and methodologies to determine the role of humans in the reunited whole.

Importantly, the ecological worldview and its regenerative sustainability paradigm offer an alternative definition of sustainability, based on the concept of ecosystem that redefines the built environment as a social-ecological system and integrates a system of values and ethical procedures to guide human interventions and activities.

The new vision of the built environment as a social-ecological system affects design practices. Cities are now understood as complex social-ecological systems that embed living systems as well as engineering and technological ones. New knowledge drawn from biology and emerging research fields such as urban ecology and ecosystem services analysis are proposing new approaches to architecture and urban design and planning emulating the functioning of ecological systems. This opens the field to social-ecologically based strategies for the design of healthier environments for all kinds of life. This is discussed in Chapter 4, focused on two social-ecological strategies: biophilic urbanism and regenerative development and design.

Chapter 4

Two social-ecological design approaches to regenerative sustainability

This chapter sets out the major features of two design approaches to the built environment from a social-ecological basis: Biophilic Urbanism and Regenerative Development and Design. Through the analysis of the theory of each of these social-ecological approaches, it will explore how they can contribute to the design of cities that enable solutions to repair damage and regenerate both natural environments and social systems. To that purpose, the core principles of biophilic urbanism and regenerative development and design will be used to create a framework for design practice (see Chapter 5) that will then be applied to examine the case studies in Chapters 6, 7 and 8.

4.1 Regenerative sustainability paradigm

Regeneration is about promoting positive contributions that can heal and improve place conditions, both in the social and biophysical aspects, keeping the system thriving (Reed, 2007; Reed in Melk, 2015). The regenerative sustainability paradigm sees the integration of humans and their activities with the other forms of life in a harmonious and mutually beneficial manner as the core principle to solve threats to sustainability and as a leading pathway to “restoring the inherent regenerative capacity of natural and social living systems” (Benne and Mang, 2015, p. 8-9). The ecological worldview draws from indigenous peoples’ knowledge across the world the vision of humans as an integral part of nature and partners in co-creation and co-evolutionary processes (du Plessis 2012; du Plessis and Barton, 2014; Hes and du Plessis, 2015)

Contrasting the mechanistic definition that sees sustainability as a steady ideal state, in the ecological worldview the concept of sustainability is related to the concepts of ecosystem and resilience. Resilience is understood as a dynamic process of learning how to adapt to and evolve with changing situations because, as seen in Chapter 3, relationship, change and reflection are the three main themes underlying the interpretation of regenerative sustainability (Hes and du Plessis, 2015). In du Plessis words, regenerative sustainability is

> The capacity of a living system, in a continually changing environment, to maintain its core purpose and integrity in reciprocal relationship to the larger system(s) in which it is nested. Sustainability is an emergent property arising from the interaction of social, economic and ecological solutions" (du Plessis, 2012, cited in Benne and Mang, 2015, p.9).

The foundational concept of regenerative sustainability (Reed, 2007; du Plessis, 2012; Hes and du Plessis, 2015) seems to be creating a new attitude in designers and stakeholders toward the built environment, which is seen as feasible to be restored and regenerated through the implementation of "localised ecological design and engineering practices rooted in the context and its social-ecological narratives" (du Plessis, 2012, p.15).

Biophilic design and biophilic urbanism approaches to design appear to be appropriate means for the reconnection of humans to nature. Biophilic interventions facilitate access to nature through the creation of abundant green environments in cities, and onto buildings providing health and wellbeing to users and residents. This reconnection occurs particularly when the design interventions are based on the ordered complexity of natural structures, and adapted to human sensibilities (Kellert and Wilson, 1993; Salingaros and Masden, 2008; Kellert et al., 2008; Beatley, 2011; Kellert, 2012). Regenerative development and design foster a substantial advance in the understanding of sustainability because it seeks to promote conditions that are conducive to life, helping living systems to recover their capacities of re-organizing and regenerating themselves and leading to the regeneration of built environments and communities (Mang and Reed, 2012a,b).

Recalling the concepts of worldviews and paradigms discussed in Chapter 3, the following Figure 4-1 shows the relationship between the theoretical foundations related to the ecological worldview and its regenerative sustainability paradigm that support design strategies – in the case of this research Biophilic Urbanism and Regenerative Development and Design – its principles and practices, contained within this paradigm. This is relevant to the coherence of the knowledge and insights produced by the accumulated knowledge of this and the precedent worldviews, and to provide guidance on the principles that organise human actions to create, influence and transform the world (du Plessis and Cole, 2011; du Plessis Brandon, 2014).

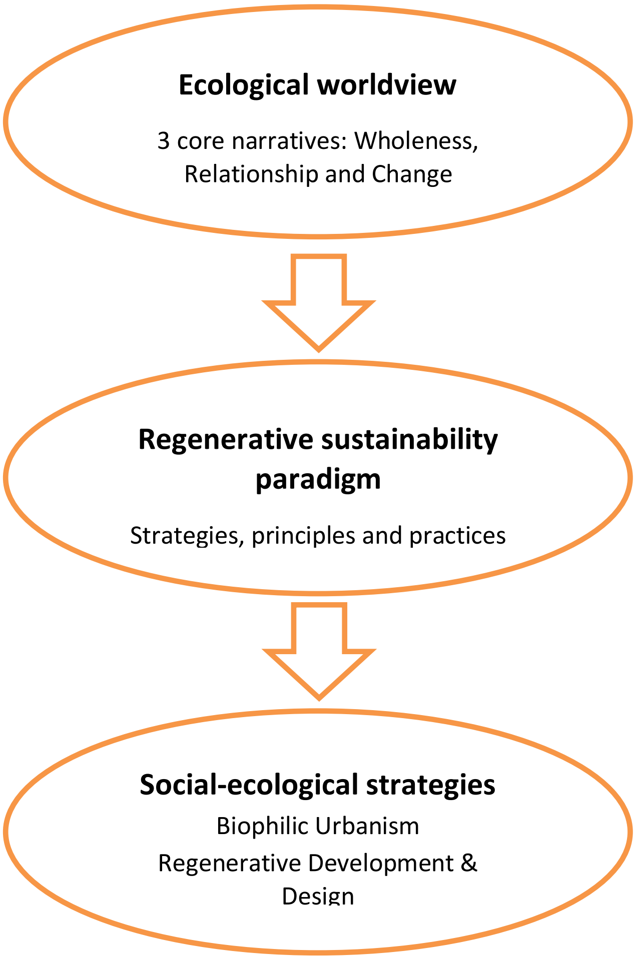


Figure 4-1: Relationship between worldview, paradigm and strategies

Source: Author

This research aims to explain that both Biophilic Urbanism and Regenerative Development and Design are appropriated strategies of the regenerative sustainability paradigm and can be used to work across scales, from buildings to neighbourhoods and entire cities, as it is demonstrated in the case studies (Chapters 6 and 7).

4.2 Biophilia, biophilic design and biophilic urbanism

Biophilia literally means "love of life". The term was coined by E.O. Wilson, an American biologist who advanced the studies on this subject in his book *Biophilia* (1984) and defined the concept as the innate affinity of human beings with all forms of life. It is also the innate tendency to focus on lifelike processes (Wilson, 1984). In addition, reflecting on its relevance and application, this inherent human inclination to affiliate with nature appears to be a crucial issue in terms of human physical and mental health in the modern urbanised world (Wilson, 1984; Kellert and Wilson, 1993, Kellert, 1997, 2012; Kellert and Calabrese, 2015).

The connection to and dependence on nature of human species had been active and influential over 200,000 years of bio-centric human evolution, to such an extent that it became biologically encoded (Kellert, 2008; Salingaros, 2010). As seen in Chapter 3, this essential connection was lost as a result of Modernity.

Studies about the relevance of recovering this essential human connection to nature in our modern societies are expanding in academic circles. Kellert (2008) argues that many of our instinctive and intellectual abilities had developed over the 200,000 years long evolutionary period through adaptation processes and responses to the natural environment, habitat of the human species. Thus, most of our emotional and intellectual competencies, such as problem-solving, critical thinking and constructive abilities rely on the skills and aptitudes learnt in those remote days of close association with natural systems and processes that are underpinning human health, maturation and productivity to the present day. Modernist assumptions of human domination of nature as a basis for progress is dangerous, not only for environmental issues but also for human physical and mental health and wellbeing.

Kellert (2008) sees biophilic design as a means to sustainable design, due to its positive benefits for humans that can lead to their attachment to buildings and places, and subsequent care for them. As the dominant approach to design, be it architectural, landscape or urban design, lacks sensory richness, much of the built environment in these days is unappealing and nature is treated as a hindrance to overcome or a mere irrelevant decoration. On the other hand, adults spend most of their time indoors, in working places that in most cases do not have a relationship with green areas, and are deficient in the provision of natural light, ventilation, views and use of materials. The outcome is an increasing humans-nature disconnection (Kellert and Calabrese, 2015).

To inform biophilic design and aiming for its successful application, Kellert (2008) has defined and described six biophilic design elements and 70 attributes (see Table 5-2 below). His study considers two principal dimensions, the organic dimension, and the place-based dimension. The first comprises four categories: Environmental features; Natural shapes and forms; Natural patterns, and Light and space, which respond to three types of experiences with nature. *Direct* experience, the most influential, associated to contact with 'wild nature' as the case of daylight and native plants and animals that are independent of human attention; *indirect* experience, relationship with natural elements that need human engagement such as domestic animals and potted plants; and *symbolic* experience, related to appreciation and contact with representations of nature like images, sculptures, architectural elements or movies (Kellert, 2008; McGee and Marshall-Baker, 2015).

The second dimension encompasses two categories, Place-based relationships and Evolved human-nature relationships, is correlated to the connection with the local natural and cultural identity. It explores the spirit of place or intimate response of a person to a place that corresponds to a unique interconnection. This is an intangible, meaningful and emotional experience, relevant for promoting stewardship, bringing together cultural and ecological aspects. When this is absent, like in so many current examples of urban and suburban developments deprived of cultural and sensory richness, the opposite phenomenon occurs, placelessness, causing lack of empathy and, consequently, lack of stewardship (Beatley, 2004;

Kellert and Calabrese, 2015; McGee and Marshall-Baker, 2015). Evolved human-nature relationships represents the integrative capability of this category that conforms the ultimate foundation of the ecological approach to design. It involves the consideration of the inherent human relationship to nature, as well as attributes oriented to design strategies leading to providing experiences that can suggest or even replicate those lived through in natural settings. This is because the human-nature reconnection occurs particularly when the design interventions are based on the ordered complexity of natural structures, adapted to human sensibilities that also include prospect and refuge, curiosity and enticement, attraction and beauty, among others, which can make architectural and urban spaces more interesting, meaningful and resilient (Kellert, 2008, Salingaros and Masden II, 2008; Hes and du Plessis, 2015).

Regarding urban design and planning, the overarching place-based dimension is most significant. As Kellert and Calabrese (2015, p.11) clearly put it,

> Multisensory encounters with nature in the built environment can greatly contribute to comfort, satisfaction, enjoyment and cognitive performance, and when feasible, should be encouraged.

Summarising,

Overarching dimensions		
Organic	Experience of nature Direct, indirect, symbolic	Categories Environmental features Natural shapes & forms Natural patterns Light & space
Place-based		Categories Placed-based relationships Evolved human-nature relationships

Table 4-1: Overarching dimensions of biophilic design

Source: Author, based on Kellert, 2008

See below Kellert's (2008) table of Elements and Attributes of Biophilic Design, presenting six categories and 70 attributes.

Elements and Attributes of Biophilic Design		
Environmental features	**Natural shapes and forms**	**Natural patterns & processes**
Colour Water Air Sunlight Plants Animals Natural materials Views and vistas Façade greening Geology and landscape Habitats and ecosystems Fire	Botanical motifs Tree and columnar supports Animal (mainly vertebrate) motifs Shells and spirals Egg, oval and tubular forms Arches, vaults and domes Shapes resisting straight lines and right angles Simulations of natural features Biomorphy Geomorphology Biomimicry	Sensory variability Information richness Age, change, patina of time Growth and efflorescence Central focal point Patterned wholes Bounded spaces Transitional spaces Linked series and chains Integration of parts to wholes Complementary contrasts Dynamic balance and tension Fractals Hierarchically organised ratios and scales
Light and space	**Place-based relationships**	**Evolved human-nature relationships**
Natural light Filtered and diffused light Light and shadow Reflected light Light pools Warm light Light as shape and form Spaciousness Spatial variability Space as shape and form Spatial harmony Inside-outside spaces	Geographic connection to place Historic connection to place Ecologic connection to place Cultural connection to place Indigenous materials Landscape orientation Landscape features that define building form Landscape ecology Integration of culture and ecology Spirit of place Avoiding placelessness	Prospect and refuge Order and complexity Curiosity and enticement Change and metamorphosis Security and protection Mastery and control Affection and attachment Attraction and beauty Exploration and discovery Information and cognition Fear and awe Reverence and spirituality

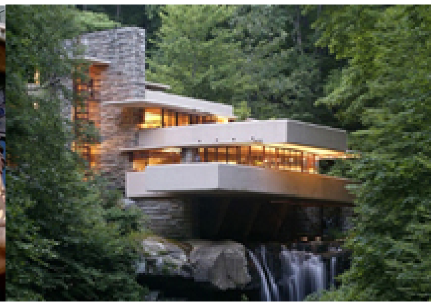
Table 4-2: Elements and attributes of biophilic design

Adapted from Kellert, 2008

In a recent study co-authored with Elizabeth Calabrese (Kellert and Calabrese, 2015), the emphasis is on the design strategies involved in the practice of biophilic design aiming to enhance the success of the application. The strategies, called experiences and attributes of biophilic design, constitute a framework for the practice (see below). They note the holistic nature of biophilic design and the necessity of adapting the process to local circumstances and constraints, special characteristics of the project and compliance with the previous principles (Kellert and Calabrese, 2015).

Experiences and attributes of biophilic design





Direct experience of nature	**Indirect experience of nature**	**Experience of space and place**
Light	Images of nature	Prospect and refuge
Air	Natural materials	Organised complexity
Water	Natural colours	Integration of parts to wholes
Plants	Simulating natural light and air	Transitional spaces
Animals	Naturalistic shapes and forms	Mobility and wayfinding
Weather	Evoking nature	Cultural and ecological attachment to place
Natural landscapes and ecosystems	Information richness	
Fire	Age, change, and the patina of time	
	Natural geometries	
	Biomimicry	

Table 4-3: Experiences and attributes of biophilic design.

Adapted from Kellert and Calabrese, 2015. Images source: https://www.google.com.au

The need for the reconnection of humans and nature resonates with the views of Salingaros (2010). This author, a mathematician and thinker of the built environment, advocates for the eco-centric worldview that recognises “the biological connection between humans and their sensory space” (Salingaros, 2010, p. 2). He contends – citing Alexander’s *The Nature of Order* seminal books – that particular and very specific geometrical properties found in the structure of nature and in the built environment have a positive and uplifting influence on the human organism, therefore these properties applied to design can enhance the quality of life in urban centres. This procedure, called by Salingaros the biophilic effect, relies on an intimate informational connection between humans and nature. In other words, biophilic effect is a process of informational nourishment from which we draw emotional sustenance that could replace consumerist lifestyles currently observed in cities, which depend on enormous amounts of fossil generated energy.

Modernist architecture and urban design lack the biophilic patterns that neuroscience disclosed as providing the informational nourishment that our brain needs for achieving physical and mental health and wellbeing. Our brain builds neurological connections with the geometry underlying life, directly affecting our quality of life mainly provided by our contact with nature and with processes that evolved from this intimate contact (Salingaros, 2010; Salingaros and Masden, 2008). Our inherent necessity for biophilic environments is explained as follows:

> Our neuro-perceptive system more easily processes a structural environment that embodies fractal properties and the organised complexity found in nature, than an environment whose geometrical order contradicts the spatial complexity of natural structures. (…) Certain geometries that we perceive as “unnatural” generate anxiety and alarm, and thus degrade psychological and physiological comfort when we are exposed to them for too long (Salingaros, 2010, p. 3).

This concept strongly supports the argument for protecting and saving the natural environment and the need for creating biophilic spaces in and on buildings, and within the city, particularly in dense urban precincts. From our long living immersed in nature, we learnt to process fractal information, colour and detail in addition to carefully interpreting spatial experiences such as prospect and refuge, mastery and control, among many others, to assure our survival. We started constructing our built environment by imitating and developing the findings from our early spatial experiences in nature.

Salingaros (2010) recommends considering our sensory apparatus when applying biophilic principles to artificial environments because of two complementary mechanisms that take place in our minds. The first is based on our ability to process complex information such as organised complexity that presents a large amount of information in the form of detail, contrast, pattern, colour and texture that imitate similar information contained in nature. The second involves the organisation of this information using mathematical techniques such as connections, symmetries, patterns, scaling symmetries, harmony among distinct colours, among others. When a delicate balance is achieved between both mechanisms of increasing information and increasing informational coherence, the result is an optimal state of biophilic information in the artificial environment. An excellent example of this process is the description of Paris as a biophilic city, by Heerwagen and Gregory (2008)[1] .

Urban environments benefit from this approach because the first human settlements drew their organisation from natural structures, forming urban codes that further developed into patterns. Alexander et al., (1977) developed a compendium of 253 patterns ranging from the urban scale to buildings and their constituent parts.

They found a rich variety of patterns in each category. Some examples of urban patterns are: buildings enclosing a central plaza; low-rise but high-density occupation and mixed-use buildings; pedestrian network connecting distributed plazas; vehicular network superimposed on the pedestrian network, among many

[1] See Chapter 13: Biophilia and Sensory Aesthetics (Kellert et al., 2008)

others. The replication and evolution of patterns give meaning to buildings and places and contribute to establishing bonds between them and the users and residents, promoting sense of belonging, sense of place and caring relationships. This is especially relevant regarding regenerative sustainability issues in the built environment.

According to Salingaros (2010), cities that have grown from urban codes, evolved and tested over time, tend to be more sustainable because they store the connective geometry that enables human scale, perceptible in the pedestrian scale and the connections among the diverse functions of human society nested in a compact spatial region. Most European cities, such as Barcelona, Rome, and again Paris, evolved following this mechanism to confirm the rule. Conversely, cities where the original code disappeared under the imposition of abstract urban typologies or are created through rationalist models, tend to be unsustainable, due to their dysfunctional urban fabrics, which lead to enormous amounts of energy consumption to keep them alive and cause psychological stress to their inhabitants. Quality of life emerges from nurturing environments. Salingaros (2010), states that to achieve this condition urban environments should be:

- rich in clean air, water, shelter and living space,
- allow frequent and close access to nature and provide built environments rich in texture, colour, ornament and art,
- provide opportunities to access other human beings in public urban spaces as well as open-access residential and commercial spaces, basically the walking city, and
- provide protection from anxiety-inducing objects such as high-speed traffic, large vehicles threatening human beings, cantilevered and overhanging structures.

Salingaros and Masden (2008) make a significant contribution to the consideration of Christopher Alexander’s work as anticipating and supporting biophilic design. They selected fifteen patterns from the book *Pattern Language* (Alexander et al. 1977) that illustrate ways leading to the reconnection of humans to nature. Once nature is a source of mental and physical nourishment, the concepts of biophilia and patterns have meaning for human life. These authors have summarised the main Alexander et al. patterns as follows:

“Pattern 3: *City Country Fingers*. Build a city radially instead of concentrically, with fingers of green space and farmland coming to its centre.

Pattern 7: *The Countryside*. Reconceive unbuilt land as one whole, encompassing farms, parks and wilderness, and provide access to all of it.

Pattern 24: *Sacred Sites*. Identify and protect sites having extraordinary importance to the community, whether they are located in a built or green area.

Pattern 51: *Green Streets*. Do not automatically build low-density/low-speed local roads out of asphalt, but instead use paving stones and gravel set into grass.

Pattern 60: *Accessible Green*. People will only use green spaces when those are very close to where they live and work, accessible by a pedestrian path.

Pattern 64: *Pools and Streams*. People need contact with natural streams, ponds, and reservoirs, so these must not all be covered.

Pattern 74: *Animals*. People need contact with animals, both domestic and wild, so the city must accommodate instead of discourage them.

Pattern 104: *Site Repair*. When siting a building, put it in the least attractive part of the lot, preserving the best of the natural environment.

Pattern 111: *Half-hidden Garden*. For a garden to be used, it must not be too exposed by being in the front, and not completed hidden by being at the back.

Pattern 171: *Tree Places*. Trees shape social places, so shape buildings around existing trees and plant new trees to generate a usable, inviting urban space.

Pattern 172: *Garden Growing Wild*. To be useful, a garden must be closer to growing wild, according to nature’s rules, than conforming to an artificial image.

Pattern 176: *Garden Seat*: One cannot enjoy a garden if it has not a semi-secluded place to sit and contemplate the plant growth.

Pattern 245: *Raised Flowers*. Flowers provide maximum benefit when they grow along frequently used paths; they must be protected and near eye level.

Pattern 246: *Climbing Plants*. A building connects to its surroundings when plant life grows into it, with the plants climbing walls and trellises.

Pattern 247: *Paving with Cracks between the Stones*. Paving stones laid directly on earth, with gaps between them, allow growing plants to create a half-natural environment" (Salingaros and Masden, 2008, p. 81).

By using patterns, adaptive and living environments can be created, because they can be combined forming more coherent wholes; in a similar way, matter and life organise themselves to form higher-level complex entities in nature. This idea is relevant to support new approaches to and methodologies in the design disciplines, particularly in architecture and urban design, leading to the creation of more liveable and resilient environments, as these authors clearly put it:

> Biophilic design reorients architecture *and urbanism* toward a world governed by coherent information; it also leads people to think in many levels of complexity (which is the way nature works) (Salingaros and Masden, 2008, p. 76).

Architecture and urban designs that aim to facilitate human-nature reconnection are those that were designed and built according to the informational content that underpins natural and traditional built environments. Both respond to a constituent logic and order embedded in their structures, built in a coherent manner, that "provide neurological connection at a human scale, and thus, emotional nourishment" (Salingaros and Masden, 2008, p. 77).

4.2.1 Biophilia at the urban scale

Beatley (2011) has extended the biophilic approach to the urban scale, imagining and encouraging biophilic cities. He defines the biophilic city in this way:

> It is a city that puts nature first in its design, planning and management; it recognizes the essential need for daily human contact with nature as well as the many environmental and economic values provided by nature and natural systems (Beatley, 2011, p.45).

Other characteristics of the biophilic city described by Beatley are richness in biodiversity, and willingness in repairing and restoring damaged areas, as well as in integrating new forms of nature in all new buildings and structures, that can also consist in reproducing forms and shapes found in nature. Thus, biophilic urban design and planning is related to green urbanism but with a specific focus on providing for human health and wellbeing.

Importantly, Beatley's conception of the biophilic city sets it in the ecological worldview, because it comprises external or biophysical aspects as well as the intangible side, as he clearly explains it:

> It is certainly about physical conditions and urban design – parks, green features, urban wildlife, walkable environments- but it is also about the spirit of a place, its emotional commitment and concern about nature and other forms of life, its interests in and curiosity about nature (Beatley, 2011, p. 17).

Beatley studies the biophilic benefits implemented at diverse scales, and argues that many places around the world show positive outcomes derived from small projects that have facilitated relationships between people and nature. This includes integrating several biophilic elements into urban environments as natural design features, across all scales, e.g. streetscapes with traffic calming design and gardens incorporated into footpaths that contribute to walking and cycling as well as air purification and wellbeing for the residents. In other cases, like dense urban precincts, mitigation of urban heat island-UHI effect and return of birds and butterflies can be achieved by implementing green walls and roof gardens now considered living architecture, which also function as new niches and habitat structure for nature regeneration; at urban scale, water management can be improved by collecting storm water in daylight streams and swales for street tree irrigation. At a bigger scale, accessibility to nature through corridors of wild life within the city could foster the protection of local species of fauna and flora while providing recreation and health to the citizens (Beatley, 2011; Newman, 2010; 2013).

The different scales of application of biophilic design in cities and regions can be seen below in Table 4-4.

Biophilic urban design elements through scales

Scale	Biophilic design elements
Building	Green rooftops Sky gardens and green atria Rooftop garden Green walls Day lit interior spaces
Block	Green courtyards Clustered houses around green areas Native species yards and spaces
Street	Green streets Sidewalk gardens Urban trees Low-impact developments Vegetated swales and skinny streets Edible landscaping High degree of permeability
Neighbourhood	Stream daylighting, stream restoration Urban forests Ecology parks Community gardens Neighbourhood parks and pocket parks Greening grayfields and brownfields
Community	Urban creeks and riparian areas Urban ecological networks Green schools City street canopy Community forest & community orchards Greening utility corridors
Region	River systems and floodplains Riparian systems Regional greenspace systems Greening major transport corridors

Table 4-4: Biophilic design through scales.

Adapted from Beatley, 2011.

Based on this new urban concept, the need to embed nature in the urban fabric arises for a crucial reason. Biophilic urbanism ensures the daily dose of nature

(Beatley, 2011) that urban inhabitants need for health and wellbeing through easy access to nature at all scales, into and onto buildings and public spaces. In addition, it importantly enables the intensification of green urban infrastructure contributing to the vital ecosystem services restoration and the increase of Earth's photosynthetic capacity. According to Schurig, urban populations consume "nearly half of nature's annual photosynthetic capacity" (World Future Council, 2014).

Biophilic cities, besides providing health and wellbeing to the inhabitants have another essential function that is their capability in relinking built environments with the bioregions on which they rely. This is achievable by restoring damaged ecosystems and their vital services and, additionally, by creating new opportunities for other ecosystems, native or not, that can thrive within and around urban areas. Biophilic urbanism is beginning to demonstrate that existing high-density precincts can be regenerated and new ones can be designed as quality living environments that can regenerate ecosystems underpinning the coexistence and, expectantly, the co-evolution of ecological and socio-cultural systems. Many cities around the world are incorporating biophilic interventions within their urban fabrics allowing the inhabitants to enjoy the benefits from a close contact with nature. Singapore, Oslo, Malmo, Vitoria Gasteiz are successful examples of biophilic cities, and members of the Biophilic Cities Network, created by Tim Beatley and his team, which is experimenting an increasing growth (For more information see http://biophiliccities.org/).

4.3 Regenerative development and design

Regenerative development and design is an emergent field of thought, theory and practice for the built environment. It is nested in the Regenerative sustainability paradigm (du Plessis, 2012; Hes and du Plessis, 2015), also called Ecological sustainability paradigm (Mang and Reed, 2012b; Benne and Mang, 2015).

According to the Oxford English Dictionary, the words regenerate or regeneration have several meanings, varying from reinvigorate, revive or restore something to a better state, to changing something into another different or better thing. Regenerative development and design resonates with the full definition; it is not restricted to urban regeneration, rather it aims to bring improved conditions of being to places in their wholeness, embracing the entire social-ecological dimension (Hes and du Plessis, 2015).

This approach fosters a substantial advance in the understanding of sustainability because it seeks to promote health, helping living systems to recover their capacities of re-organizing and re-regenerating themselves. It is founded on living systems thinking and aims to design human systems that can co-evolve with the natural ones, instead of minimising impact or reversing the degeneration of the planet's natural systems. Recognising the changing nature of the sustainable built environment concept, and the nature of practices that resonate with it, Mang and Reed (2012b) define the work of regenerative theorists and practitioners as a proposal for "integration of eco-efficient design technologies and strategies within an ecologically based approach that reverses the degeneration of both, the earth's natural systems and the human systems that inhabit them" (p.9). This approach encompasses setting new ways of thinking and methodologies, and facing challenges posed by the transition from the technological to the regenerative paradigm, such as understanding the fundamental principles that assure regenerative results, reconciling the two opposite worldviews by recognising the value of pertinent strategies and tools, and training new professionals in the regenerative practice (Mang and Reed, 2012b).

According to Cole (2012a), the regenerative development and design approach organizes into a 'cogent whole' many former alternative concepts and ideas, e.g. bioregionalism, bioclimatic and ecological design, permaculture, that had been considered as idealistic, and now congregate into a relevant framework for current best practice and future mainstream design procedures. Regenerative development and design objectives go beyond reducing the ecological footprint of buildings and cities, focusing instead on creating health and wellbeing (Reed, 2007). Furthermore, they converge in comprehending ecosystem complexity and restoring ecosystem services (Pedersen Zari, 2011), setting design goals that do not exceed the physical capacity of a site, but rather promote their adaptive and regenerative capacity in order to reconcile the built environment with their geographical magnitude

(Schurig, in WFC 2014). In Cole's words, regenerative development and design "carries the positive message of considering the act of building as one that can give back more than it receives and thereby over time building social and natural capital" (2012a, p.3). From this perspective, cities can and should be part of the solution rather than the cause of environmental impairment.

Regenerative Development and Design

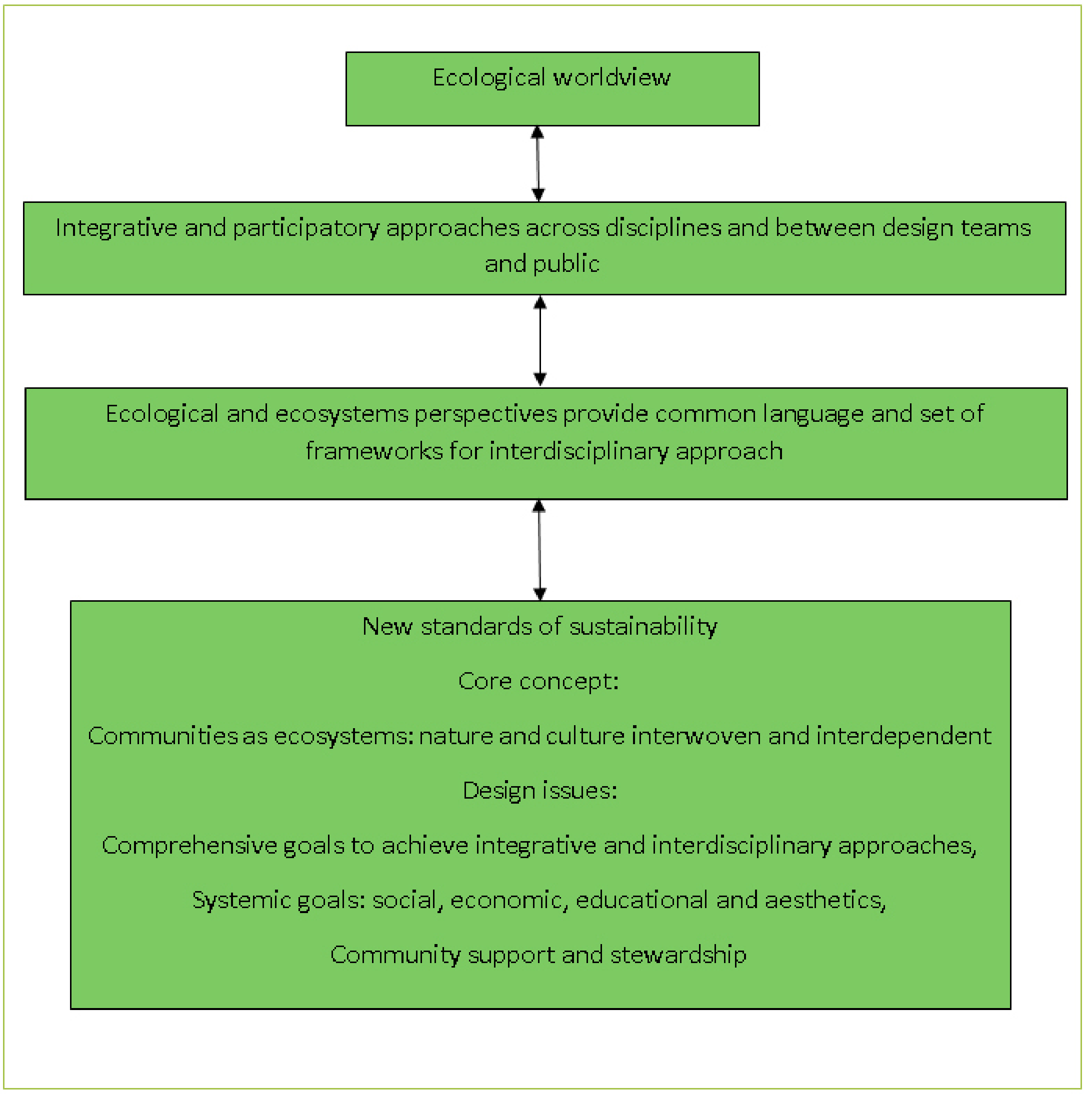


Figure 4-2: Regenerative development and design

Author, based on Mang and Reed, 2012b

4.3.1 A brief history of regenerative development and design foundational theory

The movement toward regenerative development and design began in the 1990s and developed across a number of stages following scientific discoveries and related philosophical theories. Its foundations go back to the early years of the last century, as discussed in Chapter 2. Ebenezer Howard's Garden City of To-morrow (1902) is considered a starting point of ecological thinking in relation to the built environment, followed by Patrick Geddes' ideas about urbanism that influenced European and North American regional planning. As early as 1915, Geddes, who was a biologist with increasing interest in urban planning, visualised cities as living systems and thought that the solution to urban problems should integrate the consideration of the neighbouring region. He established a solid analytic methodology for these studies and also coined the terms 'Paleotechnic' and 'Neotechnic', the former to name the industrial era's negative impacts on the natural and urban environments, and the latter for the era that would overtake industrialisation. John T. Lyle resumed this line of thought in the 1980s to discern technological and regenerative technologies (Mang and Reed, 2012b).

The second stage of theoretical foundations extends from 1930s to 1960s embedding new concepts and initiating a new science: ecology. In 1935, Tansley defined the concept of ecosystem, a new notion to ecology. In his book *The Use and Abuse of Vegetational Concepts and Terms*, he suggested the word 'ecosystem' to identify "the interactive system of living things and their non-living habitat" (in Mang and Reed, 2012b, p.4). Tansley was concerned about scientific rigour in the study of nature's complexity and the effect of human activities on it, so he advocated for the application of systems science to these studies. After making observations of how life orders and organises itself in a specific environment, Tansley and other biologists formulated the concept of life as a system, arguing that it is not possible to separate living organisms from their own landscape and geographies because both form a unique physical system. In other words, this concept legitimates the premise that humans are part of nature, ecologically interrelated with all other species, and with the abiotic components of their habitat.

The technological paradigm provoked the dichotomy humans-nature that shaped the still prevailing way of design thinking, responsible for the unsustainable pattern of development. The ecosystem concept then provided a valuable framework to study the effect of human activities on natural systems and reserves. Later on, it included the social complex or set of human institutions and actions, and the built environment, becoming a framework for sustainable urban planning and development (Mang and Reed, 2012b). In the 1950s and 1960s, ecology arose as a new science having the concept of ecosystem – the ordering structure of nature – as a core principle, based on the work of Eugene and Howard Odum, *The Fundamentals of Ecology*, published in 1953, that focused on the mutual interactions of the earth's ecological systems. Following this publication, Howard Odum developed important methodologies and theoretical principles. In addition, his studies on wetlands led to applications for water purification and opened the new field of ecological engineering (Mang and Reed, 2012b).

In 1968, Ludwig von Bertalanffy made another important contribution to the theoretical field of ecology with his book *General System Theory: Foundations, Development, Applications*. His work advanced the current knowledge of the time by introducing the concept of open systems, the difference between physical and biological systems and the notion of evolutionary thinking. This latter concept is about change, growth and development, essential principles of the new science of complexity, and to systems thinking as a major scientific field. This emerging field opposed the dominant mechanistic worldview and laid the foundations for the development of living systems science. Charles Krone, building on this, developed living systems thinking and its applicability to natural systems and human social systems. He influenced the works of Howard Odum on ecosystem modelling and energetics, and also John Lyle's work on regenerative design technologies.

Krone's work during the 1960s-1970s was remarkable for the development of living systems thinking as a technology for the development of improved systems-thinking capacities and the understanding of complex wholes within which people are participants. For this aim, the definition of systemic frameworks was necessary; Krone elaborated and applied them to the business area. The frameworks expected "to create an understanding of businesses, communities and nature as living systems, and to build the consciousness required to create reciprocally beneficial relationships through better integration of industrial, community and natural processes" (quoted in Mang and Reed, 2012b, p.5). The Regenesis Collaborative Development Group is a leading collective of professionals in design, land use planning and development that created a methodology for regenerative development and design that has Krone's work as the core foundation (Hes and du Plessis, 2015; Mang and Reed, 2012b).

A new level of theoretical progress in the field of ecological sustainability laid the foundations of regenerative development and design between 1969 and 1990. The main tenets derive from a number of publications and practices endorsed in this period. Ian McHarg published *Design with Nature* in 1969. This seminal book was written to fill some deficiencies in urban planning, which was considered just as a socio-economic process at the time. Among the problems, there were two most critical: one was the absence of environmental knowledge in the area, and the second was the lack of integration with the environmental sciences. McHarg proposed a method for ecological planning and urban landscape design called 'Environmental Impact Analysis and Statement' that enables elaborating a descriptive biophysical analysis of a site in order to determine what kind of land uses are most propitious for it, and which are the most detrimental. National environmental policies emerged from this study worldwide, and subsequently its concepts were advanced into the GIS, Geographical Information System, and a crucial tool for ecological development (McHarg, 1969, 25thedition; Mang and Reed, 2012b).

In 1978, the Australian ecologists Bill Mollison and David Holmgren developed an ecological design system called 'permaculture' (from *perma*nent agri*culture*), aiming to promote human habitats and food production based on the relationships and processes used by indigenous peoples and ecological communities. They created design technologies and practices that resulted in 'human-made ecosystems', demonstrating that it is possible to provide for a high number of human needs while reducing dependence on industrial practices that are detrimental to the environment. This ecological design system was the first to introduce the concept of regenerative effect as a new standard of ecological performance for the built environment, meaning to "generate surplus or overabundance of energy and resources that could be reinvested to evolve natural and human systems as an integrated whole". Bill Mollison compiled these ideas in *Permaculture: a designer's manual* published in 1988, which presented a framework for assessing the value of potential actions for building regenerative capacity in a system.

Robert Rodale's work contributed in relating the term regenerative to the use of land in agriculture, meaning to renew or regenerate soil and improve agricultural resources. Subsequently, he applied the term and the principle of self-renewal to economic development. John Tillman Lyle advanced the conceptualization, extending regenerative methodologies to all systems supporting life. Lyle published *Design of Human Ecosystems* in 1984. In this publication, he defined human ecosystems as places where humans and nature should be brought together again for mutual benefit and sustainable future as the result of conscious eco-systemic design. Moreover, Lyle argued that designers should understand ecological order operating at several scales and that this knowledge should be related to human values. The book also presents a number of core concepts that Lyle expanded in his future work. The most relevant are: a) Ecosystems can be shaped just like buildings, according to a set of organising principles, "drawn from an underlying order that holds the diverse pieces and all their hidden relations together"; b) In ecosystem design, "these underlying concepts of order are drawn from ecology", and principles for ecosystem design draw from the "need to comprehend and envision the ecosystem the designer is seeking to shape as a dynamic (living) whole"; c) Ecological concepts are "more or less analogous to the laws of mechanics in architecture in that they provide us with organising principles for shaping ecosystems much as architects shape buildings" (cited in Mang and Reed, 2012b, p.6).

Ecological design thinking benefitted from a fertile publication in the 1990s. Many influential publications addressed both theoretical and practical aspects of design for ecological sustainability; among them, David Orr published *Ecological Literacy:*

Education and a Transition to a Post-Modern World, in 1992. The book addresses the importance of developing the ability to understand the natural systems that support life on the planet, as well as the comprehension of the principles of organisation of ecological communities and the application of this acquired knowledge to the design of sustainable human communities. Orr and physicist Fritjof Capra coined the term eco-literacy or ecological literacy. Other ground-breaking titles are *From Eco-Cities to Living Machines: Principles of Ecologic Design,* by Nancy Jack Todd and John Todd (1993); *The Web of Life*: *A New Scientific Understanding of Living Systems*, by Fritjof Capra (1995); *Ecological Design*, by Sim van der Ryn and Stuart Cowan (1996); and *The Ecology of Place*, by Timothy Beatley (1997). It is important to include the concept of Pliny Fisk and Gail Vittory, named 'EcoBalance' a planning and design method for land use at larger scales. It applies the principle of life cycles as framework "for sustaining basic life supporting systems, balancing human needs with their ability to manage the environment using technologies for augmenting natural processes" (Mang and Reed, 2012b, p.7).

Lyle's *Regenerative Design for Sustainable Development* came out in 1994. In the opinion of Mang and Reed (2012b) it is the first comprehensive compendium of regenerative design. It encompasses theory and practical guidelines for the design of regenerative systems and presents a strategy for the design of urban landscapes to enable the regeneration of lost ecosystems. Lyle drew this strategy from circular metabolism, arguing that to be sustainable it is necessary to shift from one-way throughput flows of resources to circular flow processes so that "the supply systems for energy and materials must be continually self-renewing, or regenerative, in their operation" (cited in Hes and du Plessis, 2015, p.111).

Lyle was concerned with environmental degradation and resource depletion resulting from industrial land use practices and development. These processes, in his view, destroyed the landscapes on which they relied because they involved one-way linear flows, from source to sink. Therefore, he focused his work on developing technologies to empower "the replacement of nature's continuous cycling and recycling of energy and materials processes core to the earth's operating system". Lyle called this new approach regenerative design, which he defined as "the replacement of linear systems of throughput flow with cyclical flows at sources, consumption centres, and sinks" (cited in (Mang and Reed, 2012b, p.7). These authors note that even though the redesign of the degenerative systems was a first order of work, Lyle foresaw the importance of creating a new mindset or way of thinking in order to achieve the "conscious design of whole ecosystems" as a core tenet of regenerative design (Mang and Reed, 2012b). Lyle created the Center for Regenerative Design at California State Polytechnic University, Pomona, to test and demonstrate this technology and its future progression, but he died before accomplishing this task.

In 1995, the Regenesis Collaborative Development Group started to advance the theoretical and technological body of knowledge for regenerative development. They drew from Lyle's ideas but also incorporated sound experience from several projects based on bio-centric design, which they developed for several years aiming to produce ecological health and positive change in the systems in which the projects were nested. Moreover, they advanced the commitment to reconnect human beings and natural systems, arguing that cultural and psychological issues cause environmental problems and unsustainable patterns which ecological design has not yet addressed. They coined the term regenerative development to define "the comprehensive work of creating the conditions and building the capacities required for achieving the radical shift [in thinking and understanding the symbiotic relationship between humans and the living places they inhabit] with the aim of making development a source of harmonious integration with nature"(Mang and Reed, 2012b, p.8).

The following graphics (Fig. 4-3, 4-4, 4-5) summarise regenerative development and design theoretical chronology.

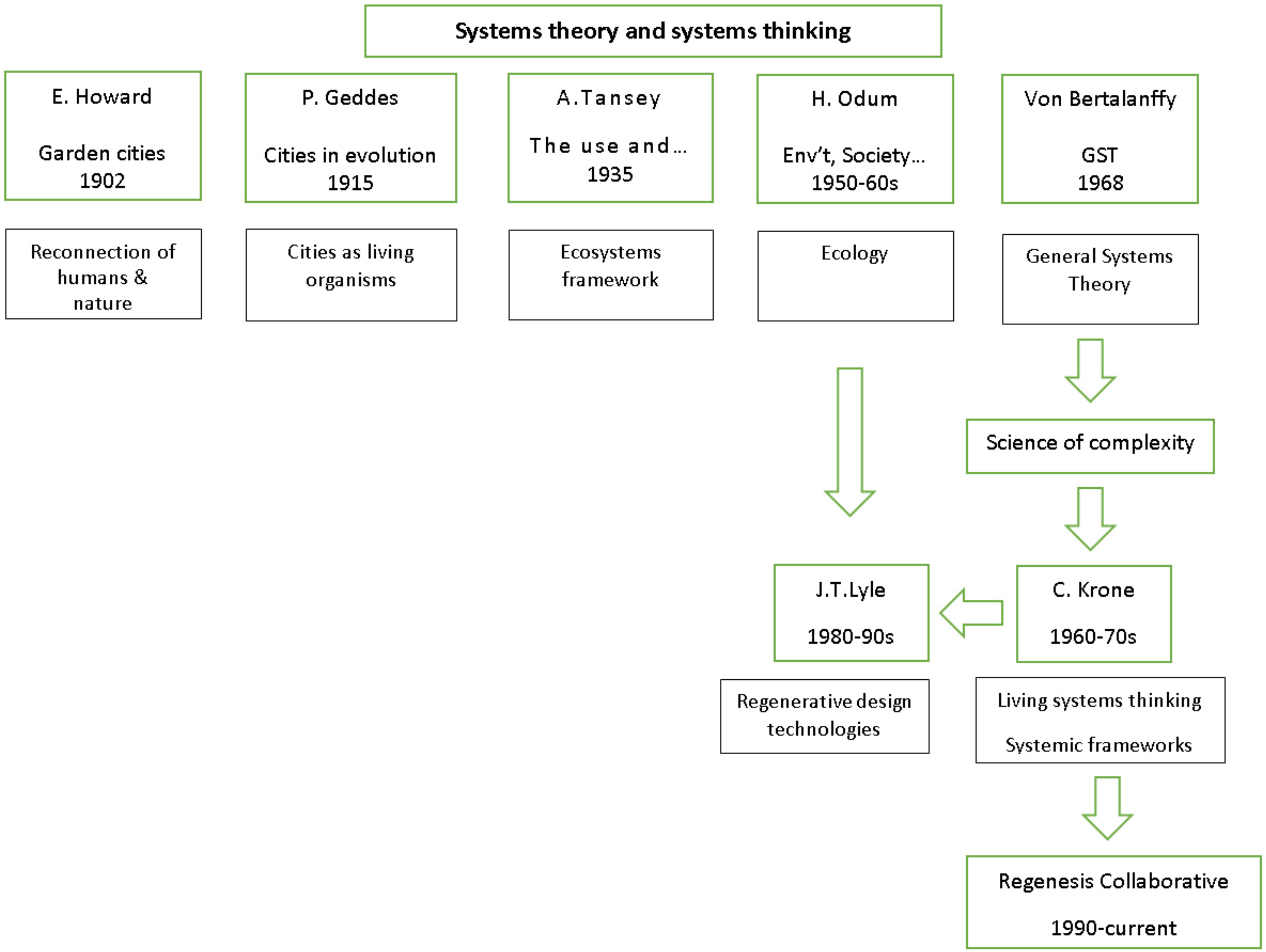


Figure 4-3: Regenerative development and design - chronology of theoretical approaches [a].

Source: Mang and Reed, 2012b

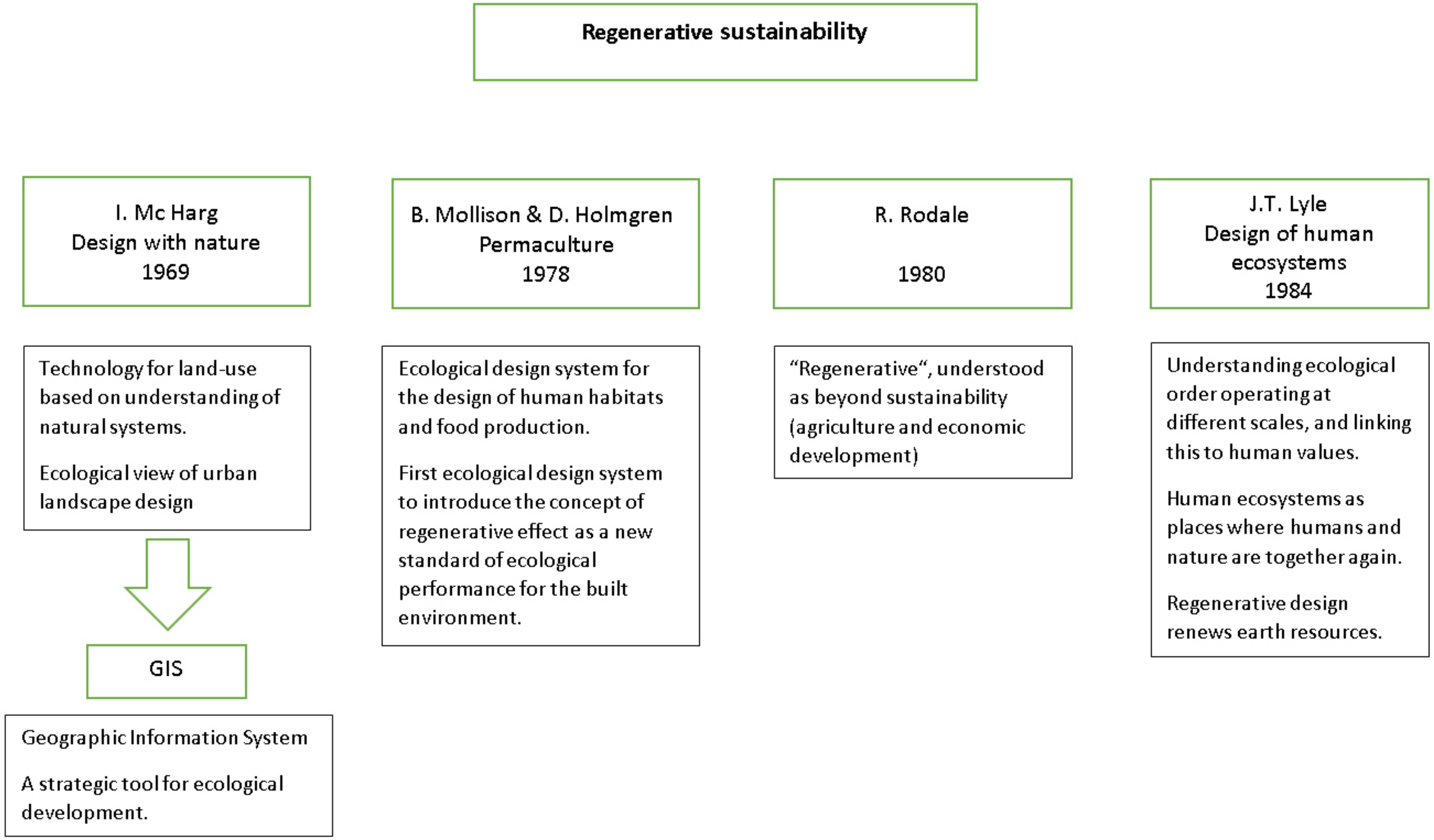


Figure 4-4: Regenerative development and design - chronology of theoretical approach [b].

Source: Mang and Reed, 2012b

1990s

Seminal publications on design for ecological sustainability (theoretical and practical)

D. Orr
Ecological literacy
1992

Eco-literacy: ability to understand natural systems that allow life on earth and how they organise themselves in order to apply these principles to create sustainable human communities.

Todd & Todd
From eco-cities to living machines
1993

Eco-cities integrate agriculture and flowing pure water into green urban settings; Living Machines, technologies for purifying wastewaters without chemicals.

F. Capra
The web of life
1995

Brilliant synthesis of recent scientific breakthroughs and explanations of the properties of organisms, social systems, and ecosystems.

S. Van der Ryn and S. Cowan
Ecological design
1996

Sparks dialogue and triggers collaboration across spatial scales and design professions.

J.T. Lyle
Regenerative design for sustainable development
1996

Handbook for Regenerative Design. Framework, principles and strategies for a design technology aiming to reverse environmental damage.

Lyle saw the work of regenerative design as the "conscious design of whole ecosystems" (p.8).

Regenerative development and design as distinct disciplines.

T. Beatley and K. Manning
The ecology of place
1997

Holistic approach to repairing and enhancing communities, introducing a vision of "sustainable places" that extends beyond traditional architecture and urban design.

P. Fisk
EcoBalance
1999

Land-use planning and design method employed for larger scales, based on life cycles, as a framework for sustaining basic life supporting systems, balancing human needs with ability to manage the environment using technologies for increasing natural processes.

Regenesis Collaborative & Development Group, 1996

Theoretical and technological foundations for Regenerative Development.

Bio-centric design inspired by natural processes "enables human communities to co-evolve with the natural living systems they inhabit while continuously regenerating environments and cultures" (p.8).

Environmental problems are caused by the dichotomy between humans and nature; they are not addressed through ecological design systems; the core issue is cultural and psychological.

The group proposes the term 'Regenerative development' for the work of creating conditions and building capacities to achieve a radical shift in thinking and understanding development as a source for harmonious integration with nature.

Figure 4-5: Regenerative development and design - chronology of theoretical approach [c].

Source: Mang and Reed, 2012b

4.3.2 Regenerative Development & Design framework and methodology

Strategies for a sustainable built environment in the regenerative paradigm are mainly qualitative; their purpose is to create conditions that enable and sustain all living systems in a specific place, allowing their co-evolution over time. The concept of ecosystem influences how we define the built environment, the role of buildings, precincts and cities, as well as the role of design practitioners and the thinking, technologies, and standards of ecological performance that support their practices. The uniqueness and particular flows of life in a place determine the concepts, design and processes on which the strategies rely, steering the potential of the contribution that the proposed building or development can offer to the site. Regenerative solutions are site-specific and entail the comprehension of relationships between local human and ecological systems to support and enhance life. In this way, humans and nature are co-creative partners and participants in their mutual evolution (Mang and Reed, 2012; Cole, 2012a,b; Hes and du Plessis, 2015; Benne and Mang, 2015).

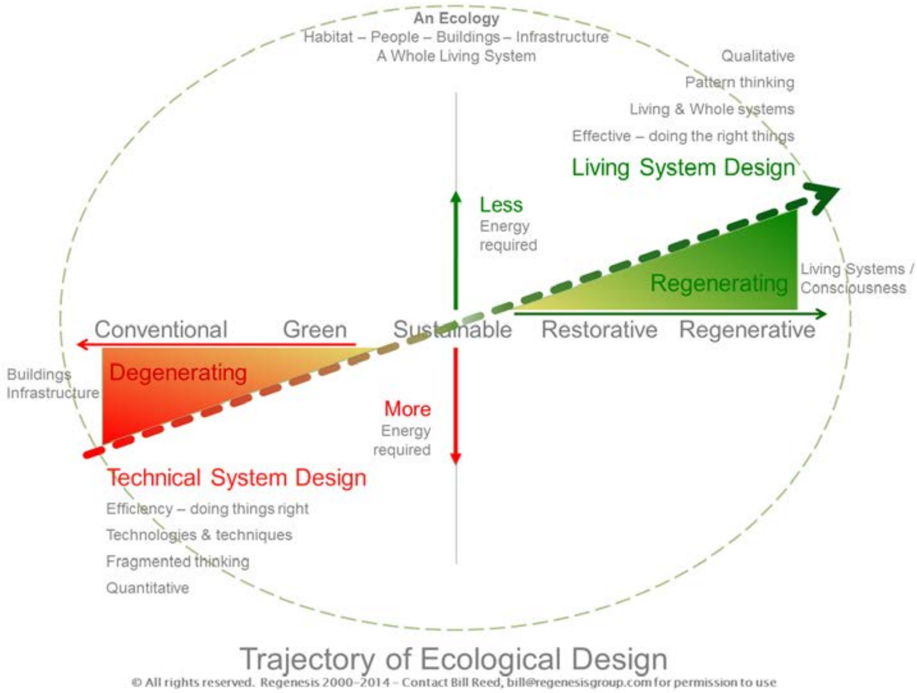


Figure 4-6: Contrast of technical system design and living system design.

Source: Bill Reed, with permission.

The regenerative sustainability paradigm promoted the emergence of a number of strategies for achieving net positive goals in the built environment. They conform to design philosophies that aim to integrate human structures, processes, and infrastructures with natural living systems. Surpassing traditional fields of design, they are still developing and expanding to cover a broad scope of sustainability issues, with several challenges to overcome. One of them is the necessary deep understanding of a holistic approach comprehending the principles that can lead to a regenerative result; another is reconciling the two contrasting worldviews, incorporating into the practice what is helpful from each of them in the appropriate contexts.

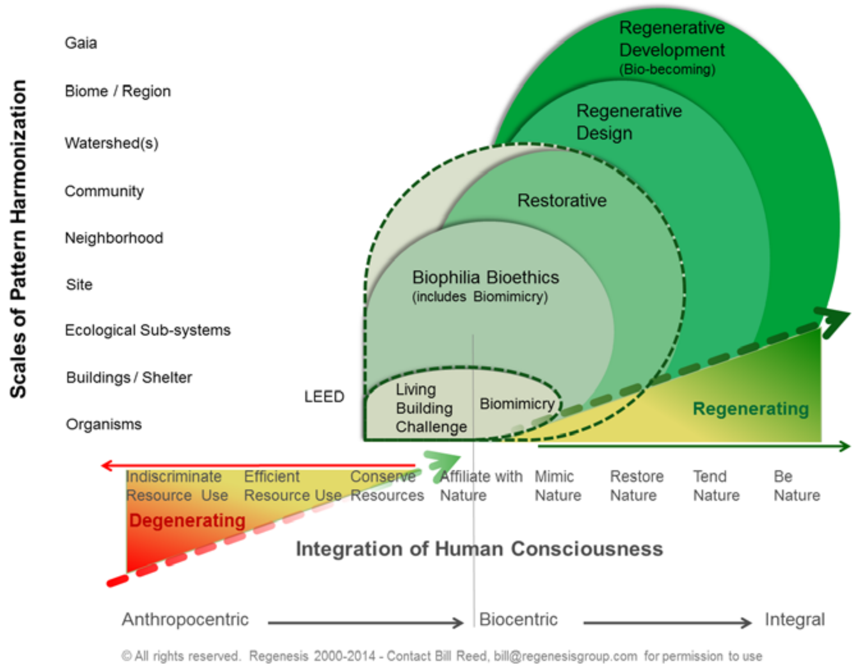


Figure 4-7: Trajectory of ecological design.

Source: Bill Reed, with permission.

Mang and Reed (2012b) describe the following ecological technologies and strategies in this paradigm:

- Biomimetic
- Biophilic
- Restorative
- Regenerative

The Biomimetic strategy looks at nature as inspiration. Its approach is functional and anthropocentric, because it captures the way nature works, its processes and the characteristics of natural organisms to create new products or processes to meet human needs, in the belief that human activities would be more appropriate and harmonious with nature if stimulated by it. Several technological processes, industrial products, designs of buildings, cars or boats are examples of biomimetics. Biomimicry and Cradle-to-Cradle design philosophies encompass this strategy.

The Biophilic strategy is based on the human affiliation with other living organisms; Biophilia means "love of life", as explained earlier in this chapter. This design philosophy encourages relational approaches between people and nature, is anthropocentric in its purpose because it points to human health and wellbeing and is rather passive in its engagement. Regarding design application, there are three main ways of applying the strategy:

- Literal connection, which is a direct relation to natural features and elements like outdoors spaces, vegetation, water, daylight and natural materials among others;
- Facsimile connection, which refers to the use of nature imagery in forms, shapes and decorative elements and materials ; and
- Evocative connections that make use of qualities and attributes of nature in design: prospect and refuge, serendipity, sensory variability, discovered complexity.

Biophilic design is increasingly being applied in architecture, interior architecture, and urban design and planning, importantly in creating healing places and green urban infrastructure (Kellert, 2008; Beatley, 2011).

The Restorative strategy studies and resets the capacity of living systems in re-organising themselves and evolving, and recognises the role humans play in ensuring ecosystem restoration. It is a bio-centric approach because it seeks bio-remediation but human intervention is only temporary, ceasing when the objective is achieved. It is also a better integrated and active approach, generally implemented to re-establish the health conditions of an ecosystem and community or parts of them. Examples are remediation of degraded areas, riparian corridors, wetlands, beach dune systems, and degraded social systems such as high crime areas.

Regenerative strategies consider humans as an inherent part of nature and their positive role within it. Mang and Reed (2012b) argue that when there is a conscious human intention of interdependence with nature, the potential for co-evolution increases, creating an integral interconnection that promotes a mutually beneficial relationship between them. Then, awareness of evolutionary potential arises, in which the health of each part (humans, ecosystems and whole ecology) is interdependent on the other. These authors have named this bio-becoming process 'regenerative'. Then, postulated it as the basis for a new mindset, an essential requirement for this approach, in order to enable looking always forward for new potential in the systems rather than trying to solve problems with existing technologies or tools (Mang and Reed, 2012b; McLennan and Reed, 2013).

Table 4-5 below summarises the described ecological strategies for sustainability:

Ecological strategies for sustainability			
Biomimetic	Biophilic	Restorative	Regenerative
Approach to nature			
Functional	Relational	Integrative	Integral
Engagement with nature			
Passive	Passive	Active: Humans have a role to play	Active: Humans have a positive role to play
Purpose perspective			
Anthropocentric	Anthropocentric	Biocentric	Biocentric
Potential			
Conceptual starting point	Introductory	Initial basis	Co-evolutionary

Table 4-5: Ecological strategies for sustainability

Author, based on Mang & Reed, 2012b

Regenerative development and design is a theoretical and methodological approach to the design of sustainable built environments. The Regenesis school of thought has been a primary source of direction for developing this concept; they are a collective of professionals from different fields of practice, namely design, land use planning, development and business. The approach draws on organization and human development theory, living systems thinking, bioregionalism and permaculture, and incorporates ancient technologies encompassing existential knowledge built up by indigenous peoples and traditional communities along time.

The group has also developed a methodology to test and refine the concepts implemented in several projects along two decades. Subsequently, a number of tools have emerged motivated by this approach: one is REGEN, a regenerative design framework for the US Green Building Council, elaborated by the architectural firm BNIM- Berkebile, Nelson, Immenschuh, McDowell; another is LENSES, a facilitation tool created by the Institute for the Built Environment at Colorado State

University (Hes and du Plessis, 2015). Recently, in a co-authored publication Bill Reed, founding partner at Regenesis, and Jason McLennan, CEO of ILFI-International Living Future Institute, have announced the convergence of both schools of thought (McLennan and Reed, 2013). They have aligned not only their conceptual basis founded on "the regeneration of the whole living system of mutually supportive interrelationships" (p. 39), but ILFI has endorsed it in the recently released Living Building Challenge 3.0 version informed by these principles, creating another essential tool for the design of regenerative built environments. ILFI defines the Living Building Challenge as a "philosophy, certification and advocacy tool for projects to move beyond merely being less bad and to become truly regenerative" (Living Building Challenge 3.0, p. 4).

Both schools of thought share core principles. They consider the whole of life as being the top and bottom line of sustainability, and see humans as part of nature, acknowledging their active and positive role as integral to the health of the whole system of life. They believe that human activities are promising opportunities to engage in healthy interrelationships with all living systems, by grounding actions in their own places, which are unique social-ecological systems, by developing life-supporting relationships, and consciously participating in evolutionary processes. This transformational thinking requires principles, perspectives, skills, and commitment of practitioners, stakeholders and users, because "the design process provides a unique opportunity to address explicitly the potential for humans and nature to be in mutually beneficial relationship" (McLennan and Reed, 2013, p.37).

4.3.3 Core principles of the regenerative methodology

Drawing on the ecological worldview and on its premises of integration, interdependence, relationship and emergence, Regenesis developed the regenerative development and design methodology that allows the generation of specific knowledge and its application to the design process in order to produce life-enhancing social-ecological environments ensuring regenerative outcomes. This methodology demonstrates the significance of working within the frame of a worldview that is intentionally held (Mang and Reed, 2012b; Hes and du Plessis, 2015; Benne and Mang, 2015). It is founded on four postulates:

- Humans are an innate part of nature; therefore, they have an active and positive role to play in the health of the whole system of life. Lining up with Lyle, humans are particularly responsible for ecosystems' health and future once their developments and social structures compose a cultural ecosystem service affecting the entire planet's web of living systems (Mang and Reed, 2012b). Human activities have to be planned so that they continuously provide for, and are provided by the living systems where they take place. Mang and Reed (2012a, p.26) argue that co-evolution, or the "reconnection of human aspirations and activities with the evolution of natural systems" can be achieved by aligning human communities and economic activities with place's capacity to support life, and by directing these activities toward the development of human potential in relation to the dynamic essence of nature. This is a regenerative process because it integrates both the tangible biophysical and the intangible or cultural aspects of place, which differentiates it from ecosystem preservation or restoration (Mang and Reed, 2012a; Hes and du Plessis, 2015).
- A transformative standpoint or new mind. A new worldview is a necessary part of the change to promote the shift of focus, one that underpins a different perception of the world, particularly of the built environment, as a collection of energy systems, a web of interconnected processes that continually transforms and restructures the place (Haggard, 2002; Mang and Reed, 2012a,b).
- A new role for designers and the design process. Within the ecological worldview, designers need to understand how life support systems and their subsystems work in the sites where interventions will take place. In other words, they need to be ecoliterate. 'Ecoliteracy' is a term coined by David Orr to define the understanding of how living systems work. Mang and Reed (2012a, p.26) add the requirement of "psychological and cultural literacy, and the ability to tap the latent creativity of a community by weaving broader sets of expertise and insight into the design process". Regenerative practitioners need to elevate their own awareness in relation to the characteristics of place to produce designs that are in themselves

ecosystems that integrate natural and human living systems, and resonate with and respond to the needs of the existing integrated whole, not only in a harmonious manner but in a way that intensifies its potential (Reed, 2007; Mang and Reed, 2012a,b).

- Working developmentally. Reed describes *develop* as the action to “bring forth new potential”, that in simple words is “to add value”. He explains that when we build something in a place, we are enabling people and other living systems “to create their new potential, to actually participate in moving forward”. It is important to note that as the regenerative perspective is holistic the concept of wholeness is always at the forefront, thus all stakeholders should be working in their own development as well as participating, whilst being aware of their relationships with the other living systems in order to create a shared meaningful experience (Reed, cited by Hes and du Plessis, 2015, p. 117). Haggard (2002, p.24) argues that regenerative development seeks to “improve the living and working conditions for both natural and human communities, and to do so by healing the earth *through* development”. This means to work with the aim of increasing the value of the whole by taking systems to a higher order while developing the capacities to engage in this process (Mang and Reed, 2012a,b).

4.3.4 Main concepts to support practice

Regenesis Group has developed a practice methodology based on 15 years of experimental practice, based on a deep understanding of place that comprises three main stages: Understanding the relationship to place; Designing for harmony with place; and Co-evolution.

Understanding the relationship to place comprises a whole systems assessment of place and site, involving biophysical and cultural aspects. Called by Regenesis ‘Story of Place’, it determines the basic understanding and thinking that are necessary to comprehend how human intervention (the project) and all parts involved in it can contribute to the health and evolution of the place and themselves. In this stage, the ‘Story of Place’ is co-developed with the client or community “to articulate the essence of place, how it fits in the world, and what the role of those who inhabit it can be as collaborators in its evolution" (Mang & Reed, 2012b, p.22).

Designing for harmony with place is about putting the 'Story of Place' into design principles and construction processes that aim to optimise human intervention in the site's pattern of place while harmonising it with the larger landscape (bioregion, watershed).

Co-evolution is the result of the two previous stages that were focused on creating a "culture of co-evolution in and around the project" rather than the physical building or development. This marks an essential shift in the role of the designers who become "the [providers] of processes and methods for sustaining the connection to place as the context that enables owners, managers and maintenance contractors, and community stakeholders to recognise and incorporate new social, economic and ecological opportunities as their place evolves"(Mang & Reed, 2012, p.23).

To underpin the three stages of the process described above, Regenesis created a framework for regenerative development and design comprising six principles: Regeneration as a level of work, Development and design, Place as a core, Pattern literacy, Power of story and Potential (Mang and Reed (2021a, b). I have summarised their main characteristics in the table below:

Regenerative development and design core principles

Regeneration as a level of work	Development + Design	Place as a core	Pattern literacy	Power of stories	Potential
Inherent capacity within an open living system Developmental process is essential to regeneration to take systems to a higher level and improve the value of the whole 'Levels of work' systemic framework	Determines the right phenomena to work on; informs and provides direction for design solutions that can realise the greatest potential for the evolution of the system Builds the capability and the field of commitment and caring involving stakeholders as co-designers	Place as organising core for design and development, reconnection of people to place Intimacy with nature instead of dominance Coherent holistic view: Geographic, historic, ecological, cultural connections, indigenous knowledge, and landscape consideration Spirit of place Commitment and meaning. Individual and collective identity Placemaking Humane dimension, Natural and social capital	Facilitates the understanding of living qualities of a site and its place Underpins design that harmonizes with and contributes to the flows of the landscape Mutuality in relationships among different levels Ecological assets of place Resonant human systems to amplify those of place and facilitate co-evolution Indigenous knowledge Permaculture Understanding place's metabolism	Stories reveal a holistic understandable image of human interaction with place "Common ground" between story and aspirations of place Stakeholders engagement as co-designers and stewards for the long term Dialog between design teams & community Active involvement of inhabitants Leadership and consensus around essential community issues	Inherent capacity for coming into existence of all living systems Living systems thinking Developing patterns of relationship between the uniqueness of an entity and its relationship to the largest system it is nested and dependent Rises from the uniqueness of place

Table 4-6: Regenerative development and design core principles

Author, based on Mang and Reed, 2012a,b; Hes and du Plessis, 2015; Benne and Mang, 2015

This regenerative process can be applied to different scales enabling designers and teams to work even in the whole city, harmonizing social and ecological systems within the urban area and its surrounding bioregion. Importantly, in this way it is possible to transform existing built environments to support and enhance the social-ecological systems they rely on, as the case studies developed in this thesis, Curitiba and Singapore, aim to demonstrate (See Chapters 6 & 7).

For further description of each principle, see Appendix C. Detailed information can be found in Mang & Reed, 2012a, b; Benne & Mang, 2015; Hes & du Plessis, 2015.

4.3.5 Regenerative sustainability theoretical underpinning

A recent article authored by John Robinson and Ray Cole (2015) introduces another stream of thought and practice within the regenerative approach to the design of net-positive built environments called 'Regenerative Sustainability'. This approach presents similarities with regenerative development and design in various theoretical aspects but also some differences, particularly in its scientific and philosophical underpinnings. In Robinson and Cole's (2015) view, regenerative sustainability is based on the concept of procedural sustainability, rooted in an understanding of reality founded in social constructs. It is procedural in that its principles are seen as emerging from social processes, and not considered to be absolute truths, but provisional properties that may change according to unpredictable circumstances. Hence, the overarching frame of regenerative sustainability would be emergent rather than predefined, using collaborative planning for sustainable community development methodologies, according to the constructivist social theory, and recognizing that there are many ways to design net-positive environments targeting human and environmental outcomes. This approach seems to be appropriate for the analysis of the case studies comprised in this thesis.

In terms of commonalities, both approaches –regenerative development and design and regenerative sustainability- focus on net-positive outcomes in both environmental and social terms at the building and urban levels, emphasising the pre-design process, in which a broader range of participants is involved aiming educational outcomes for the design team, clients and community stakeholders. The method is based on the types of questions asked at the pre-design stage, who is asked and how discussion is guided. Both approaches also advocate rethinking the role of buildings as catalysts in the process of mutually beneficial co-evolution of human and ecological systems. Robinson and Cole (2015) suggest that regenerative sustainability and regenerative development and design could be complementary approaches, but due to their emergency it is necessary to observe in future practice how their differences in the interpretation of their core tenets may perform (e.g. ‘set of truths’ vs ‘reality contested and socially constructed’). See below a table showing the commonalities and distinctions between Regenerative sustainability and Regenerative development and design:

Regenerative Development & Design	Regenerative Sustainability
Offer net–positive contributions and add value	
Roots: Science of ecology Living systems theory Whole systems thinking	Roots: Participatory integrated assessment/back casting Science studies/Science & Technology
Emphasis: Coevolution of human and natural systems Build natural & social capital Sustainability **dictated** by ecological constraint	Emphasis: Collective decision-making about desirable futures Sustainability **informed** by ecological, social & economic consequences of different courses of action
Process: Primacy of process over predetermined **outcomes** Collaborative processes in order to discover social-ecological stories of place	Process: Primacy of process over predetermined **goals** Collaborative processes in order to seek ways in which net-positive activities can be undertaken

Table 4-7: Commonalities and distinctions between regenerative sustainability and Regenerative development and design. Source: Robinson & Cole 2015

The concept of regenerative sustainability has been expanded and applied to projects as is the case of the Living Laboratory Campus, ongoing project at the University of British Columbia, in Canada. This project envisions to be the first net-positive campus in the world by implementing a regenerative sustainability approach to produce a healthy environment -socially and biophysically- which is adaptable to changing needs over time. The approach integrates design strategies seeking for multiple effects, ranging from self-sufficiency in energy and water to producing a suite of benefits to users such as health, productivity and happiness (Cole 2012; Cole et al 2013, Robinson and Cole 2015).

4.4 Conclusions

This chapter has reviewed the theory of two ecological design approaches to the built environment embedded in the ecological or regenerative sustainability paradigm: Biophilic design and urbanism and the regenerative approaches, Regenerative development and design, and Regenerative sustainability. These approaches aim to make significant contributions to the thinking and design of built environments within a net-positive perspective.

The concept of biophilia as an inherent affiliation of humans with nature is crucial to sustain the recoupling of both. The aim of biophilic design is to reconstruct human abilities to positively contribute to harmonising the human role in social-ecological systems. This occurs because our evolutionary process took place along an intimate relationship with the natural world where we developed an informational nurturing connection from which we draw emotional and physical support. Therefore, Biophilic Design and Urbanism approaches to the built environment appear to be significant means to provide urban dwellers contact with nature on a deeper level and facilitate contributions and stewardship to sustainability. The 'Biophilic cities network' (Beatley, 2011) provides many successful examples. Although biophilia has an anthropocentric purpose, providing health and wellbeing to humans, Biophilic Urbanism has demonstrated active and positive inputs to foster and increase urban biodiversity. This is achieved through the creation of abundant green spaces within cities and inside and onto buildings offering opportunities of new habitats for flora and fauna (e.g. green roofs and walls), as well as through restoration of damaged urban and regional ecosystems.

Regenerative development and design is a holistic social-ecological design approach calling for a new mindset. It integrates systems thinking and the concept of co-evolution that embody a shift in the human attitude toward nature, seeking for symbiosis with the natural world. By working on the potential of the whole system, the regenerative methodology enhances the concept of sustainability, demonstrating the significance of working within the frame of the ecological worldview, which is purposely held. It allows the generation of specific knowledge and its application to the design process in order to produce life-boosting social-ecological built environments ensuring regenerative outcomes. The most recent stream of regenerative approaches to the built environment, called 'regenerative sustainability' by its authors, Robinson and Cole (2015) brings a strong focus on socio-cultural aspects while encompassing ecological aspects too. Proposing a procedural understanding of sustainability, it adapts to changing circumstances, according to the principle of impermanence. Processes are guided by goals and incorporate collaborative planning for sustainable community development recognising that there are many ways to design net-positive environments comprising social, economic and ecological aspects. In order to simplify nomenclatures, this thesis uses 'regenerative development' to refer to regenerative development and design, and regenerative sustainability, acknowledging the commonalities and distinctions between both streams, but also their complementarity as stated by Robinson and Cole (2015).

The convergence of biophilic and regenerative approaches' standpoints in many aspects and the possibility of their implementation in urban settings opened the opportunity to develop an integrated approach to urbanism –Regenerative Sustainable Urbanism- that combines the key characteristics of both biophilic urbanism and regenerative development to enhance performance and potential in urban transformation. A framework for this alternative approach is presented in chapter 5.

Chapter 5

An integrated framework for Regenerative Sustainable Urbanism

As seen in Chapter 4, the theory and empirical evidence drawn from applications of biophilic urbanism and regenerative development approaches to urban planning, e.g. 'biophilic cities' (Beatley, 2011), Regenesis' projects (Mang and Reed, 2012a,b) and the University of British Columbia's Living Lab Campus (Robinson and Cole, 2015) suggest that integrating design strategies founded in socio-ecological approaches to urbanism may lead to regenerative outcomes in cities. Having in mind this hypothesis, this chapter presents the development of a framework for regenerative sustainable urbanism that combines biophilic and regenerative development principles. The framework was developed to assist the conception of sustainable built environments where healthy communities and ecosystems can thrive together. Its performance and potential will be tested in two case studies, the cities of Curitiba, Brazil, and Singapore.

As discussed in Chapter 1, this research used grounded theory methodology to build the framework for the practice of regenerative sustainable urbanism, guiding data collection and analysis from the extended literature review of the theory of biophilic urbanism and regenerative development due to their essential influence in the conception and design of restorative and regenerative built environments.

5.1 Integrating principles for Regenerative Sustainable Urbanism

This section presents the background, rationale and the theoretical foundations of the framework for Regenerative Sustainable Urbanism, its scope and application, in this case to the case studies.

The framework results from the logical development of all precedent sections of the thesis as summarised in figure 5-1 below:

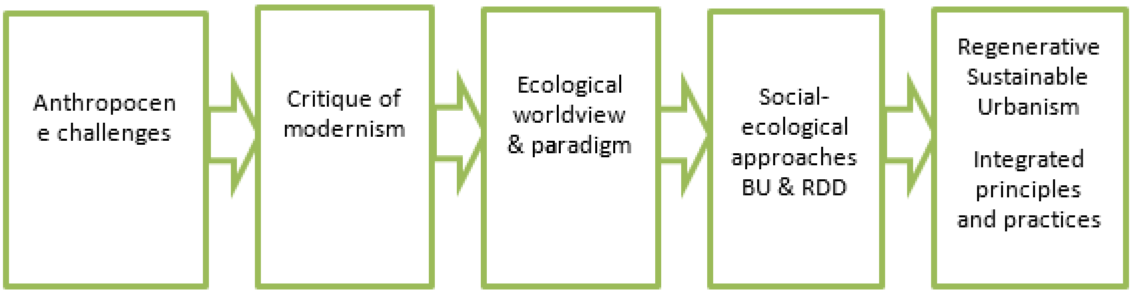


Figure 5-1: Framework background

Source: Author

The framework builds upon the theory of biophilic urbanism and regenerative development combining their key characteristics and emphasising their interrelationships to serve as a guide for design solutions conducive to restorative and regenerative outcomes in urban precincts and cities. This framework is intended to facilitate broader interactions, thinking and discussion among designers, clients, stakeholders and practitioners of related disciplines to place and project. It also intends to assist with the integration of restorative and regenerative principles into urban design and planning methodologies in order to contribute to a major goal that is the co-evolution of socio-cultural and ecological systems, locally and regionally.

The framework acknowledges that urban sustainability comprises a broad scope of variables such as energy, water, carbon emissions, transport, infrastructure, services, inhabitants' health and wellbeing, productivity and happiness among others. Through the combination of the principles of both social-ecological approaches, regenerative sustainable urbanism emphasises human and environmental aspects, contributing as well to the more engineering parts such as transport and infrastructure by facilitating walkability and cycling, helping to fix carbon, reducing urban heat island effect, purifying the air while promoting urban biodiversity and healthy urban lifestyles.

Concepts from biophilic urbanism and regenerative development were explored and collated to determine the framework categories, and then the categories were refined defining eight main principles: Place, Progressive human-nature relationships, Pattern literacy, Development, Ecosystem services, Community engagement (co-responsibility), Liveability (co-evolution) and Beauty.

The following Table 5-1 presents the Regenerative Sustainable Urbanism Framework:

Regenerative Sustainable Urbanism Framework

Place	Progressive human-nature relationships	Pattern literacy	Development and Design	Ecosystem services	Community engagement *(co-responsibility)*	Liveability *(co-evolution)*	Beauty
Place as organising core for design and development: Reconnection of people to place[1] Harmonious blend of culture and nature in a geographical context[11] Coherent holistic view: geographic, historic, ecological, cultural connections; indigenous knowledge, and landscape consideration[1, 11] Potential: Developing patterns of relationship. Rises from the uniqueness of place[1] Spirit of place: Commitment and meaning. Individual and collective identity Placemaking: Humane dimension, Natural and social capital[2,11]	Organised complexity: Complex order underlying nature [9] Harmonious geometries, proportions, symmetries beneficial to human health and wellbeing[8,9] Attraction and beauty: Deep aesthetic/biological connection to nature[,8,9] Affection and attachment: Care for and commitment to natural and designed environments[8,9,11,12] Enticement and curiosity[9,11] Change and metamorphosis[9] Exploration and discovery[9,,11] Security and protection[8,9] Prospect and refuge Information and understanding[9, 8] Reverence and spirituality [9,11]	Understanding the living qualities of a site and its place[1] Underpins design that harmonizes with and contributes to the flows of the landscape[1] Mutuality in relationships[1] Meaningful places[11] Resonant human systems to amplify those of place and facilitate co-evolution[1] Indigenous knowledge[1,9] Permaculture: Understanding place's metabolism[1] Stories: Reveal a holistic understandable image of human interaction with place[1]	Aims active and reflective stewardship, from designers to users, creating an ongoing regenerative capacity in the place, that is sustained over time[5] Widening of boundaries[11] Understanding of the larger ecological and social systems that lay the basis for long-term possibilities[5] Respect for site capacities and planetary boundaries[3] Practice-driven movements[7] Contribution to the capacity of all systems affecting place[1] Design builds regenerative capacities of designed and natural systems[1] Development creates the conditions for its positive, sustained evolution. Improves the value of the whole[1]	Ecological assets of place[3] Informs design for generation of new and healthier patterns to place[1] Ecological regeneration goals for a built environment[3] Targets for measurable regenerative design[3] 6 most suitable ecosystem services for regenerative design in a built environment: Supply of fuel/energy, Supply of water, Purification, Climate regulation Nutrient cycling, Habitat provision[3] Performance levels are specific to a site, locality or region, continually evolving over time[3]	"Common ground" between story and aspirations of place. Stakeholders engagement as co-designers and stewards for the long term[1,4] Dialogue between design teams & community[7] Active involvement of inhabitants[11] Leadership and consensus around essential community issues[7,11] Community empowerment, ownership of projects, feedback loops, durable evolution over time[7,11] Feedback loops promote a reflective attitude essential to a regenerative capacity[7] Dialogue leads to solutions and creates momentum and longevity needed for stewardship of reg. development[7]	Co-evolution of socio-cultural and ecological systems as a partnered relationship[1,2,6] Establishing and maintaining a symbiotic and regenerative mutual relationship[4] Moving from thinking about buildings as artefacts to considering them as adaptive processes over time[2]. Moving from a focus on the building and its site to the wider neighbourhood[2] Shifts apply to both ecological and socio-cultural systems. This mutualistic partnership supports health and resilience of both systems in the long term[2] Identify opportunities for synergistic regenerative interactions over time in the built environment[2]. Intimacy with nature instead of dominance[10,11] Aesthetics and cohesive existence of environmental and cultural resources.	Affection and attachment[9] Attraction and beauty[9] Reverence and spirituality[9, 11] Meaningful places[11] Mutuality in relationships[1] Deep aesthetic/biological connection to nature[,8,9] Spirit of place[1, 9, 11] Aesthetic performance of designed landscapes, and aesthetic experiences leading to stewardship and transformational change [12] Intimacy with nature instead of dominance[10,11] Care for and commitment to natural and designed environments[8,9,11]

Table 5-1: Regenerative Sustainable Urbanism Framework

Author, based on Mang and Reed (2012)[1]; Cole et al (2013)[2]; Pedersen Zari (2012)[3]; du Plessis and Cole (2011)[4]; Cole (2012a) [5]; du Plessis (2012)[6]; Hoxie et al (2012)[7]; Mehaffy and Salingaros (2012)[8]; Kellert et al (2008)[9]; Reed (2007)[10]; Beatley (2011)[11]; Meyer (2008)[12]

A detailed description of each principle follows:

Place

From the regenerative development views, based on systems thinking, place is the core concept, integrating a number of other related concepts inherent to the process toward achieving regenerative sustainability in the built environment. They include the power of storytelling to formulate the essence of place, potential, regeneration as a level of work, pattern literacy, development and design, community engagement, and co-evolution (Mang and Reed, 2012a,b; Benne and Mang, 2015). Considering communities and places as living systems, the concepts of potential and co-evolution have a critical meaning. du Plessis and Cole (2011) defined co-evolution as a symbiotic and regenerative partnered relationship, which is enabled through a different relationship with nature, based on intimacy instead of dominance, promoting opportunities and conditions for co-evolution. This can be achieved by shifting current thinking and practice to facilitate understanding of how living systems work and discovering their purpose, widening in this way the focus from buildings and their sites to the broad neighbourhood and region (Mang and Reed, 2012; Cole et al., 2013).

Biophilic design also highlights the importance of place. As seen in Chapter 4 (table 4-2), Kellert (2008) defined and described six biophilic core principles and 72 attributes. In the *Place-based relationships* principle, biophilic design includes a holistic approach to place integrating biophysical and cultural aspects, landscape considerations and the spirit of place or intimate response of a person to a place that corresponds to a unique interconnection. This is a meaningful and emotional experience, relevant to promoting stewardship, bringing together cultural and ecological aspects. When spirit of place is absent, placelessness, the opposite phenomenon, occurs causing lack of empathy and, consequently, lack of stewardship (Beatley, 2004; Kellert and Calabrese, 2015; McGee and Marshall-Baker, 2015).

These concepts resonate with several regenerative development and design (Mang & Reed, 2012a, b) tenets that consider place as an organising core principle for architectural, urban and regional design. In this approach, the understanding of patterns and processes that shaped the place in the past and continually shape the place in both the natural ecology and the local culture, allows realigning both aspects to create a harmonious blend in a geographical context. Thus, place is re-located to its core position in human life, creating an emotional bond that facilitates ownership and the interest in caring for it, developing strong local communities (Mang and Reed, 2012; Beatley, 1997, 2004). When working on a project, the regenerative methodology considers *place* not only the site or area occupied by the project itself but also the neighbouring ecosystems, allowing connectivity and regenerative benefits to ripple through the region.

Table 5-2 below shows the comparison between both approaches to indicate the potential for integrating these understandings.

Biophilic design	**Regenerative development**
Geographic connection to place Historic connection to place Ecologic connection to place Cultural connection to place Indigenous materials Landscape orientation Landscape features that define building form Landscape ecology Integration of culture and ecology Spirit of place Avoiding placelessness	Place as the organising core for development and design; reconnection of people to place Coherent holistic view: geographic, historic, ecological, cultural connections, indigenous knowledge, and landscape consideration Spirit of place: commitment and meaning. Individual and collective identity Sense of place; Placemaking Natural and social capital

Table 5-2: Place comparison between biophilic urbanism and regenerative development

Source: Author, based on Kellert, 2008 and Mang & Reed, 2012a,b

As shown in the comparative table above, the description of this principle shares many elements in both approaches, such as its holistic nature, its core position in design purposes, and the significant consideration of the spirit of place and its implications in generating stewardship for regenerative sustainability. According to this analysis, the first principle selected for the framework is Place.

Progressive human-nature relationships

Similarly, the human-nature relationship is essential in both regenerative development and biophilic design approaches, which converge in the essential premise that humanity is a constituent part of nature. Biophilic design plays a relevant role in this reconnection by proposing design methods for architecture and urban design and planning that aim to nurture human-nature reconnection, providing health and wellbeing. According to Salingaros and Masden (2008), this is enabled by translating into new designs the informational content that underpins natural and traditional built environments. Both respond to an integral logic and order embedded in their structures, built in a coherent manner, that "provide neurological connection at a human scale, and thus, emotional nourishment" (Salingaros and Masden, 2008, p. 77). Evolved human-nature relationships represent the integrative capability of this category that form the ultimate foundation of the ecological approach to design. They involve the consideration of the inherent human relationship to nature, as well as attributes oriented to design strategies leading to providing experiences that can suggest or even replicate those lived in natural settings. This is because the human-nature reconnection occurs particularly when the design interventions are based on the ordered complexity of natural structures, which are adapted to human sensibilities that also include prospect and refuge, curiosity and enticement, attraction and beauty, among others, which can make architectural and urban spaces more interesting, meaningful and resilient (Kellert, 2008, Salingaros and Masden, 2008; Hes and du Plessis, 2015).

In Table 5-3, the Human-Nature Relationship principle is dissected to show the elements and attributes for design, based on Kellert's approach (2008) along with other authors on this topic, including those from the regenerative development school of thought. These integrated design principles show how the two approaches are able to provide cohesive design guidance.

Prospect and refuge	Prospect: places enabling long views and perspectives for exploration. Refuge: secure and protecting structures and settings. Complementary use to produce functional and satisfying environments.
Organised complexity	Places rich in options and opportunities. Detail, ornament and art, texture and colour. Variability. Places that promote encounters. Walkability.
Curiosity and enticement	Complementary inclinations that promote exploration, creativity, interactivity and production. Enriched public and private spaces.
Change and metamorphosis	Places that reflect the passage of time and continuous process of change of living systems, capturing the flow from one stage to another. Capacity to adapt to ever changing conditions. Resilience.
Exploration and discovery	Natural processes elicit interest and exploration, even if in representational ways. Buildings and urban settings with natural features like green walls, accessible green roofs, and landscaped public spaces.
Information and cognition	Buildings and urban designs that highlight natural forms and shapes for intellectual satisfaction and cognitive processes, creative use of ornamentation in facades, pavements etc to foster critical thinking and problem solving.
Fractals	Structures that repeat varying patterns of related and similar forms. They are present in nature and successful designs of buildings and landscapes, ornamental designs.
Hierarchically organised ratios and scales	The underlying structure of many natural and artificial successful elements and objects, responding to arithmetic or geometric laws. E.g. golden ratio, golden sections, golden proportion, golden spiral, Fibonacci’s sequence.
Affection and attachment	Human capacities that evolved through contact with nature. Building and landscapes that promote this attachment are recipients of care and loyalty.
Attraction and beauty	The aesthetic attraction of nature is another biologically inherent affinity of humans. Aesthetic experiences in landscapes, natural or designed, facilitate feeling of affection and care.
Reverence and spirituality	Designs that inspire feelings of transcendence and connection to creation. They are sustained over time.
Intimacy with nature	As humans are nature too, respectful and co-evolutionary attitude regarding nature, instead of dominance as has been the prevalent attitude towards nature since the Industrial revolution to these days.

Table 5-3: Human-nature relationship principle showing elements and attributes

Source: Author, based on Salingaros and Masden (2008); Kellert (2008); Kellert and Calabrese (2015) and Mang & Reed, (2012a,b)

This analysis also matches several elements contained in Beatley's table of biophilic urban design elements through scales (see Table 4-3, in Chapter 4), related to human-nature reconnection, and is counterpart to regenerative development that shares the approach and highlights intimacy with nature rather than dominance. Combining the concepts of Salingaros and Masden (2008); Kellert (2008); Kellert and Calabrese (2015), I selected the most significant for urban settings and related them to configure the framework's second principle that I called Progressive human-nature relationships.

Pattern literacy

Pattern literacy is the third principle. Urban environments benefit from this approach because the first human settlements drew their organisation from natural structures, forming urban codes that further developed into patterns. Alexander et al. (1977) developed a compendium of 253 patterns ranging from the urban scale to buildings and their constituent parts. The replication and evolution of patterns give meaning to buildings and places and contribute to establishing bonds between them and the users and residents, promoting sense of belonging, sense of place and caring relationships. This is especially relevant for regenerative sustainability issues in the built environment.

Both biophilic and regenerative development approaches integrate Pattern Literacy in their theory and practice. For regenerative development, it allows for a deep understanding of how living systems work. It enables probing the organised complexity of nature and the cultural systems that compose a place, through decoding patterns of relationships. This pattern literacy process permits the shift from dominance to intimacy with nature, because it allows a deep understanding of how nature works. Biophilic design recognises patterned wholes and organised complexity in its *Natural patterns and processes and Evolved human-nature relationships* elements (see Table 4-2 in Chapter 4).

Development

The fourth principle is Development because this tenet, from the regenerative development approach, is critical to regenerative sustainability. This is due to its holistic and instrumental character, presenting overlaps with most of the other principles. As seen in Chapter 4, development and design are two different but interdependent elements of a paired relationship. Mang and Reed (2012a p.28) explain the difference between regenerative development and design stating that these two concepts are “distinct, yet synergistic aspects of the regenerative methodology”. Regarding regenerative development, these authors identify two symbiotic attributes: a) it settles the correct phenomena to work on in a given place informing and providing direction for design solutions to add value and increase place potential to evolve the system; b) it develops capability and the field of commitment and caring of stakeholders in order to make them co-designers of the project, while promoting stewardship of the designed interventions. Regenerative design provides sets of strategies and technologies seeking to create conditions that are conducive to all forms of life in the place where the project is nested and its surroundings. Although a building in itself is not regenerative, the system composed by building(s), their inhabitants, and the biophysical and socio-cultural context is regenerative, shifting the way of thinking design and the role of buildings, which become catalysts for regeneration. In this sense, it is possible to think that systems designed using a regenerative approach help to transform the negative ecological footprint into a positive impact, by activating the connections between people and place (Mang and Reed, 2012a,b; Benne and Mang, 2015). Development is closely related to a place’s potential, as Mang and Reed (2012a, p.38) clearly put it:

From this standpoint, seeing and enabling the manifestation of potential benefits the project, in that it takes on new meaning and significance within a larger context. In addition, it benefits the larger community or watershed by increasing the value of the contributions the project can make to its health – ‘giving life to others as it transforms’. Revealing this potential thus requires an understanding of the relationship between two dimensions of an entity: (1) its unique character or essence; and (2) its relationship to the larger system(s) within which it is nested, and upon which it depends.

The regenerative sustainability approach (Robinson and Cole, 2015) complements the understanding of regenerative development and design, acknowledging the catalyst role of buildings in the process of mutually beneficial co-evolution of human and ecological systems and highlighting the procedural characteristic of sustainability, rooted in social processes, and adds the importance of the to the neighbourhood scale (Waldron et al, 2013), responding to some critiques that have been done to the application of regenerative development at the urban scale (Clegg, 2012; Tainter, 2012). Based on experiences drawn from the ongoing UBC Living Lab campus project, Waldron et al (2013) make the case for the neighbouhood scale as catalyst in the process of accelerating the transition toward urban sustainability for various reasons: firstly because urban precincts and cities have a strong influence on global sustainability. Secondly, cities historically have shaped themselves in an organic manner following bottom-up processes at the neighbourhood scale, so this evidence-based knowledge should be added to master planning standpoints. Thirdly, the neighbourhood scale offers more opportunities for innovation than buildings on overall urban form and function (regarding infrastructure, transport, services and public spaces), and finally but importantly, because this scale offers better opportunities for meaningful community engagement, seeking for partnering, building capability, commitment and stewardship of the co-designed solutions (Waldron et al (2013).

Summarising, development looks for increasing the potential of the system, and adds value creating the conditions for positive, sustained and partnered evolution of both human and environmental aspects.

Ecosystem Services

The fifth principle is Ecosystem Services, which includes ecology of place, a thoughtful consideration of how ecosystem services are of fundamental importance to human life (Alberti et al, 2003). Ecosystem services affect urban planning decisions because their analysis enables ecological regeneration goals for a built environment. It considers the ecological assets of place and informs design for regeneration of new and healthier patterns for place. Regenerative development and Biophilic approaches share the understanding about the fundamental role of ecosystems services in going beyond reducing the ecological footprint of buildings and cities, and focusing instead on creating health and wellbeing (Reed, 2007).

Biophilic Urbanism has demonstrated active and positive inputs to foster and increase urban biodiversity. This is achieved through the creation of abundant green spaces within cities and inside and onto buildings offering opportunities of new habitats for flora and fauna (e.g. green roofs and walls), as well as through restoration of damaged urban and regional ecosystems, comprehending ecosystem complexity and restoring ecosystem services (Pedersen Zari, 2011), setting design goals that do not exceed the physical capacity of a site, but rather promote their adaptive and regenerative capacity in order to reconcile the built environment with their geographical magnitude.

Community Engagement

Community Engagement, the sixth principle, is a crucial issue in regenerative sustainability, as seen in Chapter 4. Community is a constituent part of place and in regenerative development's methodology, community has a significant role as co-designer. This is one of the most relevant and meaningful issues in sustaining the transformative process. The involvement of all stakeholders should start at the very early stages through intense dialogue focusing on empowering community toward ownership of projects, feedback loops and durable evolution over time.

Liveability

Liveability or co-evolution, adopting Moura's (2005) definition of social and environmental quality of place, is the seventh principle of the framework. It is directly derived from involvement and ownership. Considering communities and places as living systems, the concepts of potential and co-evolution have an essential meaning. du Plessis and Cole (2011) defined co-evolution as a symbiotic and regenerative partnered relationship, which is enabled through a different relationship with nature, based on intimacy instead of dominance, promoting opportunities and conditions for mutual evolution, made evident in design and development of initiatives that promote recreation and leisure, aesthetics and cohesive evidence of environmental and cultural resources. This process requires shifts in both ecological and socio-cultural systems to support health and resilience in the long term.

Beauty

I have included Beauty as the eighth category because, similarly to biophilia, beauty is an innately emotional affiliation of human beings and an essential attribute of life. Within the ecological worldview, the concept of beauty has shifted from its historical conception to a new understanding that conceives it as an essential strength towards sustainability (Meyer, 2008). Drawing from this human affiliation with beauty, Meyer (2008) and Kagan (2011) argue that aesthetic experiences facilitated by designed landscapes, art and culture may help in reconstructing the wholeness of the system and restore the reflexive sensibility and connection between human and non-human systems leading to sustainable and regenerative processes. In this sense, beauty contributes to stewardship and long-lasting transformational change (See Appendix A).

5.2 Application of framework to practice

Considering the emergence of regenerative sustainable urbanism, there are not yet built urban developments designed according to the framework. However, to test the framework's validity and applicability, it was decided to use two case studies - the cities of Curitiba, in Brazil, and Singapore, the city-state- to see if these cities can be considered as precedents of regenerative sustainable urbanism. The aim is to analyse why and how integrated urban planning with social-ecological approaches drove these cities pathways toward urban sustainability; what was the influence in producing regenerative processes, and if there is reciprocity between their processes, practices and policies, and the theoretical principles. Moreover, the analysis looks for convergences and divergences and why this happened.

The framework is flexible and admits change, because it is developmental in that it ponders "the qualitative development of a society, technology and environment that consider our evolutionary prospects" (Moore, 2007, p.2). Therefore, the framework is not projected to use pragmatic measurable indicators; instead, it provides a guide to observe the emergence of regenerative practices from the application of social-ecological approaches to urban design and planning. From this frame, I developed a matrix comprising the theoretical principles, and the practices and policies observed in both cities, which was used as an analytic tool and was applied to both cases through a replication approach. The two-case replication approach was designed and conducted according to Yin (2009). It was believed to show literal replications, so convergence of outcomes has been sought.

This procedure is explained in Chapters 6 and 7 in the context of each case study.

The scope of this framework application is international, opening the study to cities around the world, both in industrialised and developing countries, with the necessary consideration of the uniqueness of each place.

Table 5-4 below shows the matrix format:

Regenerative Sustainable Urbanism Analytic Matrix								
Principles	**Place-based relationships**	**Advanced human-nature relationships**	**Pattern literacy**	**Development**	**Ecosystem services**	**Community engagement** *(co-responsibility)*	**Liveability** *(co-evolution)*	**Beauty**
Policy								
Practice								

Table 5-4: Regenerative Sustainable Urbanism Analytic Matrix

Source: Author

5.3 Analytic strategy

To test the hypothesis: “The implementation of integrated planning initiatives founded on social-ecological approaches to urbanism can lead to regenerative sustainability in cities”, the analysis was organised in three phases. First, the consideration of local urban planning traditions and processes; second, the application of the framework to each city; and finally, the cross-case analysis.

For the consideration of local urban planning traditions and processes, as stated in the Methodology section (Chapter 1/1.7), I used STS –Science and Technological Studies method to conduct the analysis to understand Curitiba and Singapore as wholes or sociotechnical artefacts including human systems, and to investigate how and why particular technologies – specifically urban planning processes including social-ecological approaches – appeared in both cities in the 1960 -1970s, and enabled their transformations. The STS method inquiries what kind of influence these urban planning processes had in both Curitiba’s and Singapore’s pathways toward sustainability, and how urban planning evolved as a technology in itself along the process.

For the application of the framework to each city I used the matrix as described in the previous section of this chapter.

For the cross case analysis I used the method described by Yin (2009) based on a theoretical proposition, using thick description and cross-case synthesis. Thick description is a technique used in qualitative research consisting of observing actions, behaviours or events paying attention to contextual detail. Observation seeks to establish the significance of facts and interpret social meaning. It is relevant to case studies (Dawson, 2010). Cross-case synthesis analyses each case as a separate study, arranging and displaying the data for analysis, then captures and discusses the results of all cases (Yin, 2009).

I formulated a number of questions to guide the analysis and the discussion of the outcomes.

a) Local urban planning traditions and processes

The planning history of each city (see Chapters 6 and 7) is relevant for understanding how and why the urban transformations emerged, what supported them and how they were implemented, as well as local context, policies, convergences and divergences.

- Why did this specific process of urban transformation occur in those cities and not in any other city in the country or region?
- Were there any precedents, national or international?
- How did it happen and how was it conducted?
- Is there any evidence of a shift in the process of thinking about urban planning?
- How did it reflect on urban design and planning?

b) Application of the framework to each city

- What type of practices and policies observed in each city align with the theoretical principles contained in the framework?
- How do the practices /policies reflect them?
- What kind of findings could be considered as leading to regenerative sustainability?

According to Bryman (2008), qualitative data analysis involves the description of the phenomena, the development of conceptual classification and the identification of connections between concepts.

c) Cross-case analysis

- Commonalities and dissimilarities
- Convergence of evidence in each case
- Do both cases suit the theoretical proposition?
- What has constituted supportive evidence in each case, relevant to answer the research questions?

To what extent can the findings be replicated or generalised?

Yin (2009, p. 38) defines analytical generalisation as a “mode of generalisation in which a previously developed theory is used as a template with which to compare the empirical results of the case study. If two or more cases are shown to support the same theory, replication may be claimed”.

5.4 Conclusions

This chapter explained the development of an alternative integrated framework for urban design and planning within the regenerative sustainability paradigm that combines shared principles of biophilic design and regenerative development.

The new approach is called Regenerative Sustainable Urbanism because it aims to contribute to the design and planning of future and existing cities from their buildings, to neighbourhoods, precincts and regional context. The nature of this framework is developmental, therefore it is flexible and provides a guide to observe the emergence of regenerative practices from the implementation of social-ecological approaches to urban design and planning. The framework applicability and validity is tested through a matrix comprising the principles, and the policies and practices found locally. The scope of this framework application is international, opening the study to cities around the world, both in industrialised and developing countries, with the necessary consideration of the uniqueness of each place.

This chapter also presented the analytical strategy to assess the performance of two case studies in relation to the alternative approach Regenerative Sustainable Urbanism.

The next two chapters present the case studies, the cities of Curitiba and Singapore, data collection, and application of the analytic strategy. The case studies were conducted according to the methods described in Chapter 1 (see 1.7 Research design and methodology). Chapter 6 is related to Curitiba and Chapter 7 is related to Singapore.

Chapter 6

Curitiba Case Study

Curitiba is the seventh largest city in Brazil and its fifth economic hub. It is also Brazil's greenest city awarded the UN's most ecological city title in 1992 (Macedo, 2013; Newman and Jennings, 2008). The city has achieved international renown for its integrated urban planning initiated in the 1960s, which incorporated innovative, efficient and low cost solutions for public transportation, land use and effective environmental programs (Macedo, 2013; Irazábal, 2005).

6.1 Geographic information

Location

Curitiba is located 924 metres above sea level, close to the coastal mountain ridge, 87 km west of the Atlantic Ocean. It has a mild coastal marine highland subtropical climate with no dry season and warm summers. Warmer months average 22^{o}C (September-April) and colder months 15°C (May-August) with occasional frosts during winter nights. Heavy precipitation occurs during mild winters, which are dominated by mid-latitude cyclones. The region presents rolling hills and plateaus to the north, south and southeast towards the Iguazu basin. The region is rich in rivers and streams that run across valleys and plateaus, and is covered by the subtropical broadleaf forest (warm temperate moist forest biome).

The strategic location between two of the major rivers, on the trade routes connecting Sao Paulo with the south of the country, and the temperate climate conditions attracted the first settlers in the mid-1800s. They were mostly European immigrants, mainly from Poland, Germany and Italy who appreciated the landscapes and climate (Rabinovitch and Leitmann, 1993; Moore, 2007).

Figure 6-1: Location

Source: IPPUC, 2010; Fragomeni, 2013

City

Area: 432 km^2

Population: 1,865,000 inhabitants (estimated 2014)

GDP: U$ 8 billion (6th in Brazil)

Budget: U$ 1, 3 billion

Metropolitan area (26 municipalities)

Area: 15,622.33 km^2

Population: 3,400,000 inhabitants (estimated 2014)

Growth rate: 2.4% (2013)

Source: Fragomeni, 2013

6.2 Brief history

Curitiba was founded in 1693 by the Portuguese and became a city in the mid-1800s, when the inflow of European migrations began and the city enjoyed moderate economic prosperity, mainly supported by the boom of agricultural production based on coffee, mate, cattle and wood exploitation (Rabinovitch and Leitmann, 1993). In 1853, Curitiba was proclaimed capital of the state of Parana, southern part of Brazil. Its name originates from the Guarani language *curiy-tiba,* meaning abundance of pine (Macedo, 2013). The indigenous peoples who populated the region much appreciated the fruits of the Parana pine or *Araucaria angustifolia,* a species native to the subtropical forest that covers the regional highlands.

It is interesting to note that Curitiba has not been a typical Portuguese colonial city like Salvador or Rio de Janeiro, which have a legacy of rich architecture and a long history of racial mix, but rather a "melting pot for the Europeans" as Moore (2007, p.75) describes it. The influence of European culture modelled the character of the city and its inhabitants, making it rather different from the rest of Brazil. Their compatriots consider Curitibans as cold, conservative people.

After World War II, Curitiba became a relevant service hub due to its strategic location in relation to the transportation network that encouraged industrialization, transforming the city into a processing centre for agricultural goods, exported by the port of Paranagua (Rabinovitch and Leitmann, 1993).

6.3 Urban planning history

Curitiba is renowned for its urban planning. Its planning history started in the 19th century. Macedo (2013) recognizes two phases: the first one or "pre-urbanism" comprises the first plan developed in 1857 by Pierre Taulois and further interventions that consolidated the urban form. The Taulois plan consisted of the design of an incipient orthogonal grid aimed to facilitate implementation of sanitation infrastructure and fulfilment with regulations leading to rise the city to state capital. This plan did not modify the existing spatial structure nor did it indicate direction for urban growth. By the end of the century, the construction of the railroad connecting Curitiba to the sea port of Paranagua determined the direction for urban expansion, also supported by the execution of many important infrastructure and cultural projects that defined the urban form that characterizes the city today (Macedo, 2013; Rabinovitch and Leitmann, 1993).

The second or “urbanism” phase encompasses the Agache Plan, the Wilheim-Serete Master Plan and the urban transformation developed onwards that culminated with the recognition of Curitiba as a world model of sustainable urban design and planning. The Agache Plan was the first comprehensive urban plan in the current sense, designed by the French urbanist Alfred Agache in 1943, when the city’s population was around 120,000 inhabitants. The main goals of this plan pointed to address flood issues and to enhance the spatial structure of the city core. The key idea was the definition of a central business district surrounded by residential concentric areas for urban growth, land use zoning, sewers, open spaces, and provision of areas for urban expansion. Radial avenues connected these different areas to the central district, highlighting the construction of a civic centre to house government institutions and future landmarks (Macedo, 2013; Irazabal, 2005; Rabinovitch and Leitmann, 1993). The plan was not implemented due to lack of public funds at the time, except for the radial avenues. In Rabinovitch and Leitmann’s view (1993), this plan failed to foresee the boom of automobiles in the Brazilian cities in the 1950s, but they recall its bequest as raising consciousness about the capacity of planning in helping solve growth-related problems.

From the 1950s to the 1970s, the nation’s economy experienced an irreversible change, shifting from an agricultural to an industrial economy. This forced the migration of rural populations to the cities, boosting the rate of growth and urbanisation to a greater scale across the country. In the state of Parana, besides the mechanization of agriculture, a severe decline in the production of coffee due to climatic conditions provoked remarkable changes (Macedo, 1993) and consequently, Curitiba underwent an intense population increase. In the 1970s, the urban growth rate of Curitiba and metropolitan area was around 7%, the highest in the country (Rabinovitch and Leitmann, 1993), and by 2010 around 80% of the state of Parana's population lived in urban areas, its capital city comprising 20% of the total (Macedo, 2013). The city's population grew sixteen-fold over the past fifty years (Mang, 2009).

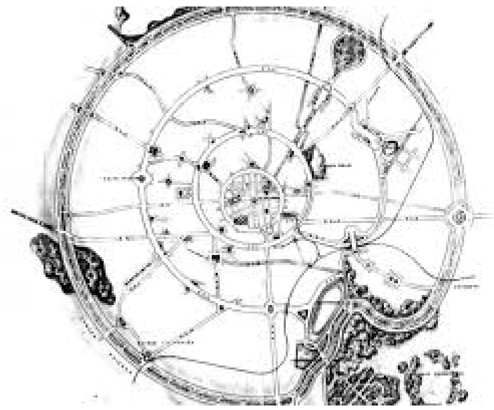


Figure 6-2: Agache Plan.
Source: Gazeta do Povo.com.br

The Agache Plan oriented development until the mid-1960s; however, the unprecedented demographic growth posed challenges that demanded adjustments, new solutions for urban expansion, and urban management. In 1964, Mayor Arzua launched a national competition for a new master plan, and a proposal authored by architect Jorge Wilheim in collaboration with the Serete Society of Studies and Projects, based in Sao Paulo, was unanimously declared the winning entry and Wilheim was appointed to develop the Preliminary Master Plan. By then, Curitiba's population averaged 500,000 inhabitants and had a growth rate of 5.6% (Irazabal, 2005).

The Master Plan development and implementation required an institution to support the management. Thus, in 1965 Parana's Governor Ney Braga, sharing the Master Plan's authors' recommendations, created the IPPUC (Portuguese acronym for the Research and Urban Planning Institute of Curitiba). The Institute was responsible for the development, coordination and creation of conditions for the plan's implementation, in addition to carrying out new studies for integrated planning (Lloyd-Jones, 1996). Since then the IPPUC has been and still is the city's primary tool and synergy hub for the urban transformation. Curitiba has a planning culture history, but it was with the creation of the IPPUC that the city became a laboratory for urban planning experiments (Macedo, 2013; Moore, 2007; Gnoato, 2006).

The Master Plan, also called Wilheim-IPPUC Plan approved in 1966, changed the urban spatial structure, adapting Agache's radial road system into five linear axes radiating from the town centre to orientate development (Macedo, 2013; Gnoato, 2006). The new integrated planning concept was based on a tripod combining road network, transportation and land use (Rabinovitch and Leitmann, 1993). The five structural axes organised the urban expansion along transit oriented corridors where high densities and mixed land uses were permitted and encouraged. These principles also incorporated urban management, industrial promotion, environmental improvement and urban quality (Macedo, 2013; Irazabal, 2005).

Figure 6-3: The five structural axes.

Source: Fragomeni, 2013; Vitruvius: http://www.vitruvius.com.br/revistas/read/arquitextos/06.072/351

It is interesting to note that the plan included requirements for pedestrian areas, open green space and heritage preservation at a time when Brazilian cities were mainly planned for or transformed to accommodate the ever-increasing number of cars. Curitiba, instead, started to implement measures to reduce car-dependency and encouraged accessibility for pedestrians and cyclists (Lloyd-Jones, 1996).

Various conditions facilitated the urban transformation of Curitiba. Gnoato (2006) points out a number of them, both in the theoretical field and in Brazil's specific political circumstances at the time. Firstly, the difficulties and problems that arose in cities that based their developments strictly on the Athens Charter, the modernist urbanism manifesto. Secondly, the influence of Jane Jacobs's ideas and activism that contributed to the human-scale approach: she defended multifunctional and diverse streets and neighbourhoods to ensure liveable and safe communities. Thirdly, in the political arena, Brazil was under military rule from 1964 to 1986 and the military were keen for the provision of planning and execution of infrastructure to enhance the "economic miracle" of the early 1970s. Moore (2007) goes further, reasoning that the military at the time needed a convincing example of urban planning to show to the rest of Brazil. In this context, Jaime Lerner, architect-urbanist and former director of IPPUC, was appointed Mayor of Curitiba in 1971 by the military and took the opportunity to begin the transformation of the city (Gnoato, 2006; Lloyd-Jones, 1996). He is criticized for the support he received from the military regime during his two first terms as city Mayor. Others note that the military supported Lerner's and his strong group of design professionals' visionary ideas because it was convenient for the military themselves (Lubow, 2007, citing Fragomeni).

Lerner was sagacious in picking the unique occasion to implement human-scale and ecologically based development in Curitiba. By implementing the Wilheim–IPPUC plan, he was opposing the modernist perspective adopted by other Brazilian cities at the time. Brasilia, the new capital, designed and built in the late 1950s according to the principles of modernist urbanism, is a predominantly car-dependent city.

The Wilheim-IPPUC plan for Curitiba comprised ideas that resonated with Jacobs' ideals which recommended reconciling the needs of modern life with the preservation of the uniqueness of the city's character, its history and architectural legacy in a human and pedestrian manner. This ideal in turn matched those of Lerner and his team of planners, thus he decided to implement the Plan in his first term as Mayor.

The first essential confrontation was against the existing interest in building an overpass over the Rua XV, the busy commercial street in the town centre, which included demolishing a number of heritage buildings, witnesses of the city's history. Jane Jacobs fought a similar battle for Greenwich Village, New York, in the 1960s, against planner Robert Moses's ideas of building highways and overpasses in the city to facilitate car navigation across it, despite displacing thousands of people and breaking down urban communities and liveable meaningful spaces.

It is well-known the fast redevelopment of Rua XV, which transformed it into a pedestrian mall renamed Rua das Flores (Flowers Street) in just one weekend, notwithstanding the claims of storeowners and members of the automobile club who strongly opposed the works. Flowers Street is the first street in Brazil exclusively dedicated to pedestrians. Equipped with benches, newsstands, cafes and many flowerbeds, it has become one of the best places to be in the city centre. In addition, those who previously had opposed it asked for its extension a few days after it was finished. Storeowners were highly satisfied with their increasing profits, facilitated by the easy access to the shops for so many people strolling around the mall. Forty years later, Flowers Street has been extended over twenty blocks and replicated in many other cities due to its success in promoting city life, cultural activities, and in helping businesses around to flourish contributing to a safer urban environment (McKibben, 1995; Mang, 2009).

Figure 6-4: Flowers Street. The old tram serves as a support for art workshops.

Source: https://www.google.com.au/search?q=rua+das+flores+curitiba&newwindow

Under Lerner's administration, the IPPUC expanded its authority and coordinated all municipal programs ranging from urbanistic to educational, to housing and circulation. The Institute was distinct from local government and had its powers strengthened to become "a quasi-autonomous planning agency" (Moore, 2007, p.77), economically supported by the federal military government, which gave the planners a unique opportunity to implement the programs independently from local politics and, importantly, of ensuring continuity.

Critiques of this planning regime come from Brazilian and international academics in addition to local design professionals who claimed a lack of opportunities for architects and planners who were not part of the IPPUC's team. On the one hand, Irazabal (2005) acknowledges the success of urban planning programs but identifies legitimacy issues in the process due to the absence of citizen participation, and goes further, arguing that the technocratic managing model threatens Curitiba's governance. On the other hand, Moore (2007, p.77) points out that Lerner's technocratic regime of sustainability must be understood in the context of the

“Brazilian anti-political, authoritarian and technocratic tradition rather than as a political anomaly that is typically claimed by outside observers of the Lerner’s regime”. In his studies of Brazilian politics, Moore perceived some local characteristics, particularly a trend in political styles based on personality rather than on ideologies, as was the case of various Brazilian presidents elected on technocratic anti-political platforms, e.g. Vargas, Kubitschek and Quadros. Thus, according to this line of thought, he argues, it is not a surprise that Lerner had been so successful in his three terms as Mayor of Curitiba, having been appointed by the military for two of them and elected by popular vote for the third (Moore, 2007).

Therefore, the making of Curitiba’s “regime of sustainability” (Moore, 2007, p.79) was possible due to the convergence of a number of circumstances and chances existing in the city in the second half of the last century. The role of Jaime Lerner in the process is perceived in different ways across the literature. Moore (2007) understands Lerner as one of the many leaders in the movement towards sustainable development in Curitiba, following Lebret, an influential French urbanist; Braga, former Mayor and governor; Arzua, former visionary mayor; and Wilheim, the Master Plan’s author. Macedo (2013) considers Lerner as the marketer, the most famous Mayor the city has ever had, and, acknowledging the numerous successful urban initiatives implemented during his three terms, she remarks that it was in that period that the city received several international awards and was recognized as a model in the international group of sustainable cities. Moreover, she argues, Curitiba and Lerner are known in planning circles as a trademark of technological expertise, creativity and constant innovation. According to Irazabal (2005), Lerner is the best example of leadership convergence regarding urban planning and politics: he was the first IPPUC president, three times city Mayor and twice state governor. Rabinovitch and Leitmann (1993) highlight Lerner’s personality and political will, remarking that the Master Plan’s implementation initiated during his first term (1971-1974) was his direct political decision. These authors also argue that the interaction between Mayor Jaime Lerner and the IPPUC planning team was “part of the daily planning exercise, and explains the success of the Curitiba experience” (p.12). The strength of this personality resonates in Souza

Carvalho's (2010) analysis of the discourse underpinning Curitiba's urban planning. This author argues that Lerner was a "bionic Mayor" (p.90) who preferred the speech of a Mayor-urbanist who is concerned with the welfare of the city, its people and the environment rather than using technocratic authoritarian discourse to communicate the planning actions to the city residents and globally. In this sense, one of Lerner's notable skills is his easy effective communication in order to facilitate understanding of key urban principles, making people comprehend and accept the profound urban transformations (Souza Carvalho, 2010).

I could grasp this phenomenon myself. When I first visited Curitiba in the early 1990s, it was exciting to feel people's enthusiasm talking about the various new initiatives in their city. This was particularly evident when we went up to the top of the Telepar tower with some Curitiban friends to appreciate a panoramic view of the city. Then, our friends who were ordinary residents described to us with genuine pride the five structural axes and explained about land use, trinary road system, transfer of development rights and environmental protection incentives. It was a lesson in urbanism culture. This experience aligns with Souza Carvalho's (2010) argument that by Lerner's third term (1989-1992), Curitiba's discourse as a planned model city was so successful that it promoted feelings of identity and belonging among the population.

The most relevant and impressive urban transformations occurred during Lerner's three administrations. In the 1970s, three main directives influenced Curitiba's progress: the rationalization of the integrated transport system, the development of the road network system, and land use legislation which encompassed environmental protection, heritage and cultural aspects, and meeting of human needs (Rabinovitch, 1992). The creation of the industrial city (CIC) in 1973, located in the west side of Curitiba, fostered economic development. Only non-polluting industries were accepted in the precinct, which was not exclusively industrial but included residential areas, open green spaces, services and connection to the transport system. In the early 1990s, it provided one fifth of all jobs in the metropolitan area (Rabinovitch, 1992).

Lerner’s third term was the golden era of sustainable planning in terms of quality, innovation and number of urban initiatives. By that time, he had 92% of citizens’ approval rating (Meadows, 1995) and Curitiba gained recognition from the international community. The political discourse emphasized environmental and ecological issues, taking the opportunity of the Rio-92 Earth Summit to the extent of dubbing the city as “the ecological capital of Brazil”. Macedo (2013) argues that the marketing campaigns for this purpose had been in the making for several years, and that this was possible due to a very selected and cohesive group of technocrats-politicians being in control of the city for at least forty years.

The political and technical continuity made possible the success of Curitiba. In 1994, two years after the end of his third term, Lerner was elected governor of the state of Parana and served two consecutive terms, from 1994 to 2003 (Macedo, 2013). The subsequent Mayors elected were from Lerner’s party with only one exception, and continued in the same direction. In short, the opposition had not enough time to derail the direction consolidated by so many years of positive results. Table 6-1 below presents the urban transformation timeline:

Urban transformation timeline

Lerner’s 1st term 1971-1974	**Lerner’s 2nd term 1979-1983**	**Lerner’s 3rd term 1989-1992**	**Master Plan 1st review: 2004**	**Master Plan 2nd review: 2014**
Master Plan implementation Industrial city development – CIC Pedestrian malls in city centre Integrated transport system Road network system Land use legislation National and international renown		“The Ecological city” Park system 52m^2 green area/inhab. Urban acupuncture Urban products Recycling programs: “Garbage that is not garbage” Housing innovations Transfer of development rights BRT system and tube stations.	Master Plan’s adaptation to the “City Statute”, federal law that made mandatory citizens participation, sustainable development and recognition of the social function of the city and urban property as priorities. 6th axis: Green Line	Creation of the **MPSUD**-Municipal Plan for Sustainable Urban Development, innovative tool that resumes long-term planning and orientates next plan revisions allowing a future vision for the city. Ongoing

Table 6-1: Urban transformation timeline

Source: Author

Some authors consider the period 1995-2005 as the fourth planning phase, when Lerner was governor of the state of Parana. It was portrayed as a period of metropolitan issues, when relationships and city-region coordination were enabled. It was also a time of acceptance of globalization that allowed the installation of heavy industries, particularly automakers that absorbed the displaced farm workers, at the cost of economic and environmental concessions required by the international corporations. Moore (2007) observes that this clientelistic system of exchanging favours kept citizen power weak but politicians strong. Many see this period as the end of the "lightness of the first era of creative planning in the city and the final acceptance of a form of globalization in which citizens would suffer" (Moore 2007, p.99).

Notwithstanding some contradictions, the urban transformative change persisted because of the nature of the process, its vision and accomplishment. In Moore's words, "[the history of planning in Curitiba] established a developmental trajectory that is more important than any individual period in itself" (Moore, 2007, p.98).

Over the early years of the 2000s, remarkable changes emerged at federal level in Brazil. In 2001, the City Statute, a federal law passed enforcing ten-yearly reviews of the master plans of all Brazilian cities. The City Statute builds on the Federal Constitution of Brazil to create a new legal urban order to provide for land access and equity in cities. It has two main functions: the first is to ensure that the social function of urban land and buildings is put before their commercial value; the second is to ensure democratic city administration, through social control and participation. Therefore, it sets up a number of important issues related to social equity and democratic management of cities, among them, mandatory public participation at national, state and local levels; a system of 'City conferences' to be held every two years to get citizens' feedback on relevant urban issues; determination of urban property's compliance with its social function, and provision of guidelines for plan preparation in terms of content, instruments and procedures (Santos Carvalho and Rossbach, 2010; Fragomeni, 2013).

The first review of the Master Plan occurred in 2004, in compliance with the City Statute. The 2004 review culminated in the Master Plan 2004, which added a new structural axis to the previous five, called Green Line. It forms the sixth structural axis incorporating a completely new avenue that comprises a mass transportation corridor, traffic lanes, cycling facilities, sidewalks and a linear park. Located in the area occupied by the former BR 116 national route that split Curitiba from northeast to southeast, it runs along 22 km within the city with various purposes. It forms a biodiversity restoration corridor in the sector degraded by the former BR 116 national route, re-establishing the urban fabric and orienting urban growth.

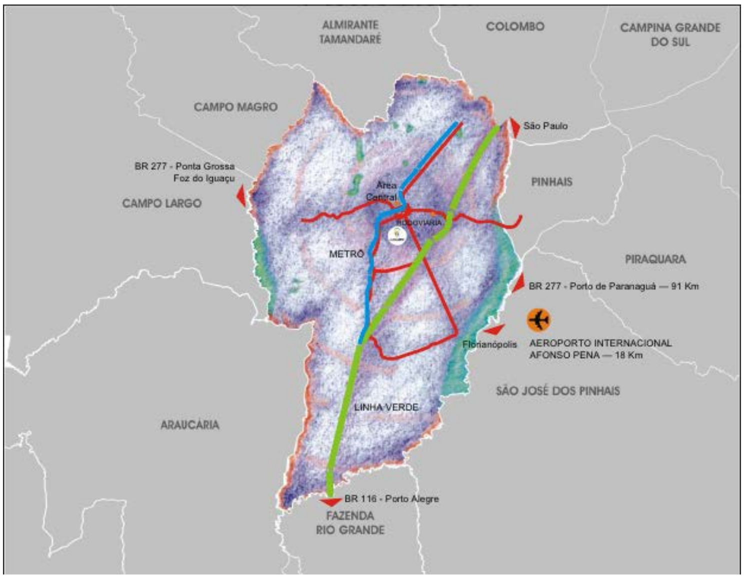


Figure 6-5: The six structural axes.

Source: http://mobilidade-urbanismofaacz.blogspot.com.au/2010_06_01_archive.html

The second review of the Master Plan is ongoing. During 2014, nine public hearings were conducted to discuss the proposal for the Master Plan 2015. They took place at the City Hall, with involvement of the Urbanism and Public Works Board of the Municipal Legislature of Curitiba. Public participation was organised in workshops to discuss the principal themes, which are urban mobility, accessibility, social housing, infrastructure, environment and sustainability, culture and safety, creative economy, and the metropolitan regional consortia. At the time of this writing, the proposal is under City Hall examination for approval. It resumes the long-term planning concept that consolidates and expands the application of the planning tripod (public transport integration, road network, and land use control) to five new areas. The aim is to create a mesh across the transit corridors, interconnecting the existing axes with the new ones. This mesh should encourage the occupation of areas that already have infrastructure to optimize their use. Public transport will act as a catalyst to speed the growth of these less dense neighbourhoods and the construction of new trade and service centres creating autonomous regions in the neighbourhoods (PMC, 2015a,b).

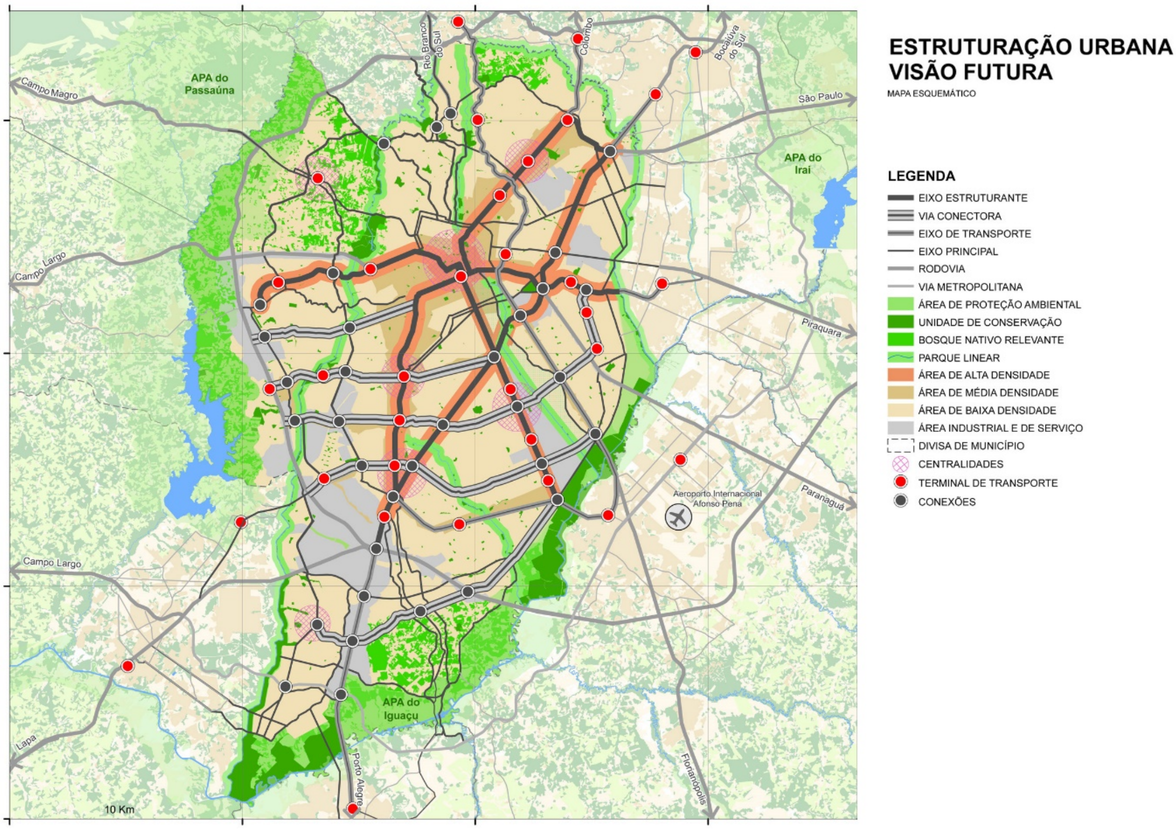


Figure 6-6: Master plan 2015's proposal: Future urban structure vision.

Source: http://www.curitiba.pr.gov.br/noticias/revisao-do-plano-diretor-retoma-tradicao-de-planejamento-de-longo-prazo/35757

The proposal also incorporates the Municipal Plan for Sustainable Urban Development -MPSUD, an innovative planning tool that will orientate the next plan revisions allowing a future vision for the city (PMC, 2015b).

In the views of the president of the Council of Architecture and Urbanism of the state of Parana, urban public policies in Brazil have been conducted to satisfy private interests over public, resulting in policy discontinuity that promotes urban inequality. He claims that the City Statute is not being fully explored or respected.

The expectations of the Master Plan revision 2014 are focused on Curitiba resuming its place at the forefront of outstanding urban planning, upgraded by the requirements of the present day where landscape and territory are strategic supports for urban policies leading to a genuinely democratic and participatory city (CMC and CAU-PR, 2014).

6.4 Planning methodology: a new mindset for urban planning

Curitiba's achievements in urban planning have been stable and productive for more than forty years, due to a number of factors. Firstly, creativity and innovative thinking to design programs and initiatives aiming to change outdated practices and overcome deficient budgets, dubbed 'brilliance on the cheap' by McKibben (1995). Secondly, international support and recognition that gave value to local efforts and ensured the city was on the right track, making citizens feel proud of their city and care more for it. Thirdly, leadership. Lerner and his core team of professionals took the opportunity of particular political support to develop ideas that were implemented unchallenged. Essential components like political will, continuity and perseverance (Macedo, 2013) and the developmental nature of the planning trajectory (Moore, 2007) have been present during the process enabling success.

However, the making of the urban transformation received criticism varying from legitimacy issues (Irazabal, 2005) to underlying political interests converting the process in a case of city marketing and "spectacle urbanism" (Sanchez Garcia, cited in Macedo 2013), to myth-creation strategies to attract international attention (Hazan, cited in Macedo 2013). Moore (2007) explains the phenomenon as an alternative way to accomplish sustainability. To this author, there are multiple pathways that lead to greater urban sustainability, and Curitiba makes the case for a successful sustainability pathway for local governance with the right vision, technological support and political will, even though its history of democracy and its culture of citizen participation and engagement is not significant.

Yet, there is another approach to understanding how the urban transformation happened. There was a change in mindset which started with the planning approach and methodology. Lerner and the planning team designed a unique work methodology, dividing the working days in two periods. They met every morning in a special office dubbed "*Chapéu pensador*" (Thinking hat), a log cabin retreat in the middle of one of the city's forested parks in order to work on the city vision and large-scale issues, "on what it would affect a large number of people and would create change for the better" (Mang, 2009, p.9). The afternoons, at the city hall offices, they dealt with the daily needs of the city and residents. In this way, they always had in mind the city as an integral system that was grounded by the interactions with the day-to-day requirements and concerns of people attended in the afternoons. The method was a balance between needs and potentials that enabled planners to work on real change, avoiding short-term results on the one hand, or solutions far from reality on the other. The morning meetings used the charrette methodology, a design process from architectural practice consisting in gathering key interdisciplinary specialists in order to creatively and quickly sketch up solutions for the situation in study. The charrettes generated a creative space to discuss and understand problems, refine and continuously improve solutions, and importantly, to comprehend the city as a whole system in evolution and develop scenarios for guiding its structural growth (Mang, 2009). The innovative sustainable initiatives that made Curitiba a model of urban planning were born through this work process. The park system, the urban acupunctures and the transport system are examples of this approach to urban planning.

The idea of designing parks with lakes as a solution for storm water management and flood control originated in the planning charrettes. Nicolau Klüppel was the planning team's civil engineer specializing in flood control infrastructure, which involved channelizing the rivers crossing the cities, the state-of-the-art-technology at the time. In an interview with Macedo (2013), he said that it was during a conversation with architects and other IPPUC team professionals that the idea of creating lakes in bottom-valley parks came up. This was the most efficient and cheapest solution to prevent the recurrent floods in the city. In Klüppel's words:

> I was a narrow-minded engineer, trained to build infrastructure to control floods. One day, in a conversation with my colleagues, one of them said: ‘What Curitiba needs is water, but we can’t have a beach at 1,000 m altitude.’ I was always thinking about drainage, so I said ‘We can’t have a beach, but we can have lakes that can double as retention ponds and collect runoff from increasingly large impervious surfaces.’ And so, we decided to have a lake in every city park (Klüppel, in Macedo, 2013, p. 342).

This story reflects the significance of interdisciplinary collaboration in the charrette methodology adopted by the planning team. Many other planning programs were conceived in this way, all of them sharing innovative, low cost and easy to implement approaches. For the purpose of this thesis, three relevant planning initiatives were selected: Urban acupunctures, Strange archaeology and the Park system, which is described separately in section 6.5 due to higher complexity.

6.4.1 Urban acupunctures

Many urban transformations in Curitiba developed from small-scale and low-budget interventions called urban acupunctures. Making an analogy with the traditional Chinese medicine that identifies key points that increase energy and flow, these urban interventions serve as catalysts for the revitalisation of degraded natural areas and sectors of the city in need of rapid change. Urban acupuncture comprises a number of specific actions of revitalisation that can progressively change urban life. They allow for positive transformations that benefit the local context and further disseminate to the entire city through fostering chain reactions, once cities are highly interconnected places. In Curitiba, this technique was used as a strategy toward sustainable development (Blasco, 2012). Mang (2009) citing Lerner, describes urban acupuncture actions as quick solutions for places and communities that begin with the development of a good idea. As they are innovations, they are open processes that can be redirected or corrected at any stage. They were created and developed through collaborative and iterative processes among the key stakeholders, but criticised because they did not involve community participation.

Acupuncture interventions comprise three main characteristics:

- Change catalysts: they should be implemented into critical spaces with a high potential for transformation and address the problems of that place and its context,
- Small scale: they perform in small areas, at low cost and with rapid implementation. This scale is what facilitates agile urban renovation and allows management of more than one simultaneously,
- Priority for public spaces: the focus is on public spaces such as parks, plazas, transport stations or markets for their potential in causing impact and benefitting different social sectors.

Urban acupunctures can be grouped within a precinct needing renovation, conforming a net or system of public spaces that will promote better mobility and improve the urban image. In Lerner's words:

> A city can change in two years, independently of scale and budget. It is possible to make rapid improvement actions on concrete points, without interfering in the general planning. This is called "urban acupuncture". [Urban] planning is a process that does not achieve immediate transformations. Most times, the action starts with a spark, which propagates the action. That is good acupuncture. I think that we can and should apply some of medicine's 'magic' to the cities, because many of them are sick, some at a terminal state. As in medicine, the interaction between doctor and patient is needed, in urbanism it is also necessary that the city react. Touching on an area in a manner that can lead to the cure, improvement and chain positive actions. To revitalise, we should intervene, make the organism work in another way (cited by Blasco, 2012).

The first and most renowned urban acupuncture was the transformation of the Rua XV, into the Flowers Street, described earlier in this chapter.

Many others followed in both the social and environmental realms such as the Green exchange that aimed to remove garbage from the narrow lanes of the slums. The city greening also started with small focussed actions such as the transformation of empty lots into ecological reserves through the planting of native trees that led to the program of intensive planting around the city, targeting street canopies (more than 1.5 million trees were planted in the period 1972-1992), and the creation of urban parks (Rabinovitch, 1992).

Another example is the revitalisation of abandoned quarries that were becoming landfills, provoking the problems resulting from garbage accumulation within some of the city's neighbourhoods. They were cleaned up and received important cultural, educational and recreational facilities. The most renowned are the Wire Opera House, the Unilivre, the Tangua Park, the 24 Hours Street and the Citizenship Streets.

The Wire Opera House located within the Quarries Park, is probably the most famous example of urban acupuncture. It is a theatre built in the record time of two months, using recycled steel pipes. This building, besides giving new life to a damaged site and new use to building materials, is a celebration of nature and its everlasting power of rebirth. The Quarries Park is an open space venue for popular music concerts with capacity for 80,000 people.

Figure 6-7: Wire Opera House.

Source: SMMA

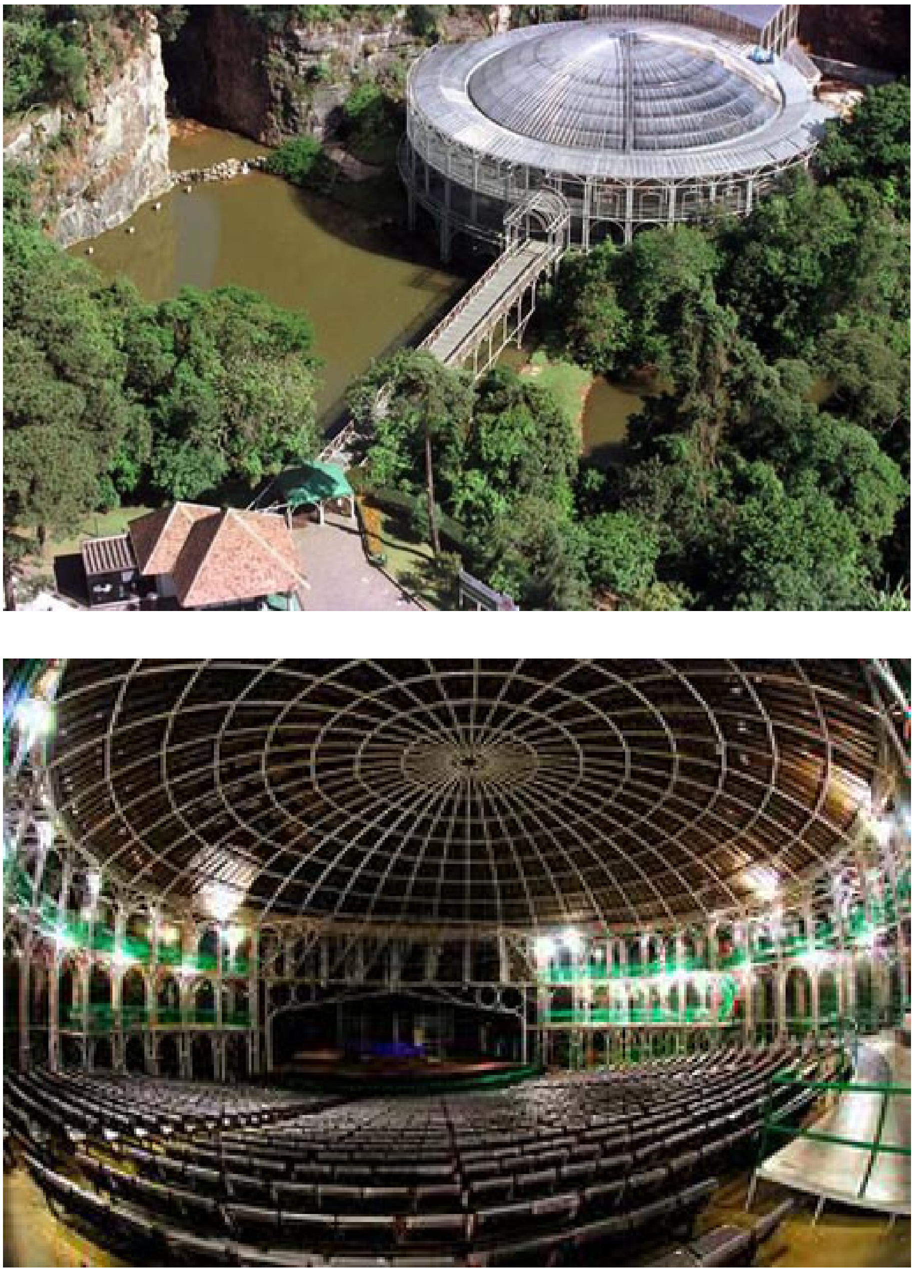


Figure 6-8: Wire Opera House, exterior/interior.

Source SMMA

The UNILIVRE, Free Open University for the Environment, also takes the place of an old quarry and uses recycled material for the structure, this time the removed eucalyptus street light posts. The main feature of this building is a continuous spiralling ramp that connects the different spaces while providing views to the site of the old quarry and its lake. UNILIVRE delivers short courses on environmental issues for people of all backgrounds, from taxi drivers to journalists and child carers, encouraging awareness about the environment and the importance of its preservation. It also has a database library and develops research projects.

Figure 6-9: UNILIVRE.

Source: google.com.au

Figure 6-10: UNILIVRE, located by the remaining old quarry lake, and recuperated vegetation.

Source: SMMA

The Tanguá Park occupies other two old quarries and surrounding land providing recreation and easy access to nature for a populated sector of the city. With an area of 450.000 m^2 it comprises two sectors located at different levels: the upper one comprises the Poty Lazzarotto gardens celebrating a local artists and the lower one offers recreation, sports and entertainment facilities. A highlight is the tunnel that crosses the rock linking the two quarries (curitiba.pr.gov.br).

Figure 6-11: Tangua park: Poty Lazzarotto garden (on top) and the lake with waterfall and tunnel.
Source: http://www.parquesepracasdecuritiba.com.br/parques/parque-tangua-4.html

The 24 Hours Street created to increase the potential of city life and economic activity in the town centre after working hours offers convenience shops, news agencies and cafes.

Figure 6-12: The 24 Hours Street

Source: google.com.au

The Citizenship Streets are relevant examples of urban acupuncture. Created in 1995, they are the material symbols of the process of urban decentralisation, which embeds new urban management and aligns with the values of the City Statute, the right to the city and the democratization of public spaces. They function as City Hall branches in suburbs distant from the town centre, offering a wide range of municipal, state and federal services to the communities in various areas, such as health, security, housing, environment, urbanism, education, sports among others. Moreover, they are spaces for community integration providing for claims and debate about regional issues and orienting the discussion on city auto-management policies (Barbosa, 2005).They were created to ease the negative impacts of rapid population growth in the periphery of Curitiba.

Located next to BRT terminal stations, on the structural axis, to enhance the idea of street, citizenship streets have pre-established architectural design formed by the addition of different volumes according to the various functions, plus leisure and sport facilities. The long central cylinder symbolises the street and the spaces on both sides provide for the service offices and the big covered space for sports, educational and leisure activities (see Fig. 6:13).

In Barbosa's (2005) view, citizenship streets only partially achieved the objective of solving the problem of social inequity, because social inequity remains very high, although the citizenship streets are initiatives within the sustainable development approach. On the other hand, they succeeded in reducing the time and cost of long commutes to the town centre, contributing at the same time to diminishing congestion in central areas. They also play an economic role attracting private investment to the area because of their location and functions that ensure a constant flux of potential customers.

Citizenship streets are references in the urban landscape, for their architecture and their social functions. Curitiba has ten. Similar initiatives can be seen in other cities in Latin America, in Cordoba, Argentina; Medellin, Colombia; La Paz, Bolivia.

Figure 6-13: Citizenship street in Curitiba's periphery.

Source: pmc.gov.br

Figure 6-14: Citizenship Street

Source: google.com.au

Lerner (2003) refers to a special case of acupuncture derived from an environmental issue. The Iguaçu's sand pits are an example of how ecological wounds made by human activity – sand extraction in this case – can be reused to solve ecological accidents. There was a huge oil spill caused by the Araucaria refinery on the Iguaçu

River, in Curitiba's metropolitan area, and it was through the pits that the oil spill was dammed and the cleansing process done. The wounds made to nature were transformed into the solution for this problem, redesigning them to act as filters for the cleansing. After the accident, the pits were transformed into an open-air channel serving as protection against floods and as a stabilization pond for treatment of pollutants before entering the river. Neighbouring residents now can enjoy a shared pedestrian and cycling path built on one side of the channel. This is an example of ecological damage turned into a solution (Lerner, 2003; Rabinovitch, 1992).

6.4.2 Strange archaeology

This urban design strategy used in Curitiba and dubbed by Lerner 'strange archaeology' is directly related to place, the recognition of its patterns shaped by soil, climate, non-human living systems and human activities along time. It allows for the understanding of how historical human settlements developed and how the ecological system worked and flowed through the place in the past. The geographical location of the city is a forested floodplain with a number of rivers and streams intersecting each other many times, with rich biodiversity in natural ecosystems alongside the river corridors (Mang, 2009). Lerner explained this concept to McKibben (1995, p. 68) in this way:

> Every city has its hidden designs –old roads, old streetcar ways. You are not going to invent a new city. Instead, you are doing a strange archaeology, trying to enhance the old, hidden design.

Indigenous peoples formerly settled on the plain near the rivers and made the first paths along them. Subsequently, the European and other immigrants constructed transportation corridors (roads and railways) replicating the river corridors. Economic activities, commerce and human exchange concentrated along and around the transportation corridors, mimicking the biological exchange flows (Mang, 2009; Ribeiro and Tavares, 1992).

Urban growth was organised over time around these corridors and enhanced by the Wilheim-IPPUC plan and the subsequent master planning revisions.

6.5 Curitiba's Green Plan

Curitiba's Green Plan was created and implemented initially in the 1970s to tackle flood problems. It evolved from its conception and expanded in the early 1990s permitting impressive outcomes not only in flood control but also in the greenery ratio per inhabitant, moving from 0.5 m^2 of greenery per inhabitant in the 1960s to 52 m^2 per inhabitant in 2008 (IPPUC, 2008b). The figure is four times the World Health Organization standard of 12 m^2 and has multiple benefits (Meadows, 1995) including providing a model for how a city can help regenerate a regional ecosystem.

The Green Plan comprises different types of conservation units, defined by the Municipal Act 9804/2000:

- *Environmental Protection Areas*: private or public owned land subject to use constraints aiming to protect watersheds, vegetation, biodiversity and any other good of environmental value.
- *Conservation Parks:* Municipality owned areas (minimum extension 10 hectares) allocated to the protection of existing natural resources, assigned to maintain community's lifestyles and common interests.
- *Linear Parks:* private or public owned land located along water bodies that aim to warrant environmental quality of bottom valleys. They may encompass other units of conservation within their region.
- *Recreation Parks:* Municipality owned areas (minimum extension 10 hectares) allocated to community recreation and leisure, equipped with appropriate facilities and containing natural assets of interest for protection.
- *Biologic Reserves:* private or public owned land with relevant representative characteristics of the Municipality's native biome. They may have variable dimensions and are allocated to preservation and scientific research.
- *Relevant Native Bush (Woods):* these are native bushes representative of the Municipality of Curitiba's flora and fauna, located in private properties that aim from the preservation of water bodies, fauna habitats, soil stability, landscape protection, and maintenance of the balanced distribution of vegetation areas where the Municipality imposes restrictions to land use.

- *Conservation Bush (Woods):* Municipality owned areas allocated to the protection of existing natural resources, which have areas less than 10 hectares and are designed to maintain the quality of life and protect the common interest of all the inhabitants.
- *Leisure Bush:* Municipality owned areas with less than 10 hectares, designed for the protection of natural resources with predominant public recreational use.
- Specific Areas: these are conservation units created for specific objectives such as botanic gardens, public orchard, zoo, or water springs.

Curitiba has a variety of conservation units that cover 20% of the municipality area distributed in 21 parks, 14 urban forests, two large Areas of Environmental Conservancy, an Ecological Station (Cambuí) and a large number of squares and community gardens for recreation and leisure of citizens (IPPUC, 2008c; PMC, 2013).

6.5.1 Biodiversity and ecosystem services

Curitiba's Green Plan and subsequent park system suggest an example of regenerative design and biophilic urbanism with impacts on the regional ecosystem. Originally designed to solve drainage problems and storm water management, the park system produces a multiple set of green outcomes, including biodiversity restoration. It is unlikely that a city will spend huge amounts of money on the regeneration of its regional ecosystem unless it can do so as part of a set of solutions to many urban issues. This approach enabled Curitiba to successfully produce regenerative design solutions that integrate various functions of the city. Thus, the Green Plan created parks that function as cultural, educational and recreational facilities whilst revitalizing abandoned quarries and neglected sites, and protecting sensitive areas from illegal settlements. At the same time, they regenerated the regional ecosystem.

McKibben (1995) argues that low cost is one of the cardinal tenets of Curitiban planning, and the park system is an excellent demonstration of brilliance on the cheap. In the late 1960s, most Brazilian cities were installing elaborate flood-control projects, based on channelizing their rivers into concrete tubes, and Curitiba had federal money to do the same with the five rivers flowing through the town. Instead, the City Hall spent the loan on parks. They constructed small dams and transformed the rivers into lakes in the centres of the parks. In this way, they solved the problem of floods respecting their natural cycles, and added aesthetic value to the recreation areas and economic value to the surroundings. At the same time, a large regional freshwater ecosystem and its associated land-water interface were regenerated.

The first seasonal parks, also called linear parks, at the bottom of valleys were designed in 1966. On the biophysical aspect, the park system evolved from the initial function for flood prevention to be a relevant part of the Integrated Water Management Plan. The city is located on a large natural flood plain, in the Upper Iguacu River Basin. The place is not the best for development because of the river's low capacity and historically frequent floods. Urban growth aggravated the natural flood risks. In the early 1980s, population pressures resulted in unauthorized settlements on the flood plain, increasing impermeable surfaces and augmented flooding in the basin six-fold, including the town centre. In addition, poor urban drainage works and infrastructure intensified the situation (Tucci, 2004).

Technically, a series of studies were done on the site, resulting in a central intervention consisting in a linear public park around the main river (the Barigui River in the case of the first seasonal park) and flood plain. The municipality bought the land along the river and resettled the people to other areas. Later, an artificial channel was built to help increase the river capacity, also acting as a border to prevent encroachment into the park. To improve water quality, some wetlands were constructed, and a flood warning system was developed. Another crucial issue in diminishing unauthorized occupation was the recreational function of the park. An Integrated Urban Drainage Master Plan followed the creation of the park recommending the creation of a strategic system of urban parks along the tributaries. Secured by land-use regulations and law enforcement, the linear parks help to absorb precipitation runoff. Moreover, regulatory procedures including new river construction standards, tax incentives for maintaining conservation areas, and integration with the city master plan were used to conserve the parks for water storage and source control (Tucci, 2004).

Figure 6-15: São Lourenço Park. It provides storm water management, recreation, educational activities in retrofitted existing buildings, and benefits from low-cost maintenance methods.

Source: google.com.au

In the 1990s a new series of parks, urban forests and ethnic memorials was created to celebrate the different groups of migrants that made the history and demographic composition of Curitiba, e.g. the Ukrainian, German, Arab and Japanese memorials and the Polish, Italian and Portuguese urban forests (Irazabal, 2005). This was another social cultural aspect added to the environmental, recreational, aesthetic and economic reasons for building urban parks, although some critics see it as a marketing issue.

The planning methodology implemented enabled Curitiba to produce successful regenerative design solutions that integrate various urban functions towards the mutual benefit of the whole. Recent programs continue the approach, like the ongoing Biocity Program, a partnership between the City’s Government and the

French Agency for Development-AFD aiming to reclaim many deteriorating urban spaces.

Despite these early victories, there is always a need to reclaim sensitive land on the edge of urban waterways. In recent years, many sites have been occupied by illegal settlements that involved considerable land clearing. Curitiba's environmental legislation, through the Sustainable Development and Environmental Control Plan implemented in 2008, is committed to protect local vegetation (mixed subtropical forest) threatened by urban development. It makes sure that the Paraná pine (*Araucaria angustifolia*) is not felled in public or private parks. It also encourages tree planting along roads and streets for canopy cover: from 1974 to 2006, municipal authorities and citizens planted 300,000 trees (IPPUC, 2008c). The legislation has also become the basis of several large-scale regional biodiversity projects as outlined below which have extended the large-scale regional biodiversity regeneration first set up through the Green Plan.

6.5.2 The Biocity Program: Live Barigüi and Green Line projects

In 2007, the City's Government, based on the need to reclaim many deteriorating urban spaces, launched the Biocity – Urban Biodiversity Program. The program encompasses application of biophilic and regenerative initiatives such as the revitalization of rivers, adoption of sustainable urban mobility alternatives and the encouragement of the RPPNs, preservation of private natural areas. The aim is to achieve the objective of reducing local biodiversity losses involving specific actions such as the reintroduction of native plants, eradication of invading exotic species and environmental education (PMC, 2007a).

One of the Biocity Program pillars is the "reorganization of the urban territory considering drainage basins as basic planning units" (PMC, 2007a) and the consideration of "biodiversity as a heritage and an element that promotes the adoption of goals for the execution of sustainability actions in natural and social dynamics" (PMC, 2007a).

The Biocity Program encompasses two relevant regeneration corridors under construction in the city area since 2009, within a partnership between the City's

Government and the French Agency of Development-AFD. They are the Live Barigui Project and the Green Line Project. The cost of € 72.3 million is supported 50% by the City Government (PMC) and 50% by the French Agency of Development-AFD (PMC, 2007b; AFD, 2007).

The AFD decided to support the Biocity Program due to Curitiba's option for sustainable urban development and the incorporation of this concept into all of its policies. This innovative program for the protection of urban biodiversity is therefore an opportunity that matches AFD's interest in supporting particularly the reduction of greenhouse gas emissions by expanding public transport services and the enhancement of biodiversity at the urban scale (AFD, 2007).

6.5.3 The Live Barigui Project

The municipality of Curitiba has five watersheds in its territory. The Barigui basin plays an essential role in the municipal policy of valley depths and water resources preservation, by means of permanent preservation areas and various existing parks located along the watercourse. The Barigui bisects the city from one end to another along 60 km (PMC, 2007b).

The Live Barigüi Project is a City Government strategic plan that aims to recover the integrity of the Barigüi urban drainage basin by regenerating the main ecosystems: cleansing the waters, conserving soil, revitalizing degraded areas, and preserving green areas in a region that comprises the main land use and occupation types. It involves 30% of the municipality's area, corresponding to 30% of its districts, which are inhabited by 30% of its population (PMC, 2007b). It will directly benefit 28,000 people and provide indirect benefits to 450,000 basin inhabitants (PMC, 2007b).

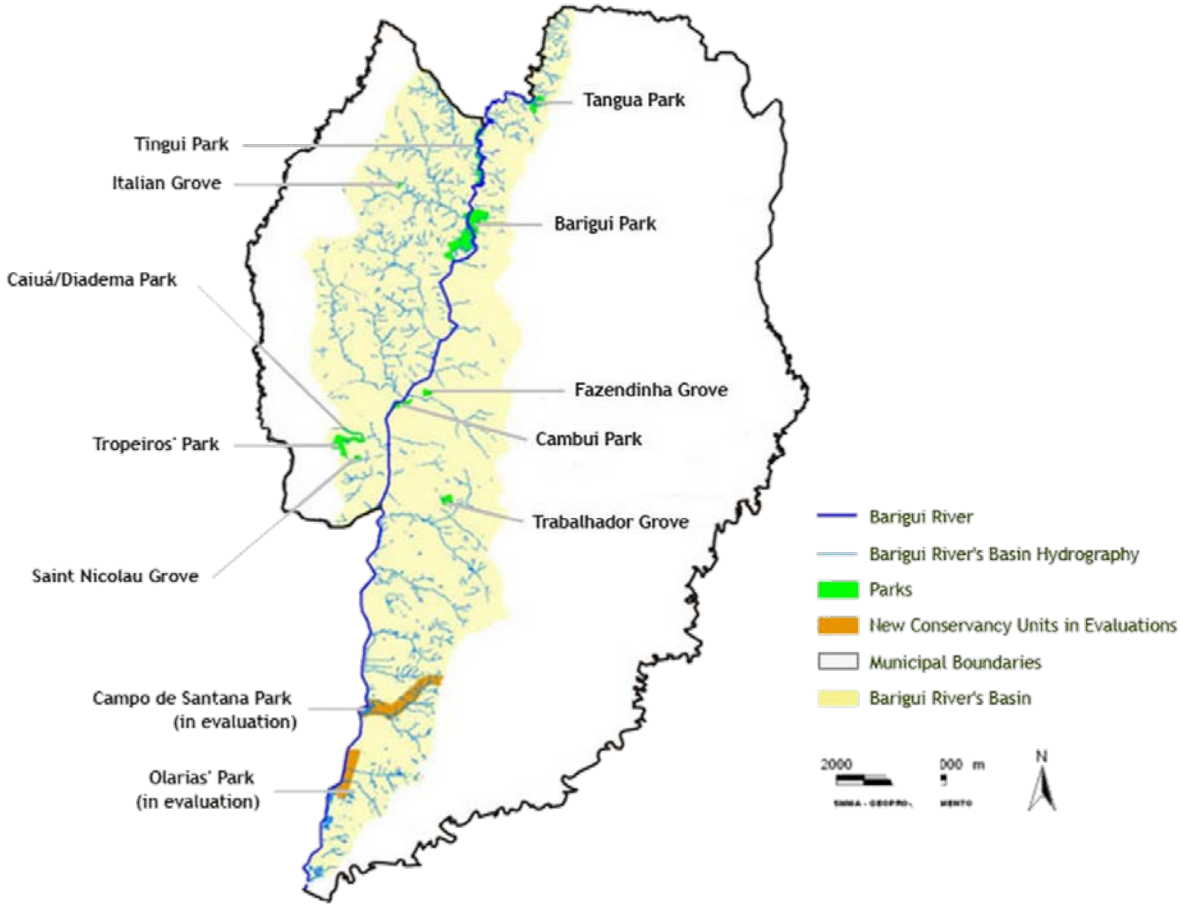


Figure 6-16: The Live Barigüi Project.

Source: PMC, 2007b.

In order to achieve the objectives, it was decided to create an ecological urban corridor encompassing the Via Park, an avenue that will be afforested with native species, provided with cycling and walking facilities and other sport and leisure equipment. They will consolidate the Barigüi Linear Park, the new biodiversity and infrastructure corridor linking all existing and future parks stretching along the Permanent Preservation Area. The park will ensure there are broad benefits and will prevent irregular settlements through public activity (PMC, 2007a; ADF, 2007). In this regard, the Barigüi Linear Park is like Singapore in that it will construct a highly utilised area but it will have very few buildings. It does show how an intensive urban project can contribute to regional biodiversity protection.

The actions established in the program include the relocation of families that live in risky precarious dwellings located on the river margins – many at risk; refilling of the Permanent Protection Area with native vegetation; supervision of the sewage system; and several environmental education activities that will promote improvements to the basin's water quality (PMC, 2007a).

It is important to point out that the region has 32 illegal developments and 100 spontaneous settlements, many of them in permanent preservation areas. Since 2010, the Biocity program is relocating 750 families that inhabit risk areas by the Barigui River's margins. Two federal government programs deliver funding: the Growth Acceleration Program (Programa de Aceleração do Crescimento - PAC) and the My Home, My Life (Minha casa, Minha Vida).

The resettlement of the families is occurring through the Social Housing Company-Cohab. The intervention in the Barigui watershed includes 1,326 families from 12 squatter occupations. Besides the 735 already resettled families, other 89 will be transferred to new dwellings, and the remaining 502 who live in places without building restrictions will be provided with urbanization and infrastructure works. The Cohab has built four social housing developments to accommodate the removed families. The biggest is the Corbelia, in São Miguel suburb already inhabited by 545 families, but it still has room left for ten more to complete the occupation. The Aquarela development is in the same suburb and houses 150 families; the Ibaiti, located close to the Industrial City received 30 families, and the Vila Bom Menino, in Mossungue suburb settled ten families. A fifth development, the Apoiti, is under construction in the Industrial City precinct with 37 units (PMC, 2013).

The Live Barigui Project is divided into three parts as follows:

- The northern sector comprising the integration of the three existing parks is to provide a larger area of environmental protection and recreation, and enable Barigui's lake silt removal. Started in July 2012, it involved 5 km of cleaning of the river; construction of 14 sports fields and a linear park with 3.7 miles of bike path are ongoing. About 735 families in a risk situation were removed from the river margins and relocated to housing built for this purpose (Caderno do Bairro, 2012).

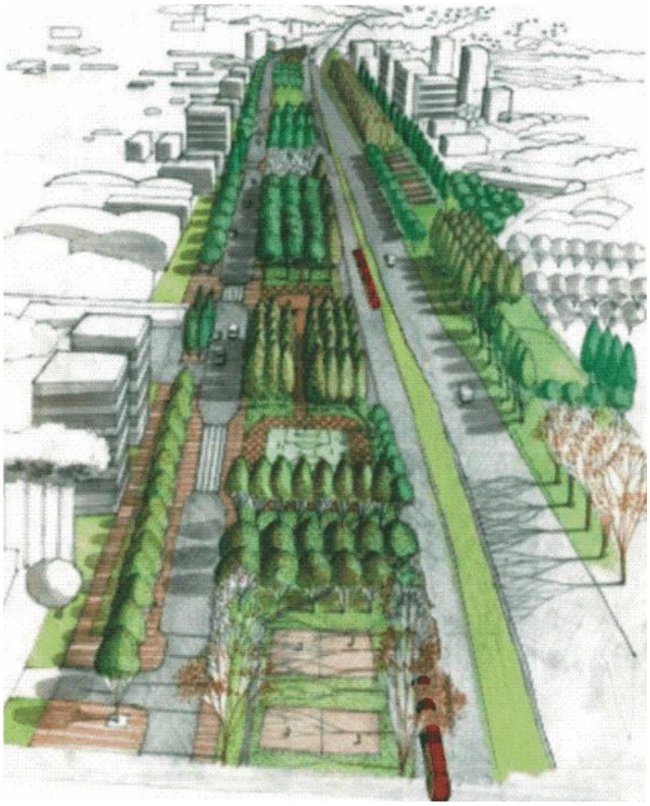
- The central sector is the most urbanized area. The project contemplates the implantation of the Biodiversity Park, revitalization of Mane Garrincha Park and the construction of accumulation ponds to capture rainwater and reduce flood risk. Cambuí Park, inaugurated in 2008, is Curitiba's 18th park and the fourth one located at the Barigui River's margins.
- The southern sector is the less urbanized. It foresees the creation of two new parks that will contribute to the preservation of riparian areas and the conservation of important massive forests aiming to conserve the regional landscape, which will also be integrated to the Barigui Linear Park.

Environmental educational programs consisting of educational campaigns and evaluations of the quality of water of the Barigui River, involving community participation, seek to identify and mobilize partners by promoting the training of multipliers and the articulation between agents capable of intervening in the basin (PMC, 2007a).

6.5.4 The Green Line Project

Green Line is another project of the Biocity Program. It includes the sixth structural axis incorporating a completely new avenue that comprises a mass transportation corridor, traffic lanes, cycling facilities, sidewalks and a linear park. Located in the area occupied by the former BR 116 national route that split Curitiba from northeast to southeast, it runs along 22 km within the city forming another biodiversity restoration corridor.

The Green Line is Curitiba's Integrated Transport Network-ITN sixth corridor and biggest avenue, aiming to integrate the west part of the city into the metropolitan area. It represents a remarkable expansion of the ITN providing improved permeability inside the city through 14 new connections (binaries). In addition, attractive innovations like sidewalks with safe crossings, cycle paths and, importantly, a biophilic intervention consisting of a linear park that will help to purify the air, reduce temperature and add biodiversity in the inner city. The Linear Park will be 20.8 km long, located in the centre of the track. The landscaping will be done entirely with native species, including the planting of fruit trees, totalling 5,200 trees (Figure 6-15).



Green Line

6th transport corridor
Extension: 18 km
Benefits 23 suburbs and 287,000 people.
32,000 pass/day
Linear park: 20.8 km

Figure 6-17: *Artist's view of Green Line Linear Park.*
Source: IPPUC www.ippuc.org.br/fichastecnicas

As seen in the previous descriptions of strategies and practices supported by the Green Plan, Curitiba has a variety of conservation units that cover 20% of the municipality area. They are distributed in 21 parks, 14 urban forests, two large Areas of Environmental Conservancy, an Ecological Station (Cambuí) and a large number of squares and community gardens for recreation and leisure of citizens (IPPUC, 2008c; PMC, 2013). Table 6-2 below shows a summary of ecologic strategies and practices implemented in the city:

Summary of ecologic strategies and practices in Curitiba

Type of initiative	Quantity	Creation/management
Ecological station	1	SMMA
Natural reserves	2	SMMA
Urban forests	14	SMMA
Parks	31	SMMA
Green squares	Large number	SMMA
Community gardens	Large number	SMMA
Inter-parks circuit	47 km	IPPUC and PMC
Strategic Bicycle Plan	130 km cycle paths; 90 km cycle routes; 80 km calm ways	IPPUC and PMC
Urban acupunctures	various	PMC/SMMA
Biocity Program	2 large projects: Live Larigui and Green Line	PMC & AFD

Table 6-2: Summary of ecologic strategies and practices in Curitiba

Author, based on data provided by IPPUC, 2008c; PMC, 2013

6.5.5 Green policies and incentives

In the 1980s, environmental legislation facilitated the creation of new preservation areas through incentives and land use controls. They were mapped to facilitate monitoring of preservation activities and as land use regulation tools. Several parks and urban forests were then created covering eight million square metres. Among the incentive tools, it is important to mention the Transfer of Building Rights, implemented in 1982. This law encourages preservation not only of natural assets but also of architectural, cultural and historic heritage. It permits underutilized development rights to be transferred to other areas of the city (Irazabal, 2005). An example of this is the RPPNM (Portuguese acronym for Municipal Natural Heritage Private Reserve), created in 1996 from voluntary acts. A green areas protection tool complements public efforts in increasing the number and extension of protected areas. It collaborates in constituting ecological corridors and the consequent increase in landscape connectivity, relevant for both biodiversity conservation and maintenance of microclimatic and environmental conditions. RPPNMs are important in strategic locations, e.g., in protecting threatened ecosystems, buffering zones of conservation units or the surroundings of protected areas (www.uc.socioambiental.org). As seen in Fig. 7-16, the voluntary creation of a RPPNM in an area of natural heritage enables the increase of the built area of a building or group of buildings in the same property or in another part of the city. Alternatively, a developer can buy building rights from the government which will invest the money in the creation of new leisure areas or public parks for the community. Cross subsidies and building incentives subsidize low income housing (Fragomeni, 2013).

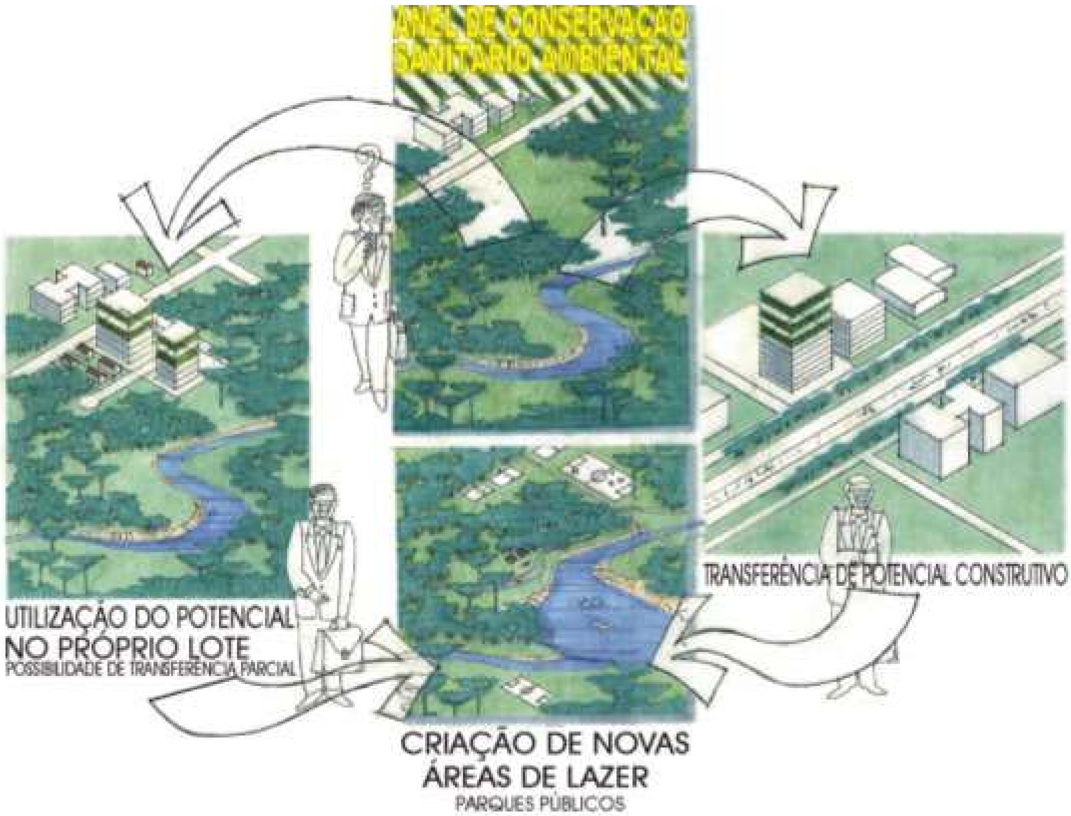


Figure 6-18: Green areas protection tool.

Source: Fragomeni, 2013

Summary of environmental laws, green policies and incentives

Curitiba has many laws and policies relative to environmental issues. The most relevant are:

Act 7833, of December 19th, 1991, on "The policy of protection, conservation and restoration of the environment and other measures", which creates the mandate of the Municipal Secretariat of the Environment, and

Act 9806, of January 3rd, 2000, on "The establishment of the Code of Forestry of the City of Curitiba and other measures", which consolidates and updates the historic process of the municipality in relation to the management of urban green areas.

Law 10785/2003: Water management in buildings. Buildings with area >3,000 sqm must collect rainwater. *Ground permeability*: Permeability index 25%.

The Plan for Environmental Protection and Sustainable Development was established in the recent Master Plan review of 2014, according to the City's Statute and the Municipal Law 11.266/04 (Articles 20, XV and 88, VI). The Plan encompasses two parts as follows (www.curitiba.pr.gov.br):

1. PHYSICAL ENVIRONMENT AND BIOTA MANAGEMENT:
1.1. Resources from Atmosphere
1.2. Green Areas
1.3. Fauna
1.4. Water
1.5. Geology
1.6. Environmental Liability

2. URBAN ENVIRONMENT MANAGEMENT
2.1. Environmental Education
2.2. Solid Waste
2.3. Urban Noise
2.4. Protected Areas
2.5. Heritage

2.6. Environmental Information Systems

2.7. Legislation

Green Exchange: benefits people from squatter settlements. They collect garbage from the narrow streets where garbage trucks cannot access and bring it to the collection spots where the exchange is done: 5 kg of garbage equals a bag of groceries and fresh food produced by local farmers and bus tickets (Fragomeni, 2013).

PIA- Adolescent Environmental Education Program, 1992: created to deliver practical education on how to grow vegetables and other skills for daily life to children and adolescents from low-income families, also providing them with food and care while the parents are at work. Granted the UN Local Government Honors Program Award for "environmental regeneration of low-income communities" (Rabinovitch and Leitmann, 1993).

Green areas incentives

- *Law 7833/91*: Tax reduction incentive. Private areas with a large green area can benefit from tax reduction:

Green area/lot	Tax reduction
> 80%	100%
50 – 80%	80%
30 - 45%	50%

Table 6-3: Tax reduction incentive

Source: www.curitiba.pr.gov.br

- Decree 194/ 2000. Transfer of building rights. Determines minimum size for plots

All environmental laws are included in can be found in www.curitiba.pr.gov.br within the area of the Municipal Secretariat of the Environment, under the topic *"legislação SMMA."*

Summary of environmental protection policy framework

Act 5234/1975 Land uses	Municipal Law
Act 7833/1991 Tax reduction incentive	Municipal Law
RPPNM- Municipal Natural Heritage Private Reserve	Voluntary action
Act 9806/2000 Code of Forestry & Conservation Areas	Municipal Law
Decree 194/2000 Transfer of building rights	Municipal Law
Act 10785/2003 Water management in buildings	Municipal Law
PEPSD/2014 Plan for Environmental Protection and Sustainable Development	Municipal Law
Green Exchange Program	Municipal
PIA- Adolescent Environmental Education Program	Municipal

Table 6-4: Summary of environmental protection policy framework - Curitiba

Source: Author, based on literature review

6.6 Analytical strategy applied to Curitiba

As mentioned in Chapter 5, the analytical strategy was organised in three phases. First, the consideration of local urban planning traditions and processes; second, the application of the framework to each city, Curitiba in this case; and finally, the cross-case analysis to be conducted in Chapter 8.

6.6.1 Urban planning traditions and processes analysis

This analysis looked for understanding how and why the urban transformations emerged, what supported them and how they were implemented, as well as local context. The analysis was conducted by the following questions:

- Why did this specific process of urban transformation occur in Curitiba and not in any other city in the country or region?
- Were there any precedents, national or international?
- How did it happen and how was it conducted?
- Is there any evidence of a shift in the process of thinking about urban planning?
- How did this shift reflect on urban design and planning?

A thorough examination of the planning history of Curitiba, the theories and practices applied and their evolution and innovations were relevant to answer these questions. Findings include local conditions and resources, momentum, a shift of mindset sustaining methodologies and orienting the planning process toward sustainability, and visionary leadership supporting the urban transformation and ensuring political will and continuity.

Local knowledge and planning tradition

The culture of urbanism in Curitiba, started in the 19th century, had a significant influence in the development of novel ideas concerning the city's spatial structure and planning for future growth. The first master plan, in the current sense, dates from the early 1940s. The most influential, the Wilheim-IPPUC Plan approved in 1966, was cutting edge decoupling from the mainstream modernist urban planning theories by changing the urban spatial structure and providing the features that still characterise the city. This plan included requirements for pedestrian areas, open green space and heritage preservation, advanced propositions for the time, which aligned with vanguard's international concepts. Curitiba started to implement measures to reduce car-dependency and encouraged accessibility for pedestrians and cyclists adopting an integrated planning concept based on a tripod combining road network, transportation and land use. Contrasting the increasing urban sprawl in other cities at the time, the plan defined five structural axes to organise the urban expansion along transit-oriented corridors where high densities and mixed land uses were permitted and encouraged. These principles also incorporated urban management, industrial promotion, environmental improvement and urban quality.

Momentum

This transformation was possible due to a number of factors. Firstly, visionary politicians and design practitioners were active in the city and in the country at the time (1960s-1970s), the Wilheim-IPPUC master plan is an example of this combination. Secondly, a propitious although incipient momentum in the international conversation about urban issues in the late 1960s helped trigger the process: the decline of the modernist city, and importantly, Jane Jacobs' ideas and activism toward humane and liveable cities, plus the rise of the environmental movement. Thirdly, in the 1970s, Brazil's accelerated economic development and political conditions provided support for innovative initiatives.

Change in mindset

As described in section 6.4, behind the long-term achievements and productivity in urban planning there is a significant factor, a shif in mindset, which allowed urban planning to evolve itself as an effective technology promoting the adoption of new methodologies and the delivery and implementation of innovative practices. By dividing the working days, Lerner and the planning team designed a unique work methodology, balancing needs and potentials that enabled them to work on real change, avoiding short-term results on the one hand, or solutions far from reality on the other. Another method was the use of charrettes to enhance interdisciplinary perspectives and innovation. The charrettes generated a creative space to discuss and understand problems from interdisciplinary perspectives, refine and continuously improve solutions, and importantly, to comprehend the city as a whole system in evolution and develop scenarios for guiding its structural growth (Mang, 2009). The innovative sustainable initiatives that made Curitiba a model of urban planning were born through this work process. The park system, the urban acupunctures and the transport system are examples of this approach to urban planning.

The set of planning practices moulded on creativity, innovative thinking and work methodologies, low budget, and effective communication led to international support and recognition, and to citizens' behavioural change and civic pride.

Visionary leadership

Jaime Lerner perceived and took the unique opportunity to implement human-scale and ecological-based development in Curitiba. Lerner's visionary leadership and professional skills enabled the process, integrating a knowledgeable team of practitioners and taking action to start transformative change in the city.

The process was facilitated and fostered by governance with the right vision, technological support, and political will ensuring continuity, despite low citizen participation.

6.6.2 Framework application to Curitiba

The application of the framework for regenerative sustainable urbanism to Curitiba aimed to test the framework's validity and applicability, seeking for evidence of emergent regenerative practices related to the integration of social-ecological approaches to urban design and planning theory and methodologies used in the urban transformation of Curitiba. The purpose was to analyse why and how integrated urban planning with social-ecological approaches could drive this city toward regenerative sustainability; what was the influence in producing regenerative processes, and if there was reciprocity between the practices, policies, and the theoretical principles. Moreover, the analysis looked for convergences and divergences and why this happened, to see if Curitiba can be considered as a precedent of regenerative sustainable urbanism.

I selected three representative examples of urban design initiatives implemented in Curitiba: Strange archaeology, Urban acupunctures and the Green Plan (specifically the park system), deemed to be examples in which regenerative processes are likely to be found. Using the matrix as a lens, and considering the guiding questions, firstly I compared the description of each theoretical tenet with the characteristics of the practice/policy at issue, utilising the analytical technique of pattern matching. Pattern matching allows comparison of predicted patterns drawn from the theory with empirically based patterns. If they match, the internal validity of the case is reinforced (Yin, 2009). Following the matchings of practices and policies with theory on the matrix, I described the phenomena, looking for connections between them.

As set in Chapter 5, the application of the framework to the case studies is conducted by the following questions:

- What type of practices and policies observed in each city align with the theoretical principles contained in the framework?
- How do the practices /policies reflect them?
- What kind of findings could be considered as leading to urban regenerative sustainability?

For this Curitiba case, I selected Strange archaeology, Urban acupunctures and the Green Plan as relevant practices and policies related to them.

According to Bryman (2008), qualitative data analysis involves the description of the phenomena, the development of conceptual classification and the identification of connections between concepts.

Table 6-5 below shows the application of the matrix to the selected practices and policies in Curitiba, Strange archaeology, Urban acupunctures and the Green plan:

Regenerative Sustainable Urbanism Analytic Matrix - Curitiba								
Theoretical principles	**Place**	**Progressive human-nature relationships**	**Pattern literacy**	**Development and design**	**Ecosystem services**	**Community engagement**	**Liveability (Co-evolution)**	**Beauty**
Policy	Linear urban growth system. Zoning policies MPSUD*** Decree 194/2000 (Transfer of building rights)	SMMA legislation Decree 194/2000 RPPNM PEPSD Green areas protection tool; Environmental education	Cultural heritage preservation	PEPSD** MPSUD	Draining basins as basic planning units. Biodiversity as heritage. Green areas protection tool; PEPSD Green incentives; Act 9806 Act 7833	Public-private partnerships: co-responsibility Green Plan Green guard;	Green Plan	Cultural and natural heritage preservation
Practice	Strange archaeology;* Urban acupuncture;* BRT Placemaking; Urban acupuncture; Green Plan	Green Plan*, Urban acupuncture, *Pro-park line;* Tree planting campaign; Cycling plan Awarded waste recycling campaigns: *Garbage that is not garbage;* *Green exchange*	Strange archaeology; Urban acupuncture; Green Plan	Strange archaeology; Use of recycled materials in public buildings and spaces Urban acupuncture; Green Plan; BRT	Green Plan Urban acupuncture Biocity program: Green Line and Live Barigui projects	Urban acupuncture; Tree planting campaign; Park & gardens maintenance by youths; Green Plan Waste recycling campaigns	Strange archaeology; Urban acupuncture ; Cultural change, Civic pride Waste treatment; Biocity program; Green Plan	City beautification; Memorials Green Plan; Streetscapes; Urban acupuncture

Table 6-5: Regenerative Sustainable Urbanism Analytic Matrix – Curitiba
Source: Author

Liveability: social and environmental quality of a place [or city] (Moura, 2005); SMMA: Portuguese acronym for Municipal Secretariat for the Environment
RPPNM: Portuguese acronym for Municipal Natural Heritage Private Reserve
(*) See description below, (**)PEPSD-Plan for Environmental Protection and Sustainable Development, (***)MPSUD –Municipal Plan for Sustainable Urban Development

Strange archaeology

This urban design strategy was used in Curitiba in the Wilheim –IPPUC plan and enhanced by the further urban transformations, fitting various theoretical principles. Defined by Lerner as the rediscovery of the hidden design of a city (McKibben (1995), it is directly related to *place* and its biophysical and cultural patterns shaped by soil, climate, non-human living systems and human activities over time. The geographical location of the city is a forested floodplain with a number of rivers and streams intersecting each other many times, with rich biodiversity in natural ecosystems alongside the river corridors (Mang, 2009).

The understanding of how the ecological system worked and flowed through the place in the past, and how historical human settlements developed in this place *(pattern literacy)* allowed for decision making on place-based relationships to organise urban functioning and growth. Comprehending these dynamics, Curitiba's Wilheim-IPPUC plan raised them to a core concept of a linear urban growth system, aiming to limit the expansion of the city's central area through the integration of roads, public transport and land use (Rabinovitch and Leitmann, 1993), which is still maintained in the 2004 and 2014 plan's revisions and in the zoning policies. The linear growth system currently composed of six structural arteries or axes concentrates the highest densities, commercial activity and greatest affluence of the public across the city, giving continuity to the natural and past flows *(Place; Pattern literacy, Development and design)*.

Moreover, the plan encompasses environmental management solving several problems with win-win solutions. The city bought the land around and along the rivers, sensitive ecological habitats, and degraded areas (e.g. abandoned quarries) to build linear parks and community facilities (*ecosystems services, liveability*). In this way, the planning ensured public access to nature, ecosystems restoration and preservation, allowing the rivers to flow and flood naturally, while avoiding illegal occupation of riparian areas, adding social benefits like education and recreation, and increasing aesthetic and economic value to the surrounding areas (Rabinovitch and Leitmann, 1993; Mang, 2009). Summarising, Strange archaeology matches the following theoretical principles: *Place, Pattern literacy*; *Development and design; Progressive human-nature relationships; Ecosystem services; Liveability and Beauty)*. In some way, *Community engagement* is approached in terms of ensuring public access to and enjoyment of the parks, although neither the decision making nor the design and development of the parks involved community participation.

Urban acupunctures

This design strategy also matches various principles of Regenerative sustainable urbanism, acting as agents of revitalisation and regeneration of degraded areas and disadvantaged communities.

Urban acupunctures are interventions strongly related to *place*, integrating culture, education, recreation and ecology. They also promote, facilitate and enhance *human-nature relationships* promoting social activities immersed in recovered natural enclaves within the city, transforming degraded places into meaningful ones aiming for co-evolution of social and ecological systems, as is the case of the regeneration of abandoned granite quarries located within the boundaries of the city, which became landfills, creating many problems for their neighbours. Examples of these interventions are the Wire Opera House and the Quarries Park, the UNILIVRE, and the Tangua Park, described in section 6.4.1, showing the transformation of the old quarries into attractive urban enclaves including the restoration of environmental damage *(ecosystem services)* and, at the same time, delivering entertainment and cultural facilities, educational premises and parks for community recreation *(liveability)*, or serving to solve ecological accidents, e.g. the Iguacu River sand pits. The Wire Opera House and the UNILIVRE's architectural conceptions embed principles of biophilic and regenerative design, such as an explicit connection with the environment, letting the exterior in through an interesting play of transparencies that allows seeing and feeling the history of this place in the remnants of the quarries: the lakes, the impressive granite walls, and the magnificent regenerated vegetation thriving everywhere. Transparency is also present in the bridge that connects the Wire Opera House building – set in the middle of the lake – to the shore: the steel mesh floor makes it possible to see the fish and aquatic plants living in the lake waters.

Moreover, urban acupunctures are examples of opportunities for synergistic regenerative interactions in the built environment, evidenced in the transformation of the Rua XV into the pedestrian mall renamed Flowers Street (see section 6.4.1), and in the number of theoretical principles they match: *Place, Development and design; Progressive human-nature relationships; Ecosystem services; Liveability and Beauty*. Again, community benefitted from these interventions but had no participation in their planning.

The Park system

Curitiba's Park system is part of a bigger program, the Green Plan, an example of regenerative development and design and biophilic urbanism integrated to urban planning that produced positive impacts on the urban and regional ecosystems *(Place, Pattern literacy, Development and design, Ecosystem services, Progressive human-nature relationships).* It should be noticed that the public green areas involve a series of initiatives that aim to both solve environmental issues and raise awareness in the population about them, as well as provide enjoyment and promote care.

This strategy of building multifunctional parks is part of the integrative approach to planning. Otherwise, it is unlikely that a city invests large amounts of money in the regeneration of its regional ecosystem unless it can do so as part of a set of solutions to many urban issues. This approach enabled Curitiba to successfully produce regenerative design solutions that integrate ecological and social functions. The park system created parks that function as cultural, educational and recreational facilities while serving for flood control, revitalizing neglected sites, as seen in some of the acupunctures, and protecting sensitive areas from illegal settlements, as the ongoing Live Barigui Project is demonstrating (see section 6.5.3). Parks also promote learning opportunities and jobs for low-income sectors of the population, e.g. the groups of youths that produce seedlings of flowering plants and give maintenance to the parks, streets and gardens around the city. In this sense, the Park systems complies with the theoretical principles of *Place, Progressive human-nature relationships, Ecosystem services, Development and design, and Beauty.* Again, the social benefits are embedded in the planning provisions but community is a passive end-user of planning decisions and interventions, which nevertheless, led to a sense of belonging and civic pride in the citizens, promoting awareness and care for place.

Considering the number of theoretical principles matched by the three sets of urban interventions selected, and the significance of the shared principles addressed, *Place, Progressive human-nature relationships, Ecosystem services, Pattern literacy, Development and design, and Beauty,* I conclude, therefore, that the initiatives called Strange archaeology, Urban acupunctures and the Park system are means toward urban regenerative sustainability. Acknowledgment is due to the fact that community involvement to take the potential co-evolution of human and natural systems to higher levels was not taken into account by the planning and political components of the process. But nevertheless, the process was successful performing positively in Curitiba, over 40 years.

The matrix shows as well that the practices' success is underpinned by inducements and legislation (described and summarised in section 6.5.5).

Chapter 7

Singapore case study

Singapore or Pulau Ujong in Malay is a modern city-state and island country in Southeast Asia. Its territory encompasses a large diamond-shaped main island, commonly referred to as Singapore Island, and more than 60 smaller islets. The urban makeover of Singapore started in the 1960s, defying many challenges such as lack of natural resources and a housing crisis at the time. As it is a highly urbanised country, it has consistently pursued expansion of its territory through land reclamation to meet the needs of a growing population. The original vegetation has diminished remarkably due to the urbanisation process and remains protected in four national reserves.

The city was awarded the Most Liveable Asian City title in 2011 (Gehl, 2012).

7.1 Geographic information

Location

Singapore is situated one degree or 137 kilometres north of the equator, off the southern extreme of the Malay Peninsula. The Straits of Johor separate Singapore from Peninsular Malaysia to the north, and the Singapore Strait is the boundary with Indonesia's Riau Islands to the south (en.wikipedia.org).

Figure 7-1: Singapore map

Source: google.com.au

Population: 5.47 million (2015)

Area: 716.1 km² (276.5 sq miles)

GDP: $297.9 billion USD (2013)

Sources: en.wikipedia.org; Straits Times, May7, 2015

Singapore enjoys a strategic geographical position, at the meeting point of sea routes at the Malacca Straits, which contributed to transforming it into a flourishing trading post. This location also resonates in the ethnic composition of its population, mainly formed by Chinese, Malay, and Indians.

Climate

Due to its geographical location one degree north of the equator and maritime exposure, its climate presents uniform temperature and pressure, high humidity and abundant rainfall. It is classified as tropical rainforest climate (Köppen climate classification Af), with no real distinct seasons, just distinguished by precipitation and the direction of winds which are very light, even at high elevation. Monsoons occur from mid-November until early March and from mid-June until early September, with heavy, frequent downpours during this period; thunderstorms occur on 51% of all days. December is the wettest month, and June is the driest (en.wikipedia.org). Tropical evergreen rainforest is the climatic climax vegetation, the richest ecosystem in the world. Even though only 5% of the native ecosystem species is currently remaining, there are still numerous important species inland, in natural and human-made systems and in marine environments which are rich in coral and seagrasses species (Chan et al., 2010).

Terrain

It is mainly lowland, with a gently undulating central plateau that contains a water catchment area and nature preserve. Singapore has significant shortages of natural freshwater rivers and lakes, so the primary source of domestic water is rainfall. Although rainfall is abundant throughout the year, demand for fresh water is approximately twice that supplied by precipitation, so the country imports much of its fresh water from Malaysia and Indonesia. The government implemented various strategies to lessen its reliance on imports, like reservoirs to collect rainwater, recycled water facilities, and a newly built desalination plant on the western coast of Tuas. With this installation, the government expects that at least half of Singapore's water demands may be met. Recent plans to produce NEWater, recycled water produced by filtration via reverse osmosis, have been very successful. Singapore has three of these plants already built to help meet the demand (en.wikipedia.org).

7.2 Brief history

Modern Singapore was founded in the 19th century. Its name derives from an ancient legend meaning "Lion's City", from the Sanskrit "Simha" (lion) and "pura" (city). In the early 1800s, the British saw the island as the perfect location to base the merchant fleet of the growing empire and as a future trade post in the region (en.wikipedia.org/wiki/Category: History_of_Singapore).

In those days, the main island was covered by swamps. This condition did not concern Raffles, Lieutenant-Governor of Bencoolen in Sumatra, who recognised its potential and negotiated an agreement with the local rulers to establish a trading station. The island's policy of free trade attracted merchants from China, India, the Middle East, and Europe. By the end of the century, with the opening of the Suez Canal in 1869, the advent of the telegraph and the steamships, Singapore's importance grew extraordinarily as a centre of expanding commerce between east and west. The population grew proportionally to prosperity, from 150 inhabitants in the early 1800s to 80,792 at the end of the century, mostly composed of Chinese, Malayan and Indians (en.wikipedia.org/wiki/Category: History_of_Singapore).

Singapore was attacked by the Japanese during World War II and remained occupied until 1945 when was handed over to the British Military Administration. In 1946, it became a Crown colony until 1959 when the first elections in the country took place selecting Lee Kuan Yew as Singapore's first Prime Minister. Malaysia was instituted in 1963, comprising the Federation of Malaysia, Singapore, Sarawak, and North Borneo. However, it was not successful and Singapore left in 1965, becoming an independent nation. By then, Singapore was a thriving city of 1.89 million people (History of Singapore; en.wikipedia.org/wiki/Category: History_of_Singapore).

Lee Kuan Yew was Prime Minister from 1960 to 1990, and it was during this period that the main transformations took place in the city-state, particularly after independence. Founding the economy on international trade, Singapore turned into an attractive destination for foreign investment, becoming one of the world's most prosperous societies. Providing services in the areas of healthcare, finance, education and tourism, the city is today a stable regional commercial capital enjoying an extended period of economic growth.

In the early days of independence, there were problems with social integration of a multi-racial population, which generated riots in the 1960s. Currently, the country remains predominantly Chinese, but inhabitants do not consider themselves entirely Chinese, Indian or Malay. Aiming to help foster a shared identity among the country's ethnicities the government adopted English as the national language. (Schiavenza, 2015; Velegrinis and Weller, 2007).

Singapore's regime has been successful in many ways, particularly in implementing a clear vision for the country's development, done with great confidence and determination. However, rising controversies and criticism subordinate this achievement at a significant cost to human rights. Free press, freedom of expression, or freedom of assembly are still challenging issues for Singaporean society (Schiavenza, 2015).

7.3 Urban planning history

The making of the city-state started in the early years of independence. It was driven by a strong and well-defined vision based on economic development toward being a model city. In Lee Kuan Yew's words:

> No other hallmark of success will be more distinctive than that of achieving our position as the cleanest and greenest city in South Asia (Lee Kuan Yew, cited in Cheam, 2015).

Several agencies were created in those days in order to develop and implement the vision. The Urban Redevelopment Authority-URA is responsible for long-term planning for the city as a whole, beyond the boundaries of individual sites. The Housing and Development Board-HDB is accountable for providing affordable and quality public housing and social amenities. The National Parks Board-NParks, focusses on the environmental aspect, developing strategies and programs that led to achieving the first vision of "Garden City", and presently the evolved version of "City in a Garden".

The Housing and Development Board-HDB pioneered the transformation process in 1960 replacing the former colonial Singapore Improvement Trust. In 1959, the total population was 1,579,000 inhabitants. The figures for living conditions and deficit of affordable housing showed a critical situation: 250,000 living in degraded slums; 330,000 in squatter settlements; both insalubrious environments were located close to the town centre (Meng and Yin, 2004). Hence, HDB's mission was to provide appropriate and affordable housing urgently for a large number of low-income residents. The increasing population growth and the country's limited land availability led to building high-rise housing towns, a solution that was not popular with residents in those days, but provided for the needs. In 1968, the government started to facilitate people buying their houses by using their government pensions. Today, 90% of Singaporeans own the flats they live in, and 84% live in HDB built residential units (Cheam, 2015).

The Urban Redevelopment Authority –URA, created in 1974, formatted and implemented the planning philosophy that guides Singapore's development since then. It is based on a tripod of values that has sustainability as its main context and encompasses economic development, attention to social needs and design for a quality environment.

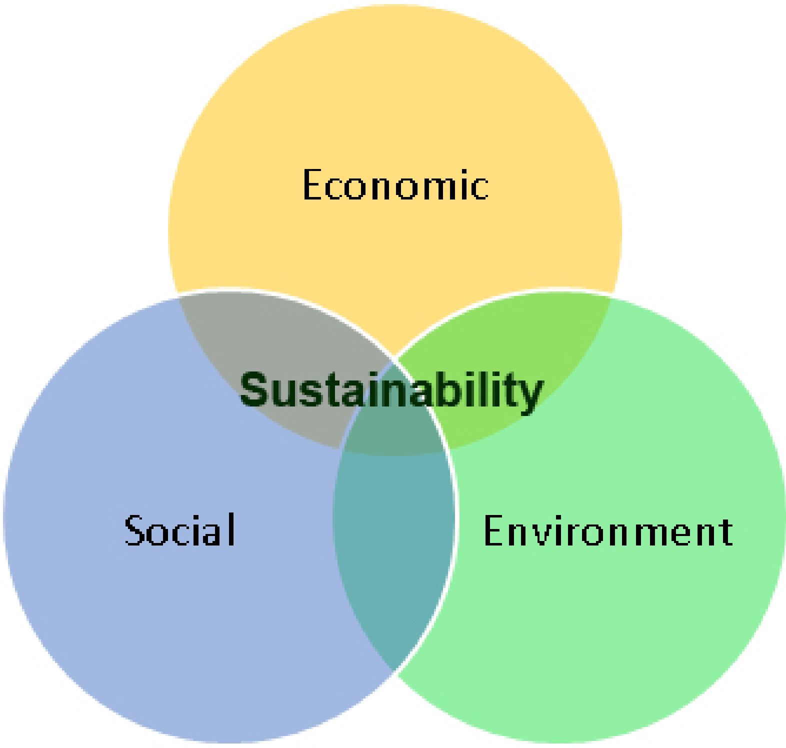


Figure 7-2: Planning tripod.

Source: A+U, 2012

URA's CEO, Ng Lang, explains that the agency pursues sustainable urban development at two levels. At the macro level, the implemented planning strategies made Singapore a successful compact, transit-oriented city with all-embracing green public spaces and quality living housing towns; and at the micro level, the city targets resource efficiency through green building guidelines and reducing energy consumption in the industrial sector (A+U, 2012a).

URA started as a part of HDB in 1964 under the name of Urban Renewal Unit-URU, aiming to clear out the slums, provide public housing, and encourage economic development by growing the industrial sector. At the end of the 1960s, with these first objectives achieved, it was time to create a vision for the city's urban landscape to guide Singapore's evolution in the long-term. In 1966, URU turned into the Urban

Renewal Department-URD, delivering the first Conceptual Plan for the city in 1971, which incorporated ideas from Kenzo Tange and M. Pei who had been previously invited to design concept plans for the city.

Urban planning is a highly centralised government function aiming to optimise the use of Singapore's scarce land resources, given a current population estimated at 5.47 million people (*The Straits Times*, May 7, 2015) living in an area of 716 sq km. The *Planning Act* controls land use, providing a framework for land use and conservation areas, and empowering URA to elaborate ten-yearly concept plans and five-yearly master plans that determine the land use intentions of the whole of government, after consultation with government agencies, public and non-governmental organisations.

Concept plans determine the long-range land use and transportation plan strategies for the city-state's physical development over the next 40-50 years. They are elaborated by URA every ten years and regularly reviewed. The intentions contained in the conceptual plans are developed into detailed land use plans for the different planning areas, constituting the master plans which guide physical development through development control. Concept plans are reviewed and amended according to changing situations and needs. For this purpose, URA consults with other government agencies and holds public exhibitions to obtain feedback from the public, which is incorporated in the amendments (Chew, 2008; www.ura.gov.sg). "The underlying objective is to ensure that there is sufficient land to support future population and economic growth while maintaining a good living environment" (Chew, 2008).

Figure 7-3: Conceptual Plan, 1971.

Source: A+U, 2012

The Conceptual Plan 1971 guided the city's long-term land use and transportation system. It shaped the spatial structure that is still visible in Singapore today. It was also called the "Ring Concept Plan" because it arranged high-density satellite towns in a circular manner around the central water catchment area. The residential areas were surrounded by green spaces, parks and open spaces to provide recreational opportunities and detach the towns while areas for low and medium-density private housing were allowed to be built alongside the towns. Industrial estates also were specified. Regarding transportation, the Plan provided for an island-wide system of expressways linking the towns. Moreover, a Mass Rapid Transit (MRT) system would connect the towns with the city and Jurong area, on the southwest part of the island, and the airport be relocated to Changi to cater for future expansion (www.ura.gov.sg).

The complexity of urban renewal programs started by the URD posed challenges that required greater autonomy and flexibility in decision-making and in implementing planning strategies. In order to meet these needs, in 1974 URD became the Urban Redevelopment Authority-URA, an independent statutory board under the Ministry of National Development. The Central Area redevelopment was the main commission at the time, which included the removal of affected residents to new destinations. To meet this objective, between 1967 and 1989, the agency vacated and sold 184 hectares of land to give place to 155 development projects that transformed the Central Area into the modern financial and business hub that it is today. In 1989, the Planning Department and the Research & Statistics Unit of the Ministry of National Development merged into URA. This shift facilitated the physical development of Singapore with greater efficiency, and enabled meeting land demands while balancing economic and social development. Also in that year, the board became the national conservation authority, responsible for the critical task of conserving Singapore's built heritage, ensuring a balanced environment of rich history and remarkable economic growth. In 2003, URA gained recognition as the national land planning authority under the *Planning Act* (www.ura.gov.sg).

The 1971 Conceptual Plan guided urban development into the 1990s, when a new Conceptual Plan was released in 1991 and, subsequently, the Conceptual Plan 2001. Both plans laid strategies to underpin economic growth, diminish traffic congestion in the city and provide a high-quality living environment (A+U, 2012a). The last review took place in 2006.

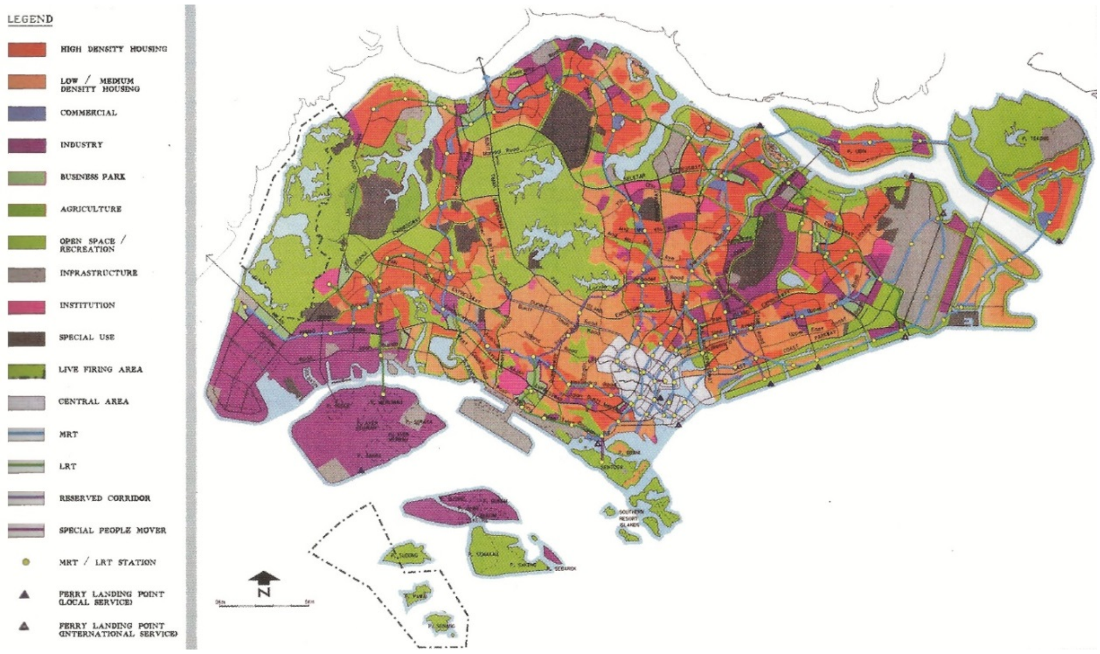


Figure 7-4: Conceptual Plan, 1991.

Source: A+U, 2012

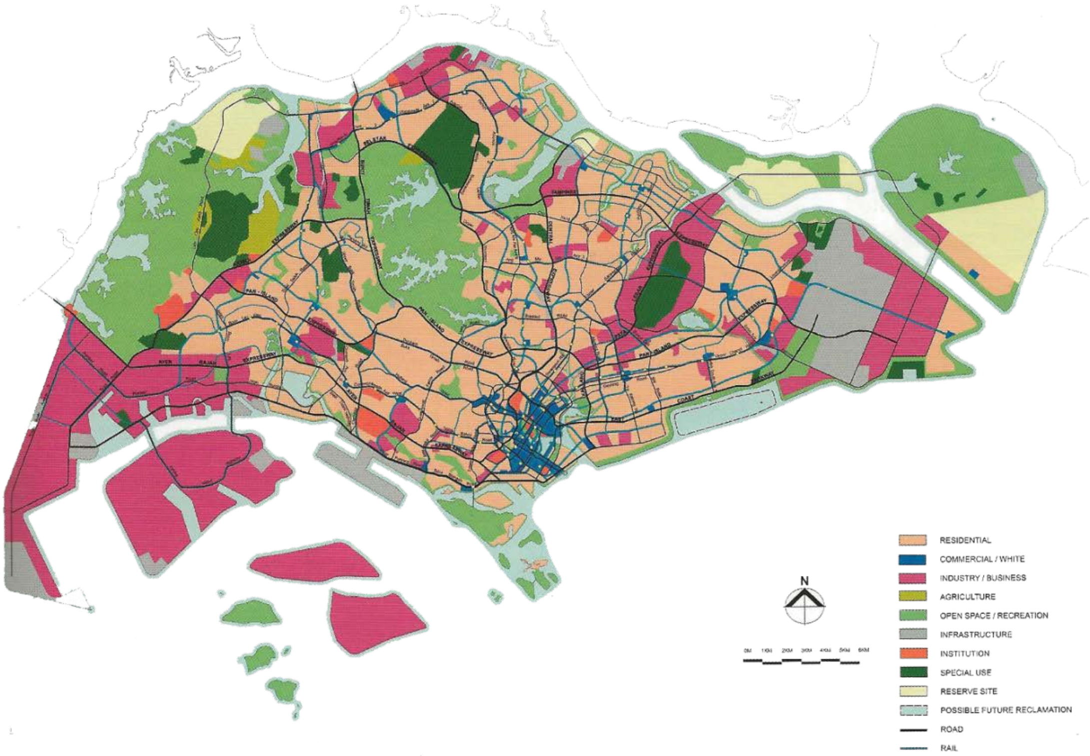


Figure 7-5: Conceptual Plan, 2001.

Source: A+U, 2012

Master plans are statutory and develop the strategic vision of the concept plan into detailed planning guidelines that will shape the physical development of the country over the next 10-15 years. They provide the foundations for the day-to-day regulation of land use by stipulating the zoning (i.e., permissible uses such as residential, commercial or institutional uses), maximum development intensity (i.e., the ratio of built-up area to site area) and building height limit for individual plots of land. Importantly, they clearly determine conservation areas and nature reserves. URA elaborates, reviews, and updates the master plan every five years. The process follows an open consultative approach similar to the one taken for the concept plan reviews. The development control system constitutes the primary tool for the implementation of the master plan. It consists of a system of permits through which the government keeps a tight control over the development of all land in the city. Construction of new buildings, change of use of buildings or land, subdivision of buildings or land, substantial additions or alterations to existing buildings and all works within a conservation area require the prior permission of the URA (Chew, 2008).

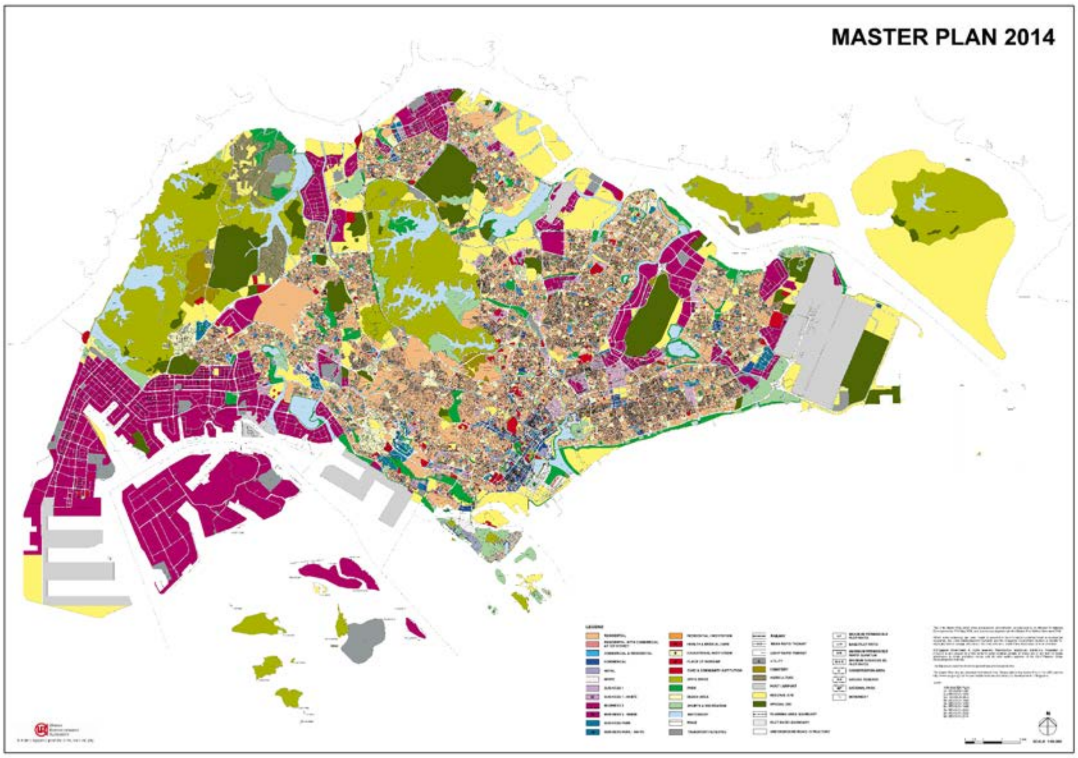


Figure 7-6: Master Plan 2014.

Source URA (www.ura.gov.sg)

7.3.1 Singapore's biophilic vision

The transformation of Singapore into a modern, attractive and dynamic first-world city in Southeast Asia gave significance to the greening of the city, elevating it to a first-level government issue. The task was allocated to the National Parks Board - NParks that became a part of the Ministry of National Development (Newman, 2013). NParks is responsible for the environmental development and the implementation of the visions for the city. The first vision, "Garden City" was launched in 1963 seeing Singapore as "nested amid lush greenery". Presently, the "City in a Garden" vision is more ambitious, "it aims to strengthen Singapore's brand as a distinctive, livable city" (A+U, 2012b, p.106).

The scope of work is diverse and convers the whole territory. Despite the urban expansion and severe land constraints, the vegetal cover of Singapore has increased extraordinarily. The integrated work of URA, HDB and Nparks, continually seeking the balance between development and conservation, has enabled the increase in vegetation cover, moving from 36% in the 1980s to 47% in 2012 (A+U, 2012b), as shown in Fig. 8-7 and Fig. 8-8.

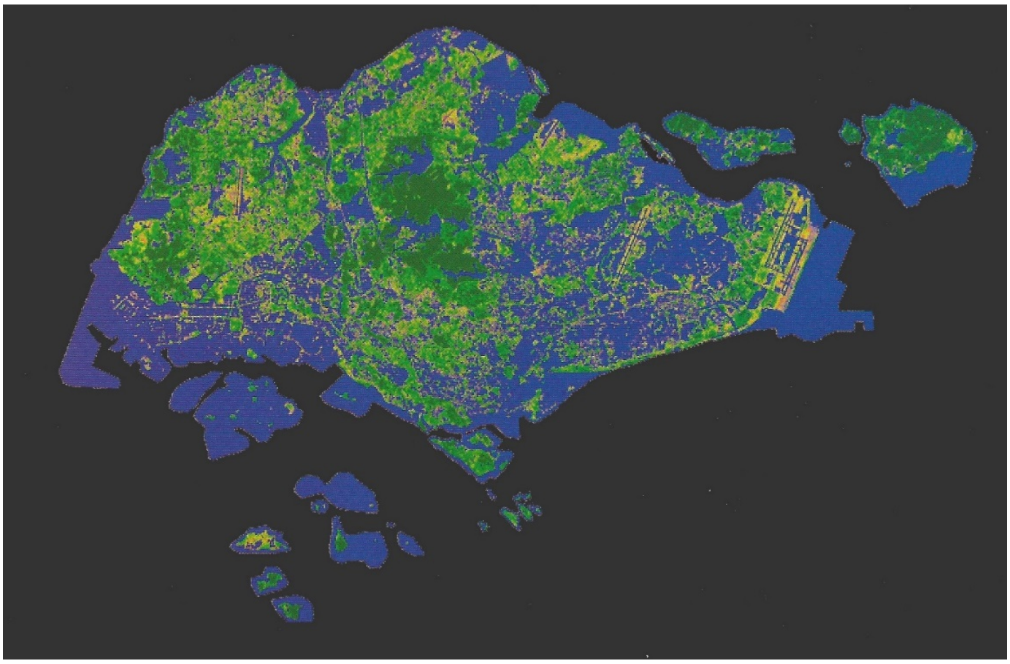


Figure 7-7: Vegetation cover in 1986.

Source: NParks

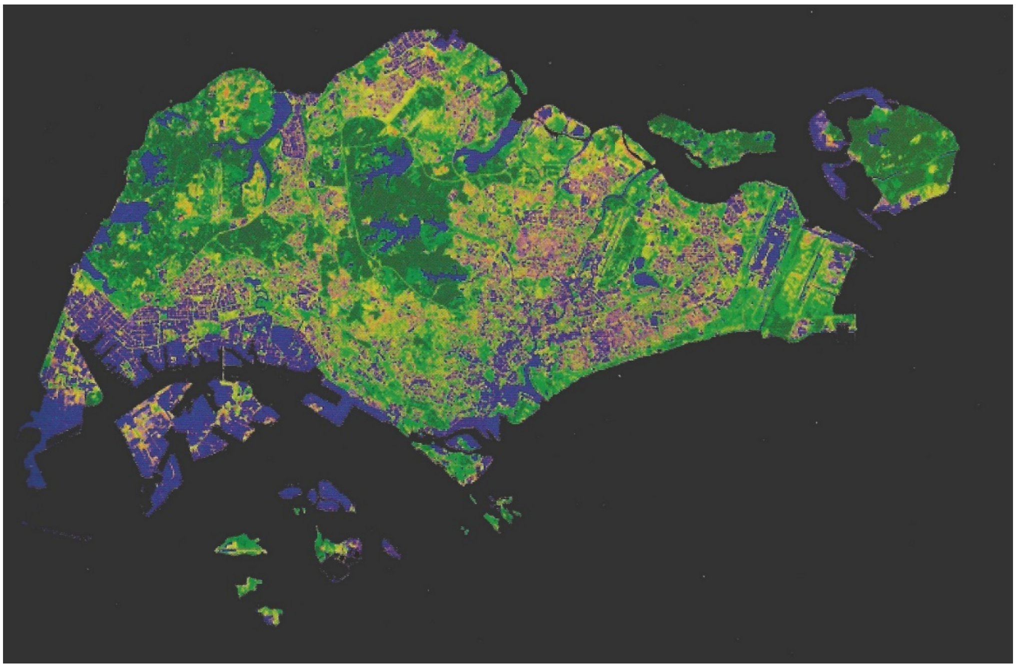


Figure 7-8: Vegetation cover in 2007.

Source: NParks

7.4 Planning methodologies

An innovative process with a focus on urban biodiversity

It should be noted that city greening was achieved in Singapore through the implementation of successful strategies, many innovative technologies and, importantly, being oriented to the improvement of biodiversity. The Convention on Biological Diversity has recognised the city as a model for biodiversity conservation. NParks, in collaboration with the United Nation's Convention on Biological Diversity, set up a National Biodiversity Centre that launched the Singapore's Biodiversity Index, a tool to measure urban biodiversity performance across the world (UNEP 2012; Newman, 2013; UN-Habitat, 2012-2013).

Chan et al. (2010) argue that conservation of biodiversity relies on the maintenance of habitats, which is dependent on land use and environmental quality. They remark that it is an important strategy to invest in biodiversity improvement, even though the existing percentage is low, because "development without biodiversity is a strategy for failure" (p. 58). Singapore has embedded conservation and development in its framework of legislation, administration, and economic structure.

Singapore's native climatic climax vegetation, the tropical evergreen rainforest, is the richest ecosystem on earth. It encompasses a broad variety of terrestrial and marine ecosystems; however, much of this lavishness has been lost to human activities over time, currently remaining at only 5% of its original extension, and from that a very small amount corresponds to its primary forest. Nevertheless, in terms of species, Chan et al. (2010) remark that many have survived the intensive development which occurred when there was not consciousness about environmental concerns, and today the green coverage resulting from recent strategies is nearly half of the nation's area: 47%, as seen in Fig. 7-8.

The main pressures affecting biodiversity in Singapore derive from land use, limited habitat availability and climate change. Due to scarcity of land and population pressures, legislation, master planning and education are essential provisions in the city-state. Climate change challenges are acknowledged and various mitigation strategies are taking place, such as extensive use of greeneries between and on buildings; creation of nature reserves aiming to protect, conserve and manage remaining native species and ecosystems; and preservation and expansion of forests and mangroves on land, and coral reefs at sea, creating frontline defences (Chan et al., 2010). With reference to land use and related limited habitat availability for wildlife, Singapore has two national parks: the Botanic Gardens and the Fort Canning Park, and four natural reserves: Bukit Timah, Labrador, Central Catchment and Sungei Buloh, where NParks works in conservation, protection, and management of ecosystems; restoration of degraded habitats and management of species loss; administration of public use; and inter-agency consultation. Besides the national parks and nature reserves, Singapore has an extraordinary number of varied nature areas, such as 415 public parks; 223 heritage trees; five heritage roads; 322 skyrise greeneries; and 629 community gardens (NParks; Chan et al., 2010).

Figure 7-9: Lim Chu Kang Heritage Road.

Source:nparks.gov.sg

Figure 7-10: Botanic Gardens.

Source: Author

Besides the Singapore Green Plan 2012, many initiatives have broadened horizons for greening the city, introducing innovative strategies and technologies that enable the generation of new niches for greeneries, like the spaces between and on buildings (Newman, 2013). The latter include green roofs and walls, also known as living architecture and high-rise greeneries. Other initiatives include the identification of all potential spaces for greening, like roads and streetscapes, vacant spaces, conservation of heritage trees and the green plot ratio, a new metric for greenery in architecture and planning. The green plot ratio permits the regulation of green areas on site without reducing the allowance of built-up area in a building development (Ong, 2002).

Figure 7-11: 6 Battery Rd, green wall by Patrick Blanc.
Source: Author

Figure 7-12: ITE College.
Source: Author

NParks created a number of new parks and restored areas previously disturbed by development, implementing some innovative technologies to make parks and nature reserves accessible, e.g. the Park Connectors, the HSBC Tree Top Walk, and the Reforestation and Out Reach Program (SGP 2012, 2006 edition).

The Park Connectors -PCN are linear parks and walking trails that connect parks and other natural areas forming a net that covers most of the island (see Fig. 8.13). It is under administration of NParks. Currently it extends for 200 km, and it is expected that by 2020 there will be 360 km of park connectors, reaching approximately 50% of the ultimate 700 km long extensive network planned to encircle the whole island (ura.gov.sg). Recreational activities are encouraged, such as cycling, with rental facilities, adventure courses, hiking, skating, mountain biking and camping spots, besides relevant flora and fauna conservation. The linear connectors reutilise in this way land formerly occupied by drainage reserves, foreshore, roads or rail reserves (Newman, 2013). The latest addition is the north-south Green Corridor along the old regional rail line Keretapi Tanah Meleyu, which ended its services a century ago. Open to the public since 2011, this narrow corridor of nature and history offers the opportunity to walk or cycle from the Woodlands, near the Straits of Johor, at the north of the island to the busy suburb of Chinatown, the city centre, and finally the art-deco old railway terminus station, built in 1932, in the south (Strand, 2014).

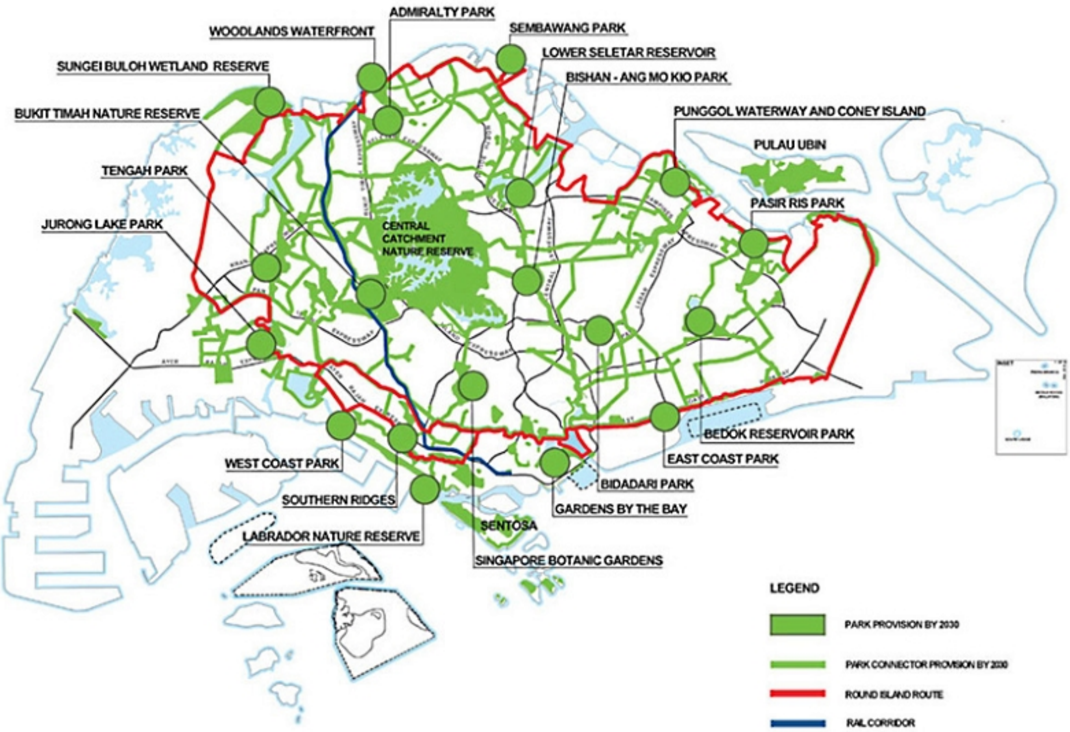


Figure 7-13: Park connectors map.

Source: ura.gov.sg/MS/walkandcycle/about/pcn.aspx

Figure 7-14: Park connectors walk and cycling.

Sources: Biophiliccities.org; nparks.gov.sg/gardens-parks-and-nature/park-connector-network

The Tree Top Walk is a free-standing suspension bridge situated within the MacRitchie Reservoir Park, one of the four reservoirs that bound Singapore’s nature reserves, within the Central Catchment Nature Reserve. It links the two highest points of the region allowing nature watching, plants and animals under the forest canopy, through the different stages of a mature secondary forest, and playing an important role in forest canopy research, an area many researchers were not able to get into because of lack of access. In this way, this bridge, besides providing recreation for Singaporeans, will facilitate surveys, plant identification work and further understanding of how forest ecosystems work (nparks.gov.sg).

Figure 7-15: Tree Top Walk.

Source: nparks.gov.sg

7.4.1 Skyrise Greenery

Also known as high-rise greenery, skyrise greenery has a significant role in contributing towards Singapore's vision of a City in a Garden. This special greening strategy has developed due to Singapore's limited land space and increased density to help mitigate UHI, improve air conditions and, consequently, to contribute to sustainable urban development. Comprising green roofs and green walls, sky terraces and landscaped balconies, skyrise greenery aims to add a new dimension to integrating greenery into urbanscapes by creating new opportunities for ecosystems and biodiversity within the built environment (Newman, 2013). It is increasingly becoming a significant component in high-density precincts for its performance in providing liveability and built-up landscape (HDB, 2013). Yok (2012) apprises that according to URA and NParks figures, by 2050 Singapore will achieve

50 ha of skyrise greeneries on buildings, acknowledging that 30 ha of high-rise greeneries have already been added to the city between 2009 and 2012.

NParks undertakes relevant research, and the development of guidelines and incentives for the promotion and implementation of skyrise greenery through seminars, publications, and awards for green roofs, vertical greenery and gardens in the sky.

This innovative technology started in the early 2000s, complemented by regulatory policies and incentives schemes. It is encouraged through the Skyrise Greening Initiative for application to residential towns, commercial and office buildings, educational and health facilities. Several policies and incentives aiming to accelerate the adoption of this innovative strategy in the city-state support its importance for Singapore's government. Among them, it is worth mentioning the Landscape Replacement Policy for Strategic Areas; Outdoor Refreshment Areas on Landscaped Roof Tops; GFA Exemption for Communal Sky Terraces, Landscaped Deck; GFA Exemption for Communal Planter Boxes; and the Skyrise Greenery Incentive Scheme that boost the urban high-rise greening (Yok, 2012).

The Khoo Teck Puat (KTP) Hospital is probably one of the most impressive buildings where benefits from biophilia are explored at their best. Opened in 2010, it is the first biophilic hospital in the world, comprising 550 beds distributed in public and private wards. Biophilic features have been incorporated into the building's architectural project from the beginning, including multilevel gardens, vegetated courtyards with ponds holding 92 species of fish, green walls and a green roof containing an edible garden that produces medicinal herbs, vegetables and fruits for the hospital's kitchen and is run as a community garden by volunteers (Newman, 2013; Newman, Beatley and Blagg, 2009). A growing body of research is demonstrating the many benefits in health and wellbeing, such as reduction of blood pressure and heart attacks, quicker recovery of patients after surgery, less use of painkillers, among others.

Figure 7-16: KTP hospital, multilevel gardens and green roof.

Source: Author

Singapore's limited land space and increased density needed a solution to help mitigate UHI, improve air conditions, and humanise tall buildings and high-rise living. Skyrise greenery seemed to be an appropriate innovative technology to tackle these kinds of challenges. High-density precincts present a number of critical issues such as temperature, energy efficiency and disconnection from the surrounding environment, among others. Built-up areas may be up to four degrees Celsius hotter than forested areas; in this case, greenery performs as a heat insulator contributing to reduce energy consumption; it also absorbs rainfall, reducing flood risks, and if well installed it can help in diminishing maintenance costs (Auger, 2013). Nevertheless, Yok (2012) advises that more research is necessary to obtain accurate data about performance issues.

Skyrise greenery can be implemented into and on buildings according to various typologies and it became an integrated part of the building rather than an aggregate. It is considered by an increasing number of architects as a primary strategy to define liveable spaces (WOHA, 2013). Skyrise greenery typologies comprise green roofs and green walls, sky terraces and landscaped balconies, as seen in Figure 7-17:

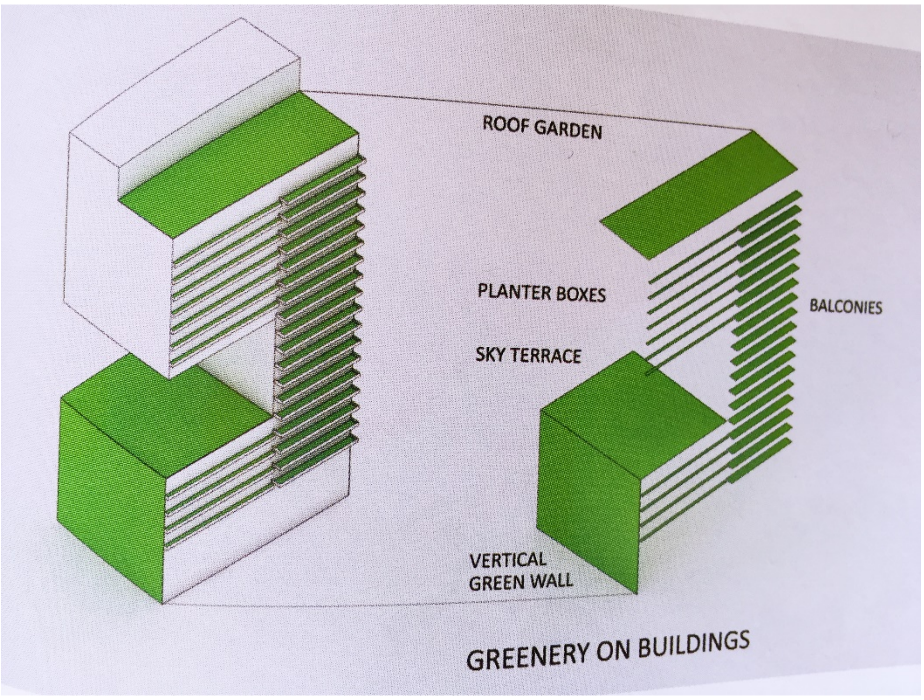


Figure 7-17: Skyrise typologies.

Source: A+U, 2012

Singapore's climate is favourable for this green technology, with suitable temperatures, frequent rains, air humidity and, importantly, low speed winds that allow plants to thrive on high-rise surfaces.

Initially developed in the early 2000s by HDB for application on top of carpark buildings in the housing towns, the initiative developed technically, functionally and aesthetically to the extent of creating "a unique, green identity in the high-rise spaces of Singapore" (Yok, 2012, p.140).

High-density precincts have quickly adopted high-rise greenery for its capacity to soften hard, reflecting concrete surfaces, vertical or horizontal, such as facades and car park roofs, bringing new green open spaces to use and enjoy, while contributing to lower tropical temperatures and make more attractive and visually relieving the views from apartment windows and streets. In other words, skyrise greenery is appreciated for its performance in providing liveability and built-up landscape (HDB, 2013). Yok (2012) apprises that according to URA and NParks figures, by 2050 Singapore will achieve 50 ha of skyrise greeneries on buildings, acknowledging that

30 ha of high-rise greeneries have already been added to the city between 2009 and 2012.

In order to support design and installation of skyrise greenery, HDB developed the Landscape Guide, which provides design and technical support. The aim is to address the social value of understanding the role of landscape design as a provider of spaces for community use with adequate aesthetic and environmental performance, principles embedded in the Design guidelines: “Community-friendly, Environmentally-sensitive and Aesthetically-pleasing” (HDB, 2013, p.15).

Regarding rooftop greenery into HDB estates, the Landscape Guide provides different designs, adaptable to several architectural typologies to enhance thermal, environmental and aesthetic performance in their residential towns, as can be seen below:

- **The rooftop garden** on top of the multi-storey car park serves as an additional landscaped space for activities such as strolling, playing, exercising and meeting with friends.

INTEGRATED MSCP ROOF GARDEN

Main landscape space of precinct,
provides greenery and recreational spaces.

MSCP: Multi-Storey Car Park

Figure 7-18: Integrated MSCP roof garden

Source: HDB Landscape Guide

- **Landscaped deck** bridges the level difference across the site, and is planted with thick foliage and equipped with benches and seating corners at the courtyards for casual meetings and relaxation.

LANDSCAPE DECK GARDEN

Designed to integrate seamlessly with the natural ground landscape, especially for sites with a difference of levels.

Figure 7-19: Landscape deck garden

Source: HDB Landscape Guide

Punggol Breeze is a development displaying one of the most recent designs of an integrated multi-storey car park, equipped with full facilities at the rooftop garden for residents to enjoy the outdoors and to participate in recreational activities.

Figure 7-20: Punggol Breeze.

Source: Author

Figure 7-21: Green roofs typologies. Common Green at Punggol Breeze.

Source: HDB Landscape Guide

- Recent high-rise residential developments, such as Pinnacle@Duxton with fifty storeys, incorporate a new high-rise greenery concept including landscaped areas at different levels to mitigate the effects of living at great heights. Pinnacle@Duxton encompasses a roof garden on the 50th floor, a landscaped jogging trail on the 26th and a landscaped roof on top of the car park.

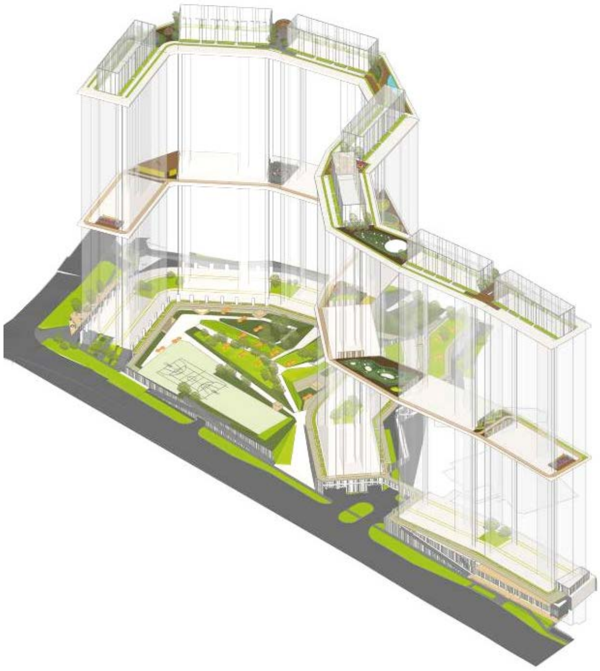


Figure 7-22: Pinnacle@Duxton.
Source: HDB Landscape Guide

Figure 7-23: Pinnacle@Duxton.
Source: www.livablecities.org/articles/high-density-livability-question

Yok (2012) argues that skyrise greenery in Singapore has proven to be beneficial in adding value, creating liveable spaces and, additionally, in developing a sense of identity in buildings. He acknowledges three central issues in this process:

- The intensity of installations, Singapore retains a remarkable proportion of skyrise greeneries in comparison to other cities due to its compactness. Thus, there is an advantage in creating visibly elevated greenery in the city; Yok recommends incorporating this advantage in growing precincts.
- The distinctiveness in architectural projects, where greenery is an inherent part of design (see examples in Figure 8-24).
- The proliferation of sky terraces in the city that seems to be a local phenomenon, probably in response to URA's incentive. However, it is also a local innovation, a new type of greenery suitable for tropical climates, because it is a semi-open space sheltered from the sun, which makes it usable during daytime, and can be built on intermediate floors, like the 26th floor at Pinnacles@Duxton (see diagram in Fig. 8-24).

School of Arts, WOHA architects[1]

Solaris Building, Ken Yeang architect[2]

Parkroyal at Pickering,

WOHA architects[1]

Parkroyal at Pickering, Sky terraces

WOHA architets[1]

Figure 7-24: Skyrise greeneries.

Sources : [1] *www.google.com.au/search?q=WOHA+Singapore&newwindow*
[2] *www.google.com.au/search?q=solaris+singapore&newwindow*

7.4.2 New era of greening programs

The Natural Green & Blue Master Plan, created by the Urban Redevelopment Authority-URA, is part of the Master Plan 2014. It boosts the creation and conservation of new green areas and waterways with eased public access, and provides for recreational and educational uses. These new developments are developed according to sensitive design guidelines aiming for the protection of existing ecosystems and environments in various parts of the island. The north region will increase the existing 700 ha of parks with another 200 ha, and will add 25 km to the Northern Explorer Park connector. Sungei Buloh Wetland Reserve will be enriched with the addition of 38 ha of new wetland park, including recreational and educational facilities such as a trail network for exploration and discovery and experiential learning, protecting and enhancing local habitats for biodiversity at the same time. The Kranji Marshes exemplify this methodology. The Natural Green and Blue Master Plan also includes the creation of a new green amenity, the Destination Parks which are parks that, besides the recreational function, serve as "pilots to test various sustainable features in a tropical climate" (Urban Redevelopment Authority). Three destination parks have been planned: the Admiralty Park in the north region; the East Coast Park in the south eastern region; and the Jurong Lakes Park in the south western region (ura.gov.sg).

In the new current vision "City in a Garden", the emphasis is on urban sustainability and mitigation of climate change effects. The vision calls for the revamp of urban parks and rejuvenation of streetscapes. Parks are now multifunctional green spaces encompassing environmental and social functions; on the biophysical aspect, they serve as carbon sinks, as places for biodiversity enrichment, and as pilots to test out sustainable features designed to solve problems related to the tropical climate such as abundant rainfall, high temperatures and fast evaporation. At the same time, on the intangible aspect, these new parks promote social gatherings, recreational activities and provide for social and cultural events (Ling, 2011; Ma & Guek, 2012). This concept reveals a shift in thinking about parks that suggests facilitating human and natural systems co-evolution.

The new concept of parks embeds different typologies that vary according to scale and purpose. The Destination Parks are large regional parks offering special amenities not found in urban parks, which were suggested by the public during an exercise of community engagement conducted by NParks. The aim is to attract people from all parts of the island optimising their use. Three parks have been selected for transformation into Destination Parks according to their location and unique features: Admiralty Park at the North, East Coast Park in the East, and Jurong Lakes Park at the West (NParks, 17 Mar 2012). An interesting example of this category is the Southern Ridges, consisting of a nine-kilometre chain of consecutive open and green spaces interconnecting the existing hill parks through two elevated bridges. The elevated bridges, trails and boardwalks give access to a variety of local fauna and flora species that can be observed in their own habitats, without disturbance, while enjoying the continuous recreational spaces in addition to the views of the city. Southern Ridges encompasses a nature sanctuary and innovative design and offers access to a nature reserve from an advantage point (Ling, 2011).

Figure 7-25: Southern Ridges.

Source: www.google.com.au/search?q=southern+ridges+singapore&newwindow

Another example of the new generation of parks is the eco-nature neighbourhood park, built within HDB housing towns. These parks incorporate eco-friendly landscape design, such as land forming and drainage systems, greeneries that improve micro-climatic conditions, easy maintenance and functions like serving as a green lung for dense built environments, considering that each HDB residential town houses from five to six thousand families. Greenwood Sanctuary @ Admiralty is an example of this typology (Ma & Guek, 2012).

Figure 7-26: Greenwood Sanctuary @ Admiralty Eco-nature Park.

Source: *www.google.com.au/search?q=Greenwood+Sanctuary+@+Admiralty&newwindow*

7.4.3 The Active, Beautiful and Clean (ABC) Waters Program

The ABC Waters Program is part of the City in a Garden vision, developed by the Public Utilities Board -PUB, that aims to "[unlock] the hidden potentials and opportunities of Singapore's waterways and reservoirs" (Malone Lee and Kushwaha, 2009, p.7), integrating water infrastructure into the urban fabric to facilitate community access to water, embracing and enjoying contact with the waterways as appealing and positive elements within landscaped urban environments.

A significant example of this program is the Bishan Ang Mo Kio Park, in the Central catchment. It is a water-sensitive urban design intervention, designed and developed by the Atelier Dreiseitl, that has multiple functions. It enhances the aesthetic qualities of the site; cleanses the Kallang River's waters through special species of plants that filter the waters, cascades, and bio-engineered processes; improves connectivity between the housing estates and the park; and provides leisure and educational activities to the community, promoting contact, awareness and sense of ownership. The Kallang River had been previously canalised into a concrete monsoon canal to prevent floods. The project returned the river to nature, leaving it free to meander and recover its natural cycles, patterns and flows. Opening and integrating the river to the park enabled the return of birds, otters, fish, butterfies and other insects; the park was reforested with native trees and plants to restore the original vegetation, and the concrete removed from the canal was recycled and reused in the river banks to help contain the volume of water during the monsoon season (Malone Lee and Kushwaha, 2009; PUBsg, 2013).

Figure 7-27: Bishan Ang Mo Kio Park.

Source Nparks

The Marina Barrage is another example of water infrastructure incorporated into the urban fabric integrating three beneficial functions: water reservoir, flood control and leisure activities for the community.

According to Malone Lee and Kushwaha (2009, p.81-82), the ABC Waters Program is a transformative process because it "reclaims these waterways for the city and integrates them back into the fabric of the city to enhance its overall visual and urban qualities". They also note that transformative processes in relation to "thinking and policy, include three significant shifts:

- Shift from cost to value: add value to the city instead of cost burden.
- Shift from mono-use to multi-functionality: from basic flood control and water conveyance to multiple use for beautification, cleansing and community engagement.
- Shift from economic necessity to social life relevance: progressing from seeing water infrastructure as needed engineering elements – totally detached from community – to facilities that contribute to social life, and community wellbeing" (Malone Lee and Kushwaha, 2009, p.82).

ABC Waters Program has a comprehensive master planning approach that includes guidelines for all recognised watersheds which are receptive to the characteristics of each area, recommending functional and design adaptations to each case, safety and protection of water quality, and integration with natural ecosystems and biodiversity (Malone Lee and Kushwaha, 2009).

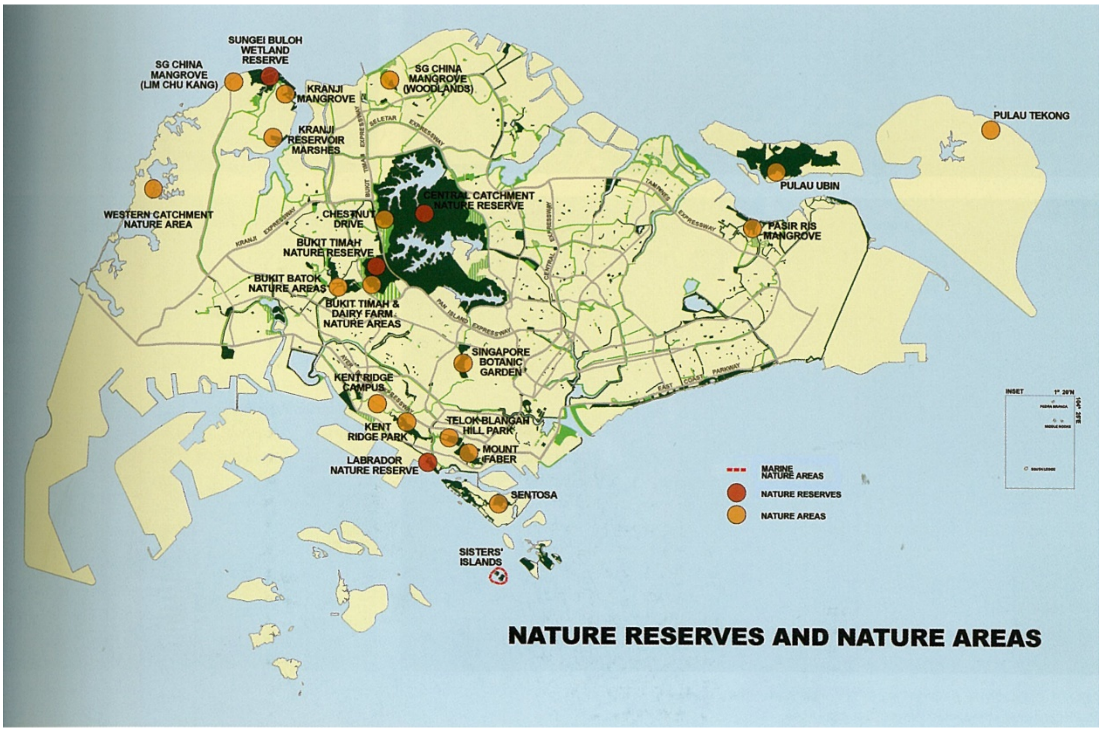


Figure 7-28: Nature reserves and nature areas map. Source: URA

The analysis suggests that alternative pathways to urban regenerative sustainability may be possible.

Biophilic strategies and practices in Singapore

Type of initiative	Quantity	Creation/management
Natural reserves	4	NParks
Parks	415	NParks
Destination parks	3	URA/NParks
Heritage roads	5	NParks
Skyrise greeneries	322	URA/NParks
Community gardens	629	HDB/NGOs
Park connectors	300 km	NParks
Tree Top Walk	1	NParks
Biophilic R&D (Hort Park)	1	NParks

Table 7-1: Biophilic strategies and practices in Singapore

Author, based on Nparks data (nparks.gov.sg)

7.5 Environmental policies, incentives, and campaigns

Singapore's making envisioned the transformation of the city into an oasis in Southeast Asia with first world standards to attract businesses and tourism (Lee K.

Yew). A number of institutions were created to manage environmental issues, among which was the setting up of a pioneering Ministry of the Environment in 1972, to monitor environmental protection. In the 1990s, it became the Ministry of Environment and Water Resources to address the increasing complexity of urban development issues, incorporating two statutory boards. The first is the National Environmental Agency–NEA, created in 2002 to safeguard air, land, and water resources. It ensures public health at high standards and encourages citizen ownership of air, land, and water as a strategy for sustainability. The second is the Public Utilities Board-PUB, which guarantees efficient, sufficient water supply. It safeguards the improvement of fresh water quality and its affordability to the citizens (CLC, 2012).

The National Parks Board-NParks, former Parks and Recreation Department, is another key statutory environmental board. Empowered to be entrusted to the Ministry of National Development in the 1990s, it congregates authority and expertise to achieve the strategic task of implementing the City in a Garden vision. The Botanic Gardens and the Centre for Urban Greenery and Ecology-CUGE, a research centre that delivers training courses and maintains partnerships with academia and the landscape industry, are under NParks' direction.

Closely integrated work by the different government agencies and stakeholders is an essential factor for successful outcomes. Therefore, URA adopted a new approach to urban design and planning, introducing long-term integrated planning driven by a strong vision and inter-agency collaboration. For example, the collaborative work between NEA and URA to ensure that master planning integrates the environmental issues. This approach, initiated in the early 1970s, remains a keystone of the country's success (CLC, 2012).

Investments in infrastructure and technology played a fundamental role in protecting the environment. The most relevant are the early investments allocated to an incineration plant to reduce solid waste in the landfill, a plant for wastewater treatment, and the construction of sewers (CLC, 2012). These investments started when Singapore was a poor country and resulted in various benefits for the population such as contributing to a cleaner environment while consolidating and improving citizens' health and quality of life. Being a highly dense city, the danger of rapid transmission of diseases in Singapore is substantially augmented. Therefore, in order to highlight the recognition that public health is closely dependent on a clean environment, public health is under the responsibility of the Ministry of the Environment instead of the Ministry of Health. Moreover, it is reinforced by public education measures to create awareness about responsible environmental practices and public health (CLC, 2012).

It is important to note that there are a number of standpoints sustaining successful environmental strategies. One is "the willingness in taking proactive steps before the need arrives"; another is choosing "forward-looking policies and proactive investments to underlie environmental standards". And more recently, "the next step: to encourage citizens to take greater personal ownership of the environment by fostering a stronger sense of social responsibility" (CLC, 2012, p.4).

Thus, Singapore's accomplishment of environmental protection required the support of a strong policy framework. Legislation is essential for good governance; laws provide clear structures to environmental policies outlined by the government, which define acceptable behaviour and penalties but must be underpinned by effective enforcement (CLC, 2012).

7.5.1 Main environmental laws and policies

In terms of legislation, the *Planning Act* controls land use, which is one of the most important issues in biodiversity and nature conservation. The *Environmental Protection and Management Act* consolidates the laws relating to environmental pollution control, provides for the protection and management of the environment and resource conservation, and for purposes related to the mentioned issues (Singapore Statutes Online, n.d, b).

The *National Parks Board Act 2005* establishes and empowers Nparks as a statutory board of government. The *Parks and Trees Act* oversees all parks and reserves, their status, as well as all actions and provisions pertaining to these areas including the absolute protection of all plants and animals included in them. Other legislation such as the Wild Animals and Birds Act 1965, and the Public Utilities (Catchment

Area) Parks Regulations 2006 protect animals and birds that are outside NParks areas; the *State Lands (Encroachment) Act* also applies to marine areas, administrating resources extraction and protecting all kinds of living organisms, including coral reefs.

Besides its national legislation, Singapore also participates in international conventions related to biodiversity conservation, such as the UN Convention on Biological Diversity – CBD; the UN Framework Convention on Climate Change – UNFCCC; UN Convention to Combat Desertification – UNCCD; the Convention on International Trade of Endangered Species of Wild Fauna and Flora – CITES (Chan et al., 2010).

In 2002, the Ministry of the Environment and Water Resources presented *The Singapore Green Plan 2012*, a government document containing the strategies to set out the change of vision: moving from a clean and green city, or “Garden City” towards an environmentally sustainable city, a “City in a Garden” (Newman, 2013). The Green Plan guides government actions in six focus areas: air and climate change, water, solid waste, nature conservation, public health and international cooperation.

Regarding nature conservation, the *Nature Reserves Recreational Master Plan* outlines NParks role in order to meet public demand for access to natural reserves while protecting native flora and fauna. The master plan determined core areas rich in biodiversity for conservation and research only, permitting recreational activities at the fringe of these areas and carefully managing their access to minimise impact.

The HDB Landscape Guide is a document created by the Housing and Development Board considering landscape design as an integral and significant component of public housing development. It orients landscape design in the Housing and Development Board’s residential towns with the aim of meeting the rising expectations of its residents, creating more liveable environments and focusing on sustainable issues. The Guide provides a broad scope of design typologies and methodologies such as:

- Variety of facilities and structures for playgrounds, community gardens, gathering places;
- Hardscape and softscape solutions not only to provide shade, but to enhance the quality of public spaces;
- Introduces new concepts such as water-sensitive urban design, skyrise greenery and biodiversity;
- Contributes to create a sense of place by endearing homes and providing public spaces that are conducive to foster community ties;
- Adds to the greening of Singapore, given the massive scale of HDB developments.

Humane environments can promote quality living in highly dense precincts such as Singapore.

Cities Biodiversity Index - United Nation's Convention on Biological Diversity and NParks.

It is a self-assesment tool for cities to benchmark and monitor the progress of their biodiversity conservation efforts against their own individual baselines. It comprises two parts: the first is the Profile of the City, comprehensive information about the city's background; the second is the city's self assessment of the 23 indicators based on the guidelines and methodology provided. The Index was originally designed as a monitoring tool, but it has other important uses: a) the indicators can be used as guidelines on how to conserve and enhance biodiversity in cities; b) it can be utilised not only in cities but also at different scales, like districts, states or provinces, and regions; c) can be incorporated as a biodiversity component of broader environmental indices, e.g., certification processes (Chan, 2012).

7.5.2 Greening programs

Active, Beautiful, and Clean- ABC Waters Program – Public Utilities Board-PUB, 2011. This master plan was created to improve water protection and community awareness of the importance of keeping waterways clean. Through this program, streams and rivers were freed from utilitarian canals and drains and transformed into important parts of parks, where communities can enjoy recreation and learn about the value of water. An exemplary outcome is the Kallang River at Bishan-Ang Mo Kio Park, designed with the collaboration of Herbert Dreiseitl Atelier, creating the first bioengineering project of this type in the city-state (Newman, 2013). Singapore's water resources have been given top priority since the early years of independence, due mainly to resource scarcity and population growth. To improve the management of water in the country, PUB applied three strategies to integrate the complete water loop: first, collect the possible maximum of rainwater; second, create a system to recover wastewater as much as possible; third, reuse wastewater. In the views of PUB, Singapore has now a sustainable water supply strategy called The Four Taps, comprising water from the catchment reservoirs; imported water; NEWater (recycled), and desalinated water (Leong, 2012).

Green Mark Scheme – Building Construction Authority- BCA. This initiative aims to reduce the environmental impact of building practices, comprising design, construction technologies and materials, also to reduce energy consumption. The scheme includes varied building scale developments, residential and non-residential (Newman, 2013).

Community in Bloom and Community in Nature are two volunteer programs under Nparks aiming to foster a gardening culture. The first is about people working with their hands where they live, in Housing Development Board's dwellings or private properties, improving their gardens and attracting life to their doorsteps, because "when people work with their hands, they get attached to where they are" (Lena Chan, A+U, p.103). The second program invites young people to do internships of volunteer work with NParks in nature reserves, parks, and park connectors. In Chan's opinion, the health and wellbeing benefits that people get from the interaction with wildlife in the urban realm is due to the fact that Singapore is a biophilic city, one in which residents enjoy natural life and biodiversity close to their homes and working places.

The *Reforestation and Out Reach Program* involves volunteers, community and schools in the activities of replanting native species in natural reserves. It has reforested 71.6 hectares between 2004 and 2006 (SGP 2012, 2006 edition; Newman, 2013).

Skyrise Greenery Incentive Scheme 2.0 (SGIS). Introduced by National Parks Board, this scheme aims to encourage implementation of green roofs and green walls. NParks funds up to 50% of installation costs of any of these greeneries**.** Since its introduction in 2009, SGIS helped in greening more than 100 existing buildings in Singapore, introducing a variety of uses: extensive green roofs, edible gardens, recreational rooftop gardens, and green walls. SGIS 2.0 is the improved version of the incentive scheme, "which features a revised maximum cap for both rooftop greenery and vertical greenery. SGIS 2.0 hopes to facilitate the development of a more lush and pervasive greenery in our built environment by encouraging more intensive forms of landscaping on built forms" (*skyrisegreenery.com/index.php).*

Summary of environmental protection policy framework

Planning Act	
Environmental Protection and Management Act	Nparks
Parks and Trees Act	Nparks
Wild Animals and Birds Act 1965	Nparks
Public Utilities (Catchment Area) Parks Regulations 2006	Nparks
State Lands (Encroachment) Act	Nparks
The Singapore Green Plan 2012	Ministry of the Environment & Water Resources
Nature Reserves Recreational Master Plan	Nparks
ABC Waters Program	PUB- Public Utilities Board
Green Mark Scheme	BCA– Building Construction Authority
Community in Bloom and Community in Nature	NParks/NGOs
Reforestation and Out Reach Program	NParks/NGOs
Skyrise Greenery Incentive Scheme 2.0 (SGIS)	Nparks

Table 7-2: Summary of environmental protection policy framework - Singapore

Source: Author

7.6 Analytical strategy applied to Singapore

Similarly to the Curitiba case study, the analytical strategy for Singapore was organised in three phases. First, the consideration of local urban planning traditions and processes; second, the application of the framework to Singapore in this case; and finally, the cross-case analysis to be conducted in Chapter 8.

This analysis looked for understanding how and why the urban transformations emerged, what supported them and how they were implemented, as well as local context. The analysis was conducted by the following questions:

- Why did this specific process of urban transformation occur in Singapore and not in any other city in the region?
- Were there any precedents, national or international?
- How did it happen and how was it conducted?
- Is there any evidence of a shift in the process of thinking about urban planning?
- How did this shift reflect on urban design and planning?

7.6.1 Urban planning traditions and processes analysis

As in Curitiba's case, a thorough examination of Singapore's planning history and the consideration of theories and practices used in the process, their evolution and innovations were relevant to answer these questions. Main findings related to local urban planning traditions and processes include in the first place a strong visionary leadership encouraging and firmly supporting the urban transformation ensuring political will and continuity; robust evolving visions founding the transformative process; and planning methodologies incorporating innovative strategies.

Leadership in Singapore

According to historic data (see section 7.3), Singapore urban makeover started just after independence in 1965, defining the city-state country. It was driven by a strong and well-defined vision based on economic development toward being a regional model city. This approach empowered urban planning as a highly centralised government function aiming to optimise Singapore's scarce land resources. This was reflected in the creation of two boards at first level of government: the Urban Redevelopment Authority-URA, responsible for long-term planning for the city as a whole, and the National Parks Board-NParks, focussed on the environmental aspect, developing strategies and programs committed to achieve the first vision of "Garden City", and currently the evolved version of "City in a Garden". The strategy of setting the boards at the first level of government facilitates fast decision-making and ensures strong political leadership, enabling long-term planning projects and infrastructure.

Robust evolving visions

The urban transformation was achieved oriented by clear visions for the country's development, done with great confidence and determination to transform Singapore into an oasis in Southeast Asia, with first world standards to attract business and tourism (Auger, 2013). The city visions have been implemented by NParks; the first one, Garden City was launched in 1963 aiming for a clean and green city, and the current vision City in a Garden established in 2012, is committed to strengthen Singapore as a distinctive liveable city. The scope is the whole territory, and includes the integrated work of URA, NParks and HDB-Housing Development Board. The National Environment Agency worked closely with URA to ensure that environmental issues were integrated into masterplanning.

Planning methodologies, from modernist approach to biophilic strategies

To achieve the vision of Garden City and sustainable development, the new city-state needed to construct an attractive image embedding attention to social needs and quality environment. However, Singapore had no relevant previous tradition in urban planning, and consequently not many design practitioners at the time. Foreign renowned architect-urbanists were hired to contribute to the first conceptual plan such as Kenzo Tange and I. M. Pei, in 1971. Therefore, Singapore's early planning stems from the modernist city, the prevalent approach to urbanism at the time. This approach, reflecting Le Corbusier's concept of the Vertical garden city, still visible in Singapore, guided the city's long-term land use and transportation system, including an island-wide expressway system plus a Mass Rapid Transit system connecting the housing towns with the town centre and Jurong. Later, with the evolution of town planning, the Corbusian concept was developed and improved. Moreover, a large part of the most remarkable landscape and architectural projects are authored by overseas practitioners.

URA formatted and implemented the planning philosophy that guides Singapore's development since 1974, based on master planning, updated every five years. Government keeps a tight control over the development of all land in the island, which is subject to regulation of land use through stipulated zoning. At the macro level, planning envisions a compact, polycentric transit-oriented city with extensive greenery and highly liveable housing towns; at the micro level, the residential sector follows resource efficiency through green building design, and the industrial sector pursues more energy efficiency practices (Ng Lang, 2012).

Innovative thinking in planning reflects in Singapore's meaningful relevance to the greening of the city, elevating it to a first-level government issue. City greening was achieved in Singapore through the implementation of successful strategies, many innovative technologies and, importantly, being oriented to the improvement of biodiversity. NParks, in collaboration with the United Nation's Convention on Biological Diversity, set up a National Biodiversity Centre that launched the Singapore's Biodiversity Index, a tool to measure urban biodiversity performance across the world (UNEP 2012; Newman, 2013; UN-Habitat, 2012-2013). The main pressures affecting biodiversity in Singapore derive from land use, limited habitat availability and climate change. To tackle this challenges, the city-state invested in legislation, masterplanning and education as essential provisions. Climate change challenges are acknowledged, and various mitigation strategies are taking place, such as extensive use of greeneries between and on buildings (Skyrise greeneries); creation of nature reserves aiming to protect, conserve and manage remaining native species and ecosystems; and preservation and expansion of forests and mangroves on land, and coral reefs at sea, creating frontline defences (Chan et al., 2010).

7.6.2 Framework application to Singapore

I also used the matrix as an analytical tool to analyse how relevant initiatives in Singapore performed in relation to the theoretical principles and if they could be considered examples of urban regenerative sustainability practices or conducive to them.

The analysis process is the same used in the Curitiba case study, and conducted by the questions:

- What type of practices and policies observed in Singapore align with the theoretical principles contained in the framework?
- How do the practices /policies reflect them?
- What kind of findings could be considered as leading to urban regenerative sustainability?

For this Singapore case, I selected the Green Plan, Skyrise greenery, and ABC Waters Program as specific urban interventions.

Table 7-3 below shows the Regenerative sustainable urbanism analytic matrix application to Singapore.

Regenerative Sustainable Urbanism Analytic Matrix - Singapore								
Theoretical principles	**Place**	**Progressive human-nature relationships**	**Pattern literacy**	**Development & design**	**Ecosystem services**	**Community engagement**	**Liveability (Co-evolution)**	**Beauty**
Policy	Planning Act; Concept plan Master plan Green Plan 2012 Zoning policies SGIS; NGBMP;	Green Plan 2012 SGIS; P&TA; NRRMP	Green Plan 2012	Planning Act; EPMA SGIS; Green Mark Scheme; Green Plan 2012;	Green Plan 2012 EPMA; CBI Green areas protection; Green incentives;	Public-private partnerships: co-responsibility Green Plan 2012	Green Plan 2012	Cultural and natural heritage preservation Green Plan 2012
Practice	Ring concept plan MRT; ABCWP; Green Plan 2012 Placemaking; Skyrise greenery	Green Plan 2012 Park connectors; Tree top walk; Destination Parks; Heritage roads and trees; Skyrise greenery; ABCWP	Heritage roads; Parks; Natural reserves ABCWP	MRT; Skyrise greeneries; Hort Park; ABCWP; Green Plan 2012 Tree planting campaign	Green Plan 2012 ABCWP; Skyrise greenery; Eco-nature neighbourh'd parks Natural reserves Destination parks;	Green Plan 2012; Community gardens; ABCWP *Community in Bloom/ in Nature*;	Concept plan; Natural Green &Blue Master plan; Cultural change, Civic pride ABCWP; Skyrise greenery	City beautification; Heritage roads and trees ; ABCWP; Skyrise greenery Streetscapes; Parks

Table 7-3: Regenerative Sustainable Urbanism Analytic Matrix – Singapore
Source: Author

EPMA: Environmental Protection and Management Act; SGIS: Skyrise Incentive Scheme; P&TA: Parks and trees Act; CBI: City Biodiversity Index; NRRMP: Natural reserves Recreational Master Plan; ACCWP: Active, Beautiful and Clean Waters Program; NGBMP: Natural Green & Blue Master Plan

The Green Plan 2012

The Green Plan 2012 contains the current forward-looking City in a Garden vision that shifts the aim towards sustainable development and liveability. The three core pillars of this vision are pervasive greenery, infusing biodiversity into the urban landscape, and community involvement, promoting active participation, ownership and pride within the population to sustain the vision (Yuen, 2012). As such, it matches most of the theoretical principles, both in the policies and goals, and in the new practices. Green Plan 2012 relates to *Place and Progressive human-nature relationships* in that it enhances the sense of place founded in abundant and easy access to nature achieved through the previous vision, through placemaking, creating a culture of connection to nature. *Beauty* is addressed with the provision of designed landscapes that offer opportunities of aesthetic experiences as well as physical and psychological connection to nature, which potentially promotes attachment, ownership and stewardship to place.

The new vision imposes a shift to the concept of green spaces moving away from the predominantly functionalist approach of the previous vision, incorporating a new concept of parks as multifunctional green spaces encompassing environmental and social functions. In this sense, it matches *Development and Design*, and opens the opportunity to potentially address *Community engagement* and *Liveability. Development and Design* is also evident in the continued investment in green spaces despite land scarcity and large population. Singapore did it as an initiative to build a healthy habitat for its large population housed in high-density estates, and as a strategy to attract investment and tourism.

Regarding *Ecosystem services*, a series of programs and policies are developed within the scope of the Natural Green & Blue Master Plan, according to sensitive design guidelines aiming for the protection of existing ecosystems and environments in various parts of the island, including the revamp of urban parks and rejuvenation of streetscapes.

The Green Plan 2012 also includes other innovative green technologies such as skyrise greenery that is remarkably increasing the green ratio in both residential and commercial precincts, and the ABC Waters Program, involving a sensitive design approach to waterways.

Skyrise greeneries

This special greening strategy is also an essential component of sustainable development, performing positively in various aspects, such as *Ecosystem services, Progressive human-nature relationships, Place, Beauty, Development and Design, and Liveability.* It contributes to urban ecology, as it aims to add a new dimension to integrating greenery into urbanscapes by creating new opportunities for ecosystems and biodiversity within the built environment (Newman, 2013). Socially, skyrise greenery improves access to and intimacy with nature and its benefits for people who live and work in high-rise buildings, while alleviating pressure on land use (Yok, 2012), developing patterns of relationships between nature and people, providing psychological comfort health and wellbeing to building occupants and surrounding urban spaces.

Regarding *Ecosystem services,* it is worth noting that these high-rise gardens, depending on the selection of plants, can perform as stepping stones for plants, birds and insects if they are part of larger ecological networks, contributing in this way to urban biodiversity (Yok, 2012). This issue also opens a new field of architectural and urban design that calls for integrative, multidisciplinary work, and for further development of knowledge and skills.

The Active, Beautiful and Clean (ABC) Waters Program

The ABC Waters Program, developed by the Public Utilities Board -PUB is part of the Natural Green and Blue master plan (URA). It aims to "[unlock] the hidden potentials and opportunities of Singapore's waterways and reservoirs" (Malone Lee and Kushwaha, 2009, p.7), by integrating water infrastructure into the urban fabric to facilitate community access to water. It is an initiative that matches most theoretical principles of regenerative sustainable urbanism, such as *Place, Development and design, Ecosystem services, Progressive human-nature relationships, Beauty, Liveability,* and has potential to address *Community engagement.*

The idea is that by promoting opportunities to embrace and enjoy contact with the waterways, the population find them appealing and positive elements within landscaped urban environments, and that this experience can lead to a sense of ownership and pride that sustains the vision (potential *Community engagement*, *Liveability*). This is a completly different approach to designing infrastructure and delivering public services that reveals a shift in the way of thinking about the built environment in Singapore. As pointed out by Malone Lee and Kushwaha (2009), the ABC Waters Program is a transformative process because it moves the functionalist nature of the previous vision interventions to innovative thinking and policy, shifting from cost to value; from mono-use to multi-functionality, including beautification, cleansing and community involvement; and from economic necessity to social life relevance.

A significant example of this program is the Bishan Ang Mo Kio Park, in the Central catchment. This is a water-sensitive urban design intervention, designed and developed by the Atelier Dreiseitl, that has multiple functions and gives evidence of addressing the principles above mentioned (see description in section 7.4.3). The Marina Barrage is another example of water infrastructure incorporated into the urban fabric integrating three beneficial functions: water reservoir, flood control and leisure activities for the community.

The matrix shows as well that the practices' success is underpinned by inducements and legislation (described and summarised in section 7.5).

Chapter 8

Cross-case analysis and discussion of results

This chapter discusses the cross-case analysis of Curitiba and Singapore, and the subsequent results. The aim is to see convergences and disparities in both cities' processes related to the integration of social-ecological approaches into their urban planning methodologies and how this initiative motivated their pathways toward urban regenerative sustainability; what was the influence in producing regenerative processes, and if there is reciprocity between their processes, practices and policies.

As stated in Chapter 5, the framework is not projected to use pragmatic measurable indicators; instead, it provides a guide to observe the emergence of regenerative practices from the application of social-ecological approaches to urban design and planning. It was used as an analytic tool and was applied to both cases through a replication approach. The cross-case replication approach was designed and conducted according to Yin (2009). It was believed to show literal replications, so convergence of outcomes has been sought.

8.1 Cross-case analysis

Cross-case analyses each case as a separate study to test the theoretical proposition, *"The implementation of integrated planning initiatives founded on social-ecological approaches to urbanism can lead to regenerative sustainability in cities"*, arranging and displaying the data for analysis, then captures and discusses the results of both cases (Yin, 2009) responding to the guiding questions.

It was predicted, as per the theoretical proposition that evidence of urban regenerative sustainability was likely to be found in both cities given the successful urban transformations both cities went through, considering their urban design and planning philosophies and methodologies.

Guiding questions:

- Which commonalities and dissimilarities were found?
- Convergence of evidence
- Do both cases suit the theoretical proposition?
- What has constituted supportive evidence in each case, relevant to answering the research question?
- To what extent can the findings be replicated or generalised?

8.1.1 Commonalities and dissimilarities, convergence of evidence

Regarding commonalities and dissimilarities, it should be noted that both cities have different geographical and cultural contexts, yet both based their developments on clear visions as starting points, safeguarded by strong leadership, political will, and institutional consolidation that ensured continuity in their processes. In addition, both of them have been globally renowned by their exemplar experiences of integrated urban design and planning, policies and master plans implemented. Results from the analysis of urban planning traditions and processes are organised showing convergences and dissimilarities in Table 8-1 below:

	Curitiba	**Singapore**
Local knowledge and planning traditions	Yes	No
Urban planning approach	Jacobs' ideals; environmentalism	Modernist
Innovation in planning strategies	Yes	Yes
Provision of green open spaces	Yes	Yes
Urban governance	Visionary leadership	Visionary leadership
Citizen participation	No	No

Table 8-1: Convergences and dissimilarities in urban planning traditions and processes

Source: Author

Curitiba had a previous relevant urban planning tradition started in the 19th century; Singapore did not, the makeover process started right after independence, in 1965. However, both cities pioneered this type of urban transformation in their countries and regions by building upon influential visions and leadership to attain their developmental objectives.

Both cities share as well the integration of a social-ecological approach in urban design and planning as a technology to produce urban transformations such as the creation of abundant green urban space, public transportation systems, and economic growth through the attraction of non pollutant industries, as shown in Table 8-2 below:

Innovative urban strategies		
Strategy	**Curitiba**	**Singapore**
Spatial form	Structural axis: linear growth	Ring plan: high density, vertical growth
Production of green space	Green Plan	Green Plan
Transportation	Transit system: BRT	Transit system: MRT
Economic strategy	Attraction of investment	Attraction of investment
Special projects	Strange archaeology Urban acupuncture Green Plan (park system)	Skyrise greenery ABC Waters Program Green Plan 2012

Table 8-2: Innovative urban strategies.

Author, adapted from Moore (2007) and extended to Singapore.

Another similarity is the timing of the urban transformation processes; the commencement of both processes occurred at the same time, in the mid-1960s; Curitiba's Wilheim-IPPUC masterplan was approved in 1966 and started implementation in 1971. Singapore's first conceptual plan was also implemented in 1971. Both cities also share their focus on dynamic urban governance: visionary leadership, strong political will underpinning policy-making and continuity, integrated master planning ensuring land use, production of green public spaces and mass transit systems, education and social development. They both had at the time visionary leaders occupying crucial positions in their cities. Contextual conditions, such as socio-cultural traditions, human and natural resources available, moreover biogeophysical aspects, determined different approaches to each city's spatial form. Curitiba's Wilheim-IPPUC masterplan diverged from the modernist city, aligning with Jane Jacob's ideas and activism toward humanistic and liveable cities; Singapore adopted the vertical radiant city model as a deemed solution to the pressing affordable housing crisis and scarcity of land. Master planning in both cases was a keystone for success; in Curitiba, it defined linear growth along six axes, integrated planning combining road network, transportation and land use; in Singapore, it envisioned a compact city, transit-oriented with extensive greenery and high density but liveable housing towns.

Regarding planning philosophy and methodologies, in Curitiba professional skills and technological support were enhanced through research, institution consolidation (IPPUC[1]), human resources development and innovative planning methodologies. In Singapore, urban planning is a highly centralised government function that sets the three planning boards – URA[2], HDB[3] and NParks[4] – at the first level of government, facilitating fast decision-making, ensuring strong political leadership, and enabling long-term planning projects and infrastructure. URA formatted and implemented the planning philosophy that guides Singapore's development, consisting of a long-term planning approach driven by a vision. In both cities, land use is stipulated by zoning regulations, and environmental issues are included in master planning; Singapore's scarcity of land and resources made the government keep a tight control over the development of all land in the island. In Curitiba, continuity was ensured by giving the IPPUC powers that expanded its authority and coordinated all municipal programs, becoming a "quasi-autonomous

[1] IPPUC: Portuguese acronym for Research and Planning Institute of Curitiba

[2] URA: Urban Redevelopment Authority

[3] HDB: Housing Development Board

[4] NParks: National Parks Board

planning agency" (Moore, 2007, p.77); planning practices were moulded on creativity, innovative thinking and work methodologies, low budget initiatives and effective communication that led to international support and recognition, as well as to citizens' behavioural change and civic pride.

Summarising, integrated urban design and planning is a relevant technology to shape the urban form and developmental trajectory. In Singapore, it also guided the nation's structure and development. The comparison between both cities shows many convergences and some divergences, the latter due to socio-cultural, political and biophysical reasons, notwithstanding that many innovative pathways towards regenerative sustainability were achieved.

8.1.2 Supportive evidence

Regeneration is about promoting positive contributions to healing and improving place conditions as a whole, including all living systems. In regards to the built environment, it means the development of human settlements that partner with natural systems and produce positive environmental benefits for the living world (Mang and Reed, 2012b; Hes and du Plessis, 2015). This concept is reflected in the special projects each city implemented: strange archaeology, urban acupunctures and the park system in Curitiba, and the Green Plan 2012, skyrise greeneries and the ABC Waters Program in Singapore.

Cross-case analysis sought literal replication, as both cases were predicted to present regenerative processes. The above mentioned urban initiatives analysis demonstrated compliance with integrated framework, as the results showed pattern matching with most of the multiple principles that underlie regenerative outcomes. The match between theoretical and empirical patterns is considered evidence of regenerative processes, because according to Yin (2009), the match of predicted patterns drawn from the theory with empirically based patterns can help a case study to have its internal validity reinforced.

Table 8-3 below shows the results of the application of the framework to both cities:

	Curitiba			Singapore		
Principles	Strange archaeology	Urban acupunctures	Park system	Green plan	Skyrise greeneries	ABC water program
Place	x	x	x	x	x	x
Progressive human –nature relationships	x	x	x	x	x	x
Pattern literacy	x	x	x	x	x	x
Development & design	x	x	x	x	x	x
Ecosystem services	x	x	x	x	x	x
Community engagement	Ongoing-Plan reviews	potential	Ongoing	potential	potential	potential
Liveability	partial	partial	partial	partial	partial	partial
Beauty	na	x	x	x	x	x

Table 8-3*: Results of application of the framework to Curitiba and Singapore*

Source: Author

In Curitiba, strange archaeology was used as a base for the correct master planning and functioning of the city. It is directly related to place, and allows the understanding of how nature shaped the place where the city was built through the recognition of soil, climate, living systems, and human activity flows and patterns over time. It matches several theoretical principles*: place-based relationships, pattern literacy, development and design, and liveability*. It allows for the understanding of how historical human settlements developed and how the ecological system worked and flowed through the place in the past. Comprehending these dynamics, Curitiba's Wilheim-IPPUC plan developed a core concept of linear urban growth system, aiming to limit the expansion of the city's central area through the integration of roads, public transport and land use (Rabinovitch and Leitmann, 1993), which is still maintained over the 2004 and 2014 plans' revisions and in the zoning policies. The linear growth system currently composed of six structural arteries or axes concentrates the highest densities, commercial activity and greatest public affluence across the city, giving continuity to the natural and past flows that enhances urban liveability.

Urban acupunctures, which represent the meridians according to the Chinese medicine metaphor, by some means overlap with strange archaeology. These interventions are part of the regenerative approach to design because they are examples of systems thinking. By studying the problem of a determined area from the systemic context of a living place, the planners could perceive a greater potential than it initially could have had, advancing the objectives for the project and postulating the basis for conceiving the regenerative role it could play. These specific actions of revitalisation can progressively change urban life. They allowed for positive transformations in many places in Curitiba, benefitting the local context, and further disseminated to the entire city through fostering chain reactions, once cities are highly interconnected places. In Curitiba, this technique was used as a strategy toward sustainable development, (Blasco, 2012) and matches all theoretical principles.

The park system, embedded into the Green Plan, suggests an example of the application of *regenerative development and design*, and biophilic urbanism integrated to urban planning that produced positive impacts on the urban and regional ecosystems as well as in the community. Moreover, it is a demonstration of systems thinking applied to urban design and planning. The Green Plan concerns the ecological implications of the city's development and contains the emerging idea of an environmentally correct city. As part of the integrative approach to planning, the Green Plan conceived and implemented the strategy of building multifunctional parks in the late 1980s. This approach enabled Curitiba to successfully produce regenerative design solutions that integrate ecological and social functions. The park system created parks that function as cultural, educational and recreational facilities whilst performing their ecological function as flood control features, revitalizing neglected sites as seen in some of the acupunctures, and protecting sensitive areas from illegal settlements as the ongoing Live Barigui Project is demonstrating (see Chapter 6 for more details). Parks also promote learning opportunities and jobs for low-income sectors of the population, e.g. the groups of youths that produce seedlings of flowering plants and provide maintenance to the parks, streets and gardens around the city.

The Green Plan and its park system represent an integral approach that reveals a strong social-ecological response to all theoretical principles of urban regenerative sustainability: it is *place-based*, demonstrating knowledge of how the local systems work, includes *pattern literacy*, *development and design*, restoration and protection of *ecosystem services* and urban and regional biodiversity[1]. It also allows for *progressive human-nature relationships*, promoting social interactions and engagement, facilitating *liveability* through frequent biophilic and aesthetic experiences (*beauty*) that lead to a sense of belonging and civic pride in the citizens, promoting awareness and care for place. I conclude that through special projects such as strange archaeology, urban acupunctures and the Green Plan, the planning philosophy and methodology implemented enabled Curitiba to produce successful regenerative design solutions that performed positively, integrating various urban functions towards the mutual benefit of the whole.

In Singapore, the continuous process of urban transformation and innovation over the last fifty years has biophilic urbanism as one of its pillars. As seen through the lenses of both city visions, Garden City and City in a Garden, it evolved from intense functional landscaping in the former to a more sustainable urban development in the latter. The result is a biophilic matrix that underpins and reconnects human and non-human life, focused on increasing biodiversity through a number of innovative technologies.

[1] Curitiba has shared its results with the CBI -Cities Biodiversity Index. Brazil is a party of the Convention on Biological Diversity –CBD since 1994.

My view of the Singaporean process is that the Garden City vision was a rather mechanistic one. The first part of the process was dedicated to solve pressing challenges like provision of affordable housing, amelioration of living conditions in a location affected by rough tropical climate, and attraction of investments necessary for economic growth. Most of these problems needed pragmatic, engineered solutions like those provided by the technological or mechanistic paradigm. The decision was taken and it worked. As du Plessis and Brandon (2014) argue, the mechanistic worldview produced knowledge and laws of great value in the fields of engineering and technology. As the first priority was providing affordable housing to a huge population living in slums in the early days of independence, with scarce land available, the Corbusian vertical radiant city model was deemed to satisfy it. The conceptual plan of 1971 adopted the idea of towers in a garden, however, it made a sensitive application to the uniqueness of place. The planning approach recognised the critical importance of the central water catchment, right at the heart of the island, and protected it from encroachment. Accordingly, it was surrounded by a ring of residential towns disposed within a network of green spaces, parks and natural reserves providing relief and protection from the tough climatic conditions. The housing towns were then interconnected among them and to the nearby parks and reserves through park connectors that made residents feel that they lived close to nature. This was the start of the biophilic matrix, acknowledging *place* and local *patterns*, conversely to the tight Radiant city. I am not discussing here the ways in which this action was implemented, however, I acknowledge criticism about this issue. The intense landscaping, creation of green spaces, and close-fitting control of land use, water resources and biodiversity demonstrate concern for preserving *ecosystems* and their *services* besides achieving the benefits in health and wellbeing inherent to biophilic interventions. *Liveability*, understood as social and environmental quality of place (Moura, 2005), is visible in many developments and in the life standards achieved, despite criticism that relate it merely to attraction of business. Singapore invested in green spaces notwithstanding its land scarcity and large population. The city-state did it as a response to build a healthy habitat for its large population housed in high-density estates, and as a strategy to attract investment and tourism.

The second vision, City in a Garden including the Green Plan 2012, was launched when the pressing problems were already solved. Then, it was time to think in the future of Singapore as a whole, including all living systems. The new vision seems to be entering the ecological paradigm, bringing a shift in mindset and practices, particularly referring to community engagement.

Singapore's skyrises also are showing how biophilic design can create new habitats by transferring landscape patterns found at ground level to the high floors or 'gardens in the sky', as Singaporeans are calling these initiatives, which could probably lead towards regenerative processes. Skyrise greenery in Singapore has proven to be beneficial in adding value, creating liveable spaces and, additionally, in developing a sense of identity in buildings. It is also a local innovation, a new type of greenery suitable for tropical climates where plants easily thrive favoured by warm temperatures, high air humidity and frequent rainfall. Vegetated balconies and sky terraces provide semi-open spaces sheltered from the sun, which makes them usable during daytime, expanding the opportunity to be outdoors living in high rise estates.

Regarding the framework, skyrises comply with *place-based relationships, progressive human-nature relationships, ecosystem services, liveability and Beauty.* I see the new approach to green infrastructure as a social-technological artefact, as shown in the ABC Waters Program, as a means toward producing regenerative outcomes on place, integrating community, environment and technology as described in the Bishan Ang Mo Kio Park, for example. It involved new biotechnologies for water management and waterways, new multifunctional parks, and the challenge to actively engage the community in the support of the vision by encouraging ownership.

The ABC Waters Program is within the scope of URA's *Natural Green & Blue Master Plan* that includes a series of programs and policies aiming to boost the creation and conservation of new green areas and waterways with eased public access, developed according to sensitive design guidelines targeting the protection of existing ecosystems and environments in various parts of the island. Parks are now multifunctional green spaces encompassing environmental and social functions; on the biophysical aspect, they serve as carbon sinks, as places for biodiversity enrichment, and as pilots to test out sustainable features designed to tackle climate change challenges and solve problems related to the tropical climate (e.g. the Eco-nature neighbourhood parks, built within HDB housing towns, described in Chapter 7). At the same time, on the intangible aspect, these new parks aim to encourage social gatherings, recreational activities and social and cultural events. This suggests a change of purpose in the conception of these parks that approaches them to a regenerative design concept and potentials the facilitation of co-evolution of human and natural systems in the future.

I see this trend as part of a pathway toward urban regenerative sustainability particularly in what is related to the biophysical part of reality. Are Singaporeans and Curitibans ready to build up social capital by effectively participating in planning processes in their cities? The local change of leadership in Singapore is still too recent to make any prevision, but it would be an interesting issue for future work. In Curitiba, the revision of the 2014 master plan has been open to community participation as described in chapter 6. At the time of writing the revision was ongoing. Hence, *Community engagement* was marked as potential and ongoing, in table 8-1. Similarly, empirical *Liveability* has not been found as totally complying with the theoretical principle, because some of the characteristics of the principle can be observed, such as social and environmental quality perceived by residents, workers and visitors, but much more is needed to achieve mutual benefits partnership between humans and nature or synergistic regenerative interactions over time in the built environment (Table 5-5). Hence, liveability as found in the examples analysed could be considered as an intermediate stage for future co-evolution of humans and nature, and an opportunity to study its influence in the tangible and intangible structure of cities.

These social-ecological processes take time, because they arise from knowledge, reflection, and awareness. Also, they depend on individual and collective will, of citizens and governance, and the constant endeavour to build and maintain the process over time. Both cities developed and implemented urban initiatives that aimed to solve social, economic and environmental problems as fast as possible, so decision-making was simplified and speeded through effective top-down processes. However, this method has its failures and rarely survives the absence of the leadership which created it.

The framework demonstrated to be an appropriate analytic tool to assess regenerative development and design principles embedded in the relevant practices and policies implemented in both cities, which showed potential towards urban regenerative sustainability if open to participatory engagement of community. As these practices matched most of the theoretical principles, it also demonstrated, together with the urban planning analysis, that the examples did not include participatory processes in their making. This cannot be considered a weakness of the framework, but a deficiency in the authoritative top-down planning decisions adopted in both cities.

8.1.3 Generalisation of findings

Yin (2009, p. 38) defines analytical generalisation as a "mode of generalisation in which a previously developed theory is used as a template with which to compare the empirical results of the case study. If two or more cases are shown to support the same theory, replication may be claimed".

Regarding the generalisation of findings, this present study considered that literal replicability was deemed to be confirmed, and in both cases the empirical results have matched most of the theoretical principles. Nevertheless, it is necessary to test more replications in other cities to see to what extent these outcomes can be generalisable. Recalling Irazabal (2005), remarkable planning outcomes need the views of empowered and participatory citizens to democratise and balance master planning. Also, considering regenerative sustainability's definition (Robinson and Cole, 2015) as a social construct of procedural nature, the framework would need to be applied to other cases, preferably more recent ones, to see how it performs and add more reflection regarding the importance of social collaboration towards achieving urban flexibility, adaptability and resilience over time.

8.2 Rival interpretations

Both regimes have been criticised for being examples of authoritative top-down processes driven by political and economic interests and managed by technocratic elites without citizen participation.

In Curitiba, the making of the urban transformation received criticism varying from legitimacy issues (Irazabal, 2005) to underlying political interests converting the process in a case of city marketing and “spectacle urbanism” (Sanchez Garcia, cited in Macedo 2013), to myth-creation strategies to attract international attention (Hazan, cited in Macedo 2013). Irazabal (2005) acknowledges the success of urban planning programs but draws attention to legitimacy issues in the process due to the lack of citizen participation, and goes further arguing that the technocratic managing model threatens Curitiba’s governance. Conversely, Moore (2007) explains the phenomenon as an alternative way to accomplish sustainability. To this author, there are multiple pathways leading to greater urban sustainability, and Curitiba makes the case for a successful sustainability pathway for local governance with the right vision, technological support and political will, even though its history of democracy and its culture of citizen participation and engagement is not significant. He points out that Lerner’s technocratic regime of sustainability must be understood in the context of the “Brazilian anti-political, authoritarian and technocratic tradition rather than as a political anomaly that is typically claimed by outside observers of the Lerner’s regime” (Moore, 2007, p.77). In his studies of Brazilian politics, Moore perceived some local characteristics, particularly a trend in political styles based on personality rather than on ideologies, as was the case of various Brazilian presidents elected on technocratic anti-political platforms. Thus, according to this line of thought, he argues, it is not a surprise that Lerner had been so successful in his three terms as Mayor of Curitiba, having been appointed by the military for two of them and elected by popular vote for the third (Moore, 2007). Summarising, the making of Curitiba’s “regime of sustainability” (Moore, 2007, p.79) was possible due to the convergence of the circumstances and opportunities existing in the city in the second half of the last century. Political changes in Brazil occurred in the early 2000s challenging the forty years productive continuity of the process, which had been stable while conducted by the planning regime; a more pluralistic view of the city replaced the technocratic governance.

In Singapore, critics point out controversies relating achievements to a significant cost to human rights. Free press, freedom of expression, or freedom of assembly are still challenging issues for Singaporean society (Schiavenza, 2015).

Blasco (2012) acknowledges Singapore's achievements in converting the challenges derived from the scarcity of land and natural resources into an incentive toward accomplishment and international recognition in urban transformation; economic success is related to the attraction of talent, the new creative classes both corporate and personal, and to the innovative high technology projects implemented in various fields. However, he points out that the Singaporean model is peculiar to local culture and socio-political characteristics, not easily exportable to the Western democracies in which cities aim to be centres of freedom and citizens have active and progressive participation in urban life and decision-making.

Velegrinis and Weller (2007) concentrate their critique on the ways creativity was applied to the built environment, looking at how the metaphor of the garden works both seemingly and structurally in Singaporean urbanism. The superficial aspect is that Singapore has no rural landscape and recent immigrants came from highly urbanised environments with no direct attachment to natural landscapes, contrary to Howard's conception of the Garden City where residents would live benefitted by the charm of rural life and the amenities of the city. In this sense, Velegrinis and Weller found rather paradoxical the vision of Garden City for Singapore, considering it as a 'gardenesque city'. On the other hand, these authors recognise that many of the HDB residential towns, beginning with Tampines in the 1990s, have set the instrumental use of the landscape in weaving architectural and landscape systems together. Another positive example they cite is the ABC Waterways Project to return the rivers into biodiverse social amenities (Velegrinis and Weller, 2007).

The results achieved in each city suggest that it is possible to bring new life to degraded systems even at urban scale if correct visions and integrative planning methodologies founded on social-ecological approaches are implemented. Curitiba and Singapore are particular cases of urban scale processes that developed understanding of and methodologies to approach urban challenges from an ecological approach. In the social aspect, although city residents significantly benefitted from the urban transformations and supported them, none of the cities integrated community's views, avoiding any participation in decision-making. Irazabal (2005) argues that the accomplishment of extraordinary results in urban planning depends on the synergy derived from three essential components: visionary leadership, extensive and continuous; plans and policies, comprehensive, coordinated and effective; and empowerment, inclusion and involvement of citizens. The history of Curitiba and Singapore urban transformations showed that they were achievable because strong leadership and effective plans and policies conducted them and made them flourish. However, they failed to integrate citizens into their planning processes. The importance of engaging community in these instances is relevant in two ways: on the one hand, to record first-hand accounts on real issues about place, social aspects, needs and aspirations; and on the other hand, empowering communities may ensure the sought community's sense of ownership and stewardship to place, which underpin long-lasting adaptation to changing circumstances over time, increasing flexibility and resilience.

Current new trends are promoting change in these aspects: both cities are now focused on achieving active citizen participation, the democratic way to ensure sustainability in their processes. In Brazil, since 2002 the Statute of the Cities and the Right to the City enforce public participation in urban decisions. In Singapore, one of the pillars of the City in a Garden vision is to promote active citizen participation, ownership and pride to sustain the vision (Green Plan, 2012). In other words, regenerative sustainable development.

Regenerative sustainability is about physical and mental development (Hes and du Plessis, 2015). When community engagement and active participation is avoided, the opportunity to develop a new mindset is restricted to the planning team. This does not build social capital, which is the capacity of people to respond together to changing circumstances. In Curitiba, the transformative period lasted the time the strong leadership of Lerner and the IPPUC was active. Singapore, also had a strong leadership that underpinned the process, however, the leader died at the time of this writing. It would be interesting to see, in future work, how the process continues into the future, particularly the involvement of community in the decision-making that the new City in a Garden vision aims to integrate.

The case studies showed that urban transformation's success is directly related to innovative thinking in urban design and planning supported by visionary leadership, which allowed to achieve fast and continuous improvements in urban living. However, at least in the case of Curitiba, continuity of the process stopped when leadership was replaced by more plural views of the city. In Singapore, the influence of recent changes in governance is still to be observed.

8.3 Regenerative sustainability as a theoretical construct

Do Curitiba and Singapore's transformative processes share a common theoretical construct? Besides geographical and cultural differences, Curitiba decoupled from modernist planning, aligning with Jacobs' ideals of human scale cities, heterogeneous neighbourhoods, diversity, and settings for casual public contacts, but did not incorporate her ideas about active citizen engagement in planning decision-making. Singapore used the radiant city concept to guide the making of the city-state tackling the challenging problem of providing housing to a huge population in a setting of scarcity of land. Yet, both cities incorporated social-ecological approaches in their planning theories and practices that some authors call "socio-technological ecology" (Perelman, 2007, p.26), evidenced in the production of their special projects and programs: strange archaeology and urban acupunctures in Curitiba, skyrise greeneries and the ABC water program in Singapore, and both cities' green plans, as pathways to urban sustainability.

In my opinion, Curitiba and Singapore can be considered as pre-regenerative sustainability examples for the reasons above mentioned, acknowledging that they failed to build social capital to support the feats over time and be really regenerative cities.

As seen in Chapter 4, the concept of regenerative sustainability is emergent and has various interpretations. To the concept built by Mang and Reed (2012a, b), Benne and Mang (2015), du Plessis (2012) of regenerative sustainability, John Robinson and Ray Cole (2015) introduce another stream of thought and practice presenting regenerative sustainability as based on the concept of procedural sustainability, rooted in an understanding of reality founded in social constructs. It is procedural in that its principles are seen as emerging from social processes, and not considered to be absolute truths, but provisional properties that may change according to unpredictable circumstances. Hence, the overarching frame of regenerative sustainability being emergent rather than predefined, uses collaborative planning for sustainable community development methodologies, recognizing that there are many ways to design net-positive environments targeting human and environmental outcomes, or co-evolution.

This approach to regenerative sustainability seems to be appropriate for the design of future urban precincts and neighbourhoods and entire cities if this is the case.

As discussed earlier in this chapter, the framework of regenerative sustainable urbanism was successful in assessing regenerative development and design principles embedded in urban design and planning applied to practices and policies in Curitiba and Singapore as pre-regenerative cities.

The regenerative sustainability framework and its principles are important tools for the evaluation of existing urban environments, particularly compact, high density ones, and for the design of future regenerative sustainable cities.

Hence, the use of the framework has two important implications for designers: on the one hand, evaluation and design, and on the other, its implementation. Regarding evaluation and design, the use as an evaluative tool has been proved in the case studies analysed in this thesis. As a design tool, the framework can provide site-specific suggestions for design interventions at varied scales, acknowledging that cities are open systems composed by elements and sub-systems nested and interconnected, ranging from buildings to regional environments. Understanding the complexity of place, as core principle, all other principles can suggest appropriate actions and proposals to achieve maximum benefit for minimum input (e.g. interventions like urban acupunctures or skyrise greeneries that incorporate community views and feedbacks).

Implementation of the framework in practice requires multidisciplinary and holistic approaches building on neighbourhood examples, which seem to be the appropriate scale for experimentation and research.

Chapter 9

Conclusion

Cities have the capabilities to transform past damage and degeneration into positive, regenerative processes. However, the state of cities globally displays a different reality. Cities have become progressively complex at a high cost to the natural environment and the safe operating systems of the planet.

It is possible to change the current situation, but the solution requires a shift in the way we think about and build cities, a shift in the mentality that caused the problem. Instead of fragmenting, as Modernity did, there is a need of reuniting human and natural worlds. It is not the case of doing less harm as many theories and movements advocate; it is the case of making a profound shift in mindset that involves a new integrative approach to urban design and planning based on an ecological view.

This research has reviewed existing knowledge about the challenges the world is facing, new concepts of the built environment that promote a novel scope for design philosophy and methodologies. It has also undertaken the review and analysis of the theory of two social-ecological design approaches to the built environment embedded within the ecological worldview: biophilic design and urbanism and regenerative development and design. That investigation constituted the basis for the development of a framework that combines principles and practices of both perspectives. This framework was then applied to two cases, the cities of Curitiba and Singapore, which have implemented successful transformative initiatives related to urban sustainability, to evaluate the framework's potential in assessing whether these initiatives support principles of regenerative sustainable design.

The reflection on these themes induced the research question:

> Can a framework be developed to give meaningful direction to the application of the concept of regenerative sustainable urbanism as a foundational and practice-oriented concept for the vision of future cities?

This research process began examining the current state of cities globally, looking for the causes of the problems. It was ascertained that Modernity provoked a significant rupture in the historic human-nature relationship, placing humans in a position of dominance over nature, a model that was reflected in all human activities, causing significant changes in the spatial structure of cities and in social and cultural urban lifestyles. The need for a shift in the still prevailing mechanistic paradigm emerged from the knowledge of how living systems work provided by the findings of the new sciences of quantum physics, urban ecology, neuroscience, and complexity science, leading to the emergent ecological worldview. Moreover, it was necessary to understand the importance of working within worldviews (Chapter 3). The new worldview opens an opportunity to reconnect the lost relationship of humans to nature and promoted a new understanding of the built environment as a social-ecological system, rising design approaches integrating social-ecological perspectives that are generating promising contributions (Chapters 3 and 4). The findings from the analysis of the theory and practices of these social-ecological perspectives, pointed to two emerging design approaches: regenerative development and design and biophilic urbanism. This led to the development of an integrated framework that combines design principles and practices from both and focuses on an alternative concept of urban sustainability, called Regenerative Sustainable Urbanism (Chapter 5).

It was necessary to test this framework to attempt to address the research question. I considered two cities, Curitiba and Singapore, as case studies for this verification (Chapters 6 and 7). First, I developed a matrix combining the principles, with the practices and policies found in each city. Then, I used the matrix as a lens to analyse their performance in both case studies.

9.1 Thesis findings

The thesis aim was to contribute to a new approach to urbanism that provides transformative change to help turn cities' negative ecological footprint into positive impacts, making cities part of the solution to planetary challenges.

This aim was approached through the development of a framework for regenerative sustainable urbanism. It was demonstrated in two stages, through a comparative analysis of local urban planning traditions and processes, and the application of the framework to Curitiba and Singapore, the two case studies.

From the analysis of results, several conclusions were drawn in terms of urban planning thinking and methodologies, and regarding the alternative approach named Regenerative Sustainable Urbanism.

Conclusions on urban planning thinking and methodologies

As determined in Chapter 8, urban planning has an influential role in defining pathways toward regenerative sustainability. However, through the analysis I found that successful outcomes were possible because a different nature of thinking and multidisciplinary interactivity was adopted. It included a more comprehensive, deeply integrative and whole systems approach, incorporating innovative design technologies, in this case regenerative development and design and biophilic urbanism, to traditional planning methodologies.

The process revealed significant influence in shaping the cities studied, producing clear spatial forms, abundant green spaces, efficient public transport systems and investment in non-polluting industries. In this sense, urban design and planning has also evolved as a technology and design approach that promotes new insights on the essence of the city and its systems, both biophysical and social when sustained by a social-ecological view. This was very clear in the case of the special projects analysed. Nevertheless, socio-cultural traditions, human and natural available resources, and biogeophysical aspects, determined different approaches to each city's spatial form, demonstrating that social-ecological approaches to urban design and planning are not universal as Modernism advocated, but site-specific.

I conclude that through special projects, the planning philosophy and methodology implemented enabled the cities to produce successful regenerative design solutions that positively performed integrative urban functions towards the mutual benefit of the whole. These interventions are part of the regenerative approach to design because they are examples of systems thinking. By studying the problem of a determined area from the systemic context of a living place, practitioners can perceive a greater potential than initially perceived, advancing the objectives for the project and postulating the basis for conceiving the regenerative role it could play. This is an example of an innovative process leading to sustainable regenerative outcomes while also revitalising the thinking and doing that generated and supported practice.

The case studies showed that urban transformation's success is directly related to innovative thinking in urban design and planning supported by visionary leadership, which allowed to achieve fast and continuous improvements in urban living. However, the framework application pointed out that citizens' participation was not significant in none of the cities, and that issue may threaten the strength and sustainability of the process. At least in the case of Curitiba, the continuity of the process stopped when leadership was replaced by more plural views of the city. In Singapore, the influence of recent changes in governance is still to be observed.

Conclusions on regenerative sustainable urbanism

Regenerative sustainable urbanism is social-ecological urbanism beginning to regenerate the failings of the past by going beyond making cities for people and natural systems. It aims to repair negative impacts by changing urban ecological impact; it restores and helps rebuild past impacts ensuring conditions for natural and human systems to thrive and flourish, both in ecosystem services and social-cultural systems. Embedding nature into the cities may help not only in increasing resilience and in mitigating the effects of climate change, it integrates into a holistic approach the benefits from biophilic urbanism and regenerative development and design, allowing cities to be part of the regional solution rather than a hindrance. This is demonstrated in Curitiba, and in Singapore, which have developed successful strategies that encompass design concepts toward regeneration of regional social-ecological systems based on the multiple benefits enabled by new ways of thinking about cities (Chapters 6, 7 and 8).

The results achieved in each city suggest that turning damage and degeneration into positive impacts is possible even at urban scale, if correct visions and integrative planning methodologies founded on social-ecological approaches are implemented, and importantly, if community engagement and sense of ownership are strong enough to underpin continuity and resilience in the process toward regenerative sustainability. Both cities underwent top-down processes, but are currently seeking active community participation to sustain the achievements over time, which is one of the tenets of the ecological worldview and the new approach to urbanism.

Thus, to achieve regenerative sustainability in cities, a qualitative shift is necessary, including a distinctive mindset, one that promotes transformative change to help reunite the whole that Modernity fragmented. Within the ecological worldview, we can comprehend the true nature of cities; they are systems of organised complexity, where human activities and ecological processes can coexist and co-evolve. Therefore, it is necessary to broaden the scope of current urban design and planning thinking, as well as their methodologies, integrating the concept of regenerative sustainability into all design strategies.

This is the aim of regenerative sustainable urbanism, an alternative approach to urban design and planning that may be foundational for the future of cities, because it is backgrounded in the ecological worldview, and embeds principles and methodologies leading to regenerative sustainability. As discussed in various parts of this thesis, the shift in mindset is not an easy process, but it is the only choice to leave a world of abundance to future generations, given the challenges posed by the Anthropocene (Hes and du Plessis, 2015).

Regenerative methodologies have been challenged from different sectors, particularly from design practitioners given the recent emergence of the theory of regenerative development and design. Some voices ask for more evidence-based examples about the benefits (Cooper, 2012); others appeal for issues of scale, monitoring and evaluation of projects, continuity of practitioners along the whole design and development process, community stakeholders empowerment to intervene at different scales (Tainter, 2012); and most are concerned with mainstreaming understanding of systems thinking and their application to implementation to urban design and planning practice, and policy-making processes (Clegg, 2012).

Curitiba and Singapore are particular cases of urban scale processes that developed understanding of and methodologies to approach urban challenges from a social-ecological approach. Based on the evidence of the data analysed, they can be considered as pre-regenerative cities, precedents of transformative change toward regenerative sustainable urbanism.

Therefore, the response to the research question,

> Can a framework be developed to give meaningful direction to the application of the concept of regenerative sustainable urbanism as a foundational and practice-oriented concept for the vision of future cities?

is positive. The application to the case studies of the regenerative sustainability urbanism framework demonstrated that it was successful in assessing regenerative development and design principles embedded in urban design and planning present in practices and policies found in Curitiba and Singapore, which then performed as pre-regenerative cities. This result also confirmed the framework's validity as an evaluative tool, so the regenerative sustainability framework and its principles are important tools for the evaluation of existing urban environments, including compact, high density ones, and for the design of future regenerative sustainable cities. Another key implication for designers is related to the framework's implementation into future urban designs, which is a topic for future research.

Limitations of the research

As mentioned before, this is a novel approach, therefore theory has to be applied to and tested in various scenarios to estimate its contribution. As stated in Chapter 1, the scope is international opening the study to urban precincts and cities around the world, both in industrialised and developing countries, with the necessary consideration of the uniqueness of each place.

Another point is the generalisability of the case studies' findings. The present study considered two cases where applicability was deemed to be confirmed and in both cases the empirical results have matched the most of the principles. Nevertheless, it is necessary to do further work testing more replications in other cities to see to what extent these outcomes are generalisable and can contribute to improving existing urban environments or designing cities supporting regenerative processes in the future.

9.2 Future work

There are many topics in regenerative sustainable urbanism, biophilic urbanism and regenerative development and design that need research due to the recent emergence of the field. There is a real need for:

- more evidence-based examples about the ways and benefits of this approach and methodologies implementation;
- monitoring and evaluation of projects;
- researching ways for practitioners' continuity along the process, and community and other stakeholders' empowerment; and
- educating designers on the complexity of systems thinking to be implemented into design methodologies and policy-making processes.

These questions open opportunities for future research.

Regenerative sustainable urbanism should be tested in some cities located in the Global South, to examine what kind of solutions it can contribute to the challenges of those parts of the world, which are the most vulnerable and threatened by climate change and growing populations' effects. Also, the applicability into cities in transition and in areas affected by natural disasters would be other areas of research interest as the opportunity to redesign and rebuild is presented.

Another possibility for future research is the educational sector. Current under-graduate curricula in the areas of architecture and urban design and planning lack disciplines addressing holistic social-ecological approaches that are becoming increasingly significant for an urbanised and threatened world. Thus, in general, new graduates need to be trained with the appropriate knowledge to develop professional skills, and in many cases, provided with the technological support needed to face the challenges of this new field of design practices.

The scope of regenerative sustainable urbanism is broad and promising.

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Hi Maria,

Yes, you are welcome to use the graphics. Thank you for asking. Herein are the originals and some variants you may find useful.

Best of success with your work and thanks for the kind words!

Bill

Appendices

Appendix A

Beauty: a powerful force for sustainability and regeneration.

Maria Elena Zingoni de Baro

Introduction

For thousands of years, humanity's relationship to nature was both enduring and profoundly respectful. From the industrial revolution onwards, and particularly since the 1950s, a fundamental and systemic change in this relationship took place leading to extraordinary impacts on the world's landscapes. They were mainly yield by the extractive economic model and the ecological footprints of urban development that stretch across much of the world, turning humanity into a predominantly urban species. This model has exploited natural resources with increasing disregard for the earth systems capability of regeneration, even compromising living systems survival.

Moving from that mechanistic worldview of fragmentation to an ecological worldview of integration, the emerging regenerative sustainability paradigm considers the world as a living, complex and dynamic whole where everything is interconnected. This comprises social and ecological systems constantly in flux. Within this whole, nature and human systems are integrated and share processes of co-creation and co-evolution. This world vision recognises existential knowledge, Eastern philosophical and religious traditions and Western thinkers that share these principles, in addition to scientific discoveries in the area of quantum physics and ecology (du Plessis, 2011).

New ways of knowing are arising, and as designers, we need to think and create buildings, cities and places in ways that reflect this philosophy. Complexity, wholeness, interrelationships and connectedness, and the value of nature and all forms of life, are the key issues of this new worldview. Mehaffy and Salingaros (2011) define the new vision for the natural and built environments in these terms:

> The new paradigm is about complexity. It shapes the patterns of our use of resources and enhances the value of nature, defines the patterns of interactions between people and nature and conditions human behaviour. By considering natural and built environments a whole system, it gives meaning to the urban realm and naturally creates resilience and sustainability. Therefore, it serves more efficiently the real needs of human beings and the planet.

Working within the regenerative paradigm principles implies a shift in the role of practitioners and stakeholders. It is necessary to have an understanding of how living systems work -or “ecoliteracy” (Orr, 1992) - to face the challenge of designing buildings, cities, and places that enable enhanced awareness for both designers and users. Practitioners and stakeholders involvement aim to promote reflective experiences, usage and behaviours that lead to a responsible attitude of care, a feeling of belonging and co-evolution within the whole system.

This chapter outlines the importance of promoting aesthetic experiences through designed landscapes (Meyer, 2008), art and culture, and even through the “very basic and transversal practices of everyday life, such as walking” (Kagan, 2011 p.71).

Part 1: Sustainability, regeneration and the necessity of aesthetic experiences

The regenerative approach considers Brundtland Commission’s definition of sustainability as a balance line and incorporates greater levels of development in the process (Reed, 2007a). As seen in Fig.1, restoration goes a step upwards, considering that human action enables the recovering of degraded natural systems to self-organise and evolve. Regeneration goes beyond this as it includes humans in the whole system as co-participants in the evolutionary process (Mang and Reed, 2012).

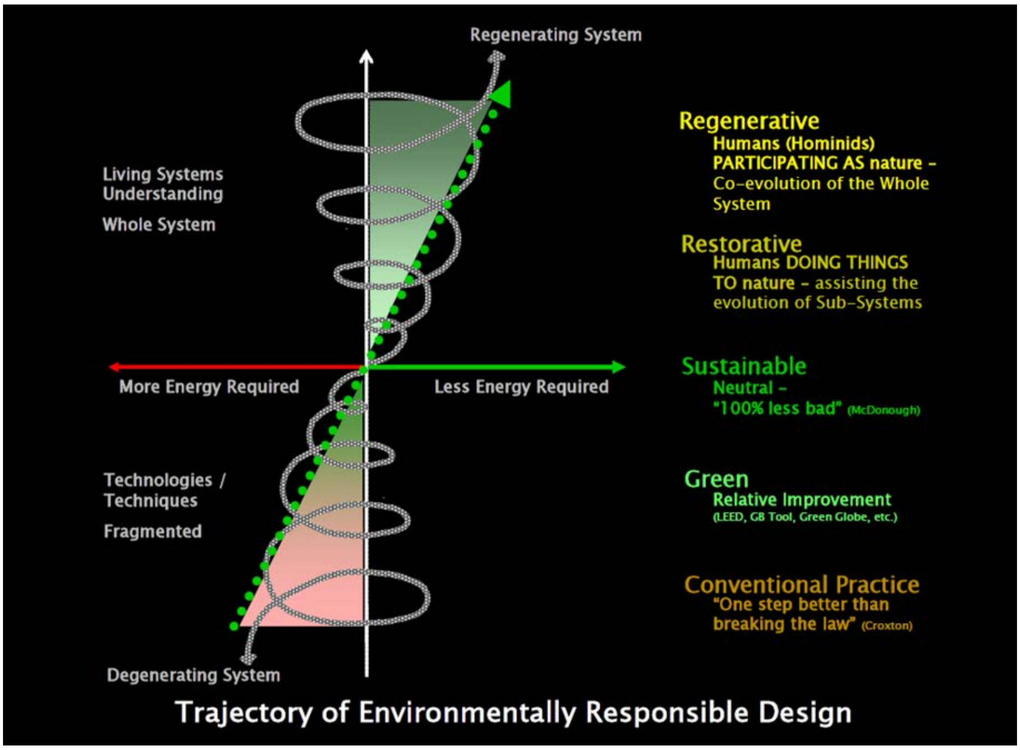

Fig.1. Source: Reed, 2007a. With permission.

Regeneration shifts from dominating nature to reflecting the constant evolution of culture and human life, integrating the reconnection of human aspirations and activities with the evolution of natural systems as part of essential co-evolution (Mang and Reed, cited by Zingoni de Baro, 2013). Thus, regeneration shares the tenets of systems thinking allowing for the main properties of the whole, such as ever-changing conditions, unpredictable processes, and impermanence, which are besides, essential qualities of life. Reed stresses this concept pointing out that “to regenerate means to give life and energy to” (2007b p.2).

The principles of regenerative design consider communities and places as living systems, ascertaining that living systems always have a purpose, and that it is through a deep understanding of place as a whole, that place recuperates its core position in human life. The consideration of purpose is crucial because it expands the opportunities and permits higher order, allowing a system to regenerate, promoting greater resilience and complexity (Reed, 2007b). The regenerative approach to design identifies patterns and processes that have both shaped and continue to shape the place, such as natural ecology and local culture. Pattern literacy and stories help in understanding how complex systems work and evolve in a place, enabling the creation of resonant human systems to enhance those of the place and, consequently, facilitating the co-evolution of both ecological and socio-cultural systems (Mang and Reed, 2012).

In this sense, regenerative design is conducive to life because it creates new opportunities for life by working with humans and nature in rebinding social and ecological systems that lead to the real potential and vocation of a community and its place. Importantly, it involves designing with and for nature creating objects, buildings, cities and regions that work as ecosystems.

Why do we need to think about objects, buildings, cities and places in a different way? How can we design better places to live?

The new ways of thinking, understanding and planning for the future are bearing in mind resilience and regeneration as essential conditions in times of climate change and population growth. Since world population is becoming increasingly urban, cities need to be rethought within this new vision to become regenerative places for life. Hence, regarding urban design and planning, the turning point has been pioneered by projects of green infrastructure, low-impact developments, energy efficient buildings, and environmental remediation. Many examples can be seen around the world, but in most cases have not been implemented in a systemic way.

Summarising, regenerative design, despite some differences in the various approaches, is an inherent component of the eco-centric paradigm, as stated by du Plessis and Cole (2011). Building on the concept of the built environment as a complex social-ecological system (Moffat and Kohler, 2008), the regenerative approach to design and development aims to foster increasing resilience. This can be achieved by reconnecting the built environment to place through relating urban life to local ecosystems, repairing degraded environments and ecosystems services, and encouraging well-being, health, and a sense of belonging (Reed, 2007, Mang and Reed, 2012; Pedersen Zari, 2012; Cole et al, 2013).

The new philosophy is directly influencing the work of architects, landscape architects, urban planners and designers, – and in general all practitioners engaged with design issues. That is, a more holistic and multidisciplinary conception of place and human activities, stakeholders and community involvement that may lead to establishing and maintaining a symbiotic and regenerative mutual relationship that can support resilience of the whole over time (Cole et al, 2013; du Plessis and Cole, 2011).

Curiously, within the efforts of aligning human development to nature, the aesthetic dimension has been absent (Meyer, 2008). Scholars, McLennan, **Meyer,** Salingaros, Lubarsky and Kagan, however, have emerged claiming for its inclusion in the sustainability discourse.

The shifting concept of beauty: understanding beauty as a means of transformative change.

Within the ecological worldview, the concept of beauty shifts from its historical conception to a new understanding that conceives it as an essential strength toward sustainability (Meyer, 2008) and regeneration. Authors from different fields of knowledge address the capabilities of beauty in promoting awareness and care for the environment and its role in education and sustainable regenerative practices.

1. Beauty as an essential attribute of life.

For Lubarsky (no date,a; no date,b) Western culture has dismissed the value of beauty during the past 200 years, and the decline in its appreciation is directly associated with the disregard for nature. She argues that the mechanistic conception of beauty as a subjective value considers the world's worth as a matter of human appreciation. In this vision, non-human life is considered as lacking intrinsic value, which leads to overexploitation and depletion of natural resources, biodiversity loss and environmental degradation.

Lubarsky asserts beauty is an "inherent attribute of all geo-biological systems which possess their own aesthetical worth" (2012, p.2) and its value is independent from pleasure or displeasure. Life and beauty are closely related, relying on the multiple patterns of life and form different types of live structures. So, beauty resides in all scales of these interwoven living patterns and when life is diminished or eliminated, beauty is replaced by ugliness and the aesthetic value of the living structure is dismissed. Beauty and sustainability are consequently related because its appreciation is embedded into our daily experiences as “a part of our deep, evolutionary memory, kept alive in our daily consort with the world” (Lubarsky, 2012, p.2). This concept is shared by Kagan (2011) as discussed further on.

Fig.2: Landschaftspark (Duisburg Nord by Latz + Partner)

2. Beauty as an innately emotional affiliation of human beings.

This approach to beauty is discussed by McLennan in his book *The Philosophy of Sustainable Design* (2004), arguing that human beings have an innate biological need for beauty. Salingaros (2010; Salingaros and Masden II, 2008) also share this argument that is substantiated by the neuroscience findings regarding “the increasing evidence of the role beauty plays in stimulating the brain” (McLennan, 2004, p.237). Since the human brain is motivated by proportion, shape and texture, this needs to be considered by designers in order to create long lasting objects, buildings and places, which is the ultimate goal of sustainable design. The importance of pleasant, attractive designs can compel people to learn and connect to buildings and places, and even to the extended surroundings including nature and community, promoting a behavioural transformation of interest and care (McLennan, 2004).

Salingaros (2010) argues that quality of life and wellbeing are related to designs that embody certain types of geometry that derive from the organisation of living organisms.

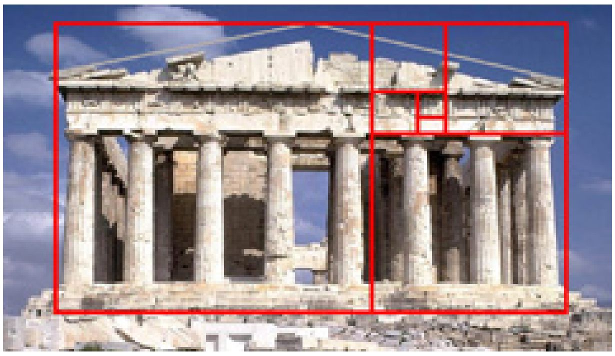
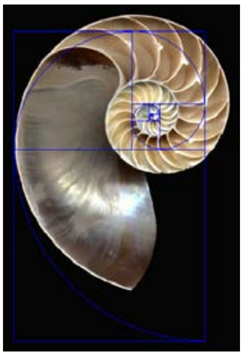

Fig 3: Traditional, sacred and vernacular architecture strongly ties to the structures found in natural organisms. The Parthenon fits into the golden rectangle and further subdivisions of the rectangle align perfectly with major architectural features of the structure. Source: http://britton.disted.camosun.bc.ca/goldslide/jbgoldslide.htm; http://www.goldennumber.net/nautilus-spiral-golden-ratio/

Salingaros (2010) also argues that the biophilic effect from the environment directly effects human physiological and psychological wellbeing. Therefore, humans also have an innate emotional affinity with living systems –or biophilia- as defined by E.O.Wilson (1984). This affiliation is due to the fact that our evolution took place in living environments, where our neuro-perceptive system developed the capacity to recognise some types of geometries and structures more easily than others. Precisely those embedded in natural and living systems like fractal structures and organised complexities (Salingaros, 2010), that suggest aesthetic experiences.

It is important to note that the human innate emotional affiliation with beauty deeply resonates with biophilia and that the binomial beauty-biophilia is then a powerful strength for sustainability and regeneration.

3. Beauty as a catalyst in encouraging awareness and care.

In her Manifesto "Sustaining Beauty. The Performance of Appearance", **Elizabeth Meyer raises the question that the** "aesthetic factor" has not been addressed in the sustainability discourse. She notes the importance of aesthetic experiences in supporting sustainable communities and developing an environmental ethic stating:

> I call for reinserting the aesthetic into discussions of sustainability. I will make a case for the appearance of the designed landscape as more than a visual, stylistic or ornamental issue, as more than a rear-garde interest in form. I attempt to rescue the visual, by connecting it to the body and poly-sensual experience. I will try to explain how immersive, aesthetic experience can lead to recognition, empathy, love, respect and care for the environment. (2008, p.7)

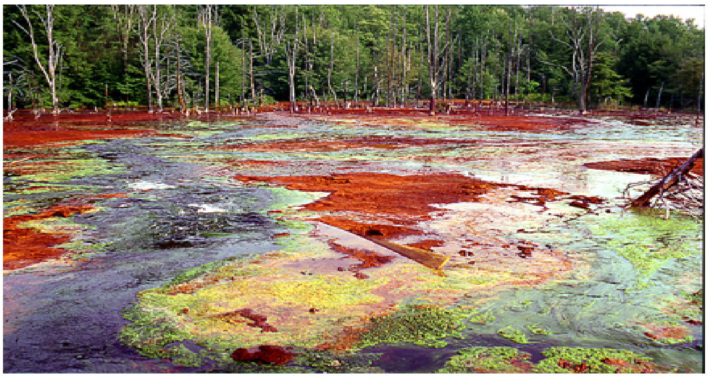

Fig 3: AMD Park, Vintondale US: "Toxic beauty" (Meyer, 2008)

For Kagan (2011), reconstructing the wholeness and restoring the reflexive sensibility and connection between human and non-human systems may be facilitated by the arts and culture, promoting sustainable and regenerative processes. He argues that ecological aesthetics embed the interrelation of culture and nature, interweaving the environment's webs of life or natural ecosystems and the social, political and economic aspects of society. This view also aims to re-awaken and incorporate a sensibility for the natural world that is inherent to humans and that modernist –industrial and post-industrial – societies have relegated to the background, but is still alive among Indigenous Peoples (Kagan, 2011).

Part 2: Fostering sustainability and regeneration through aesthetic experience. Toward the recognition of the aesthetics of sustainability.

Why is it important to 'experience' aesthetics? What kind of learnings can be drawn from that experience? Can this learning influence individual/collective behaviour?

Authors from different disciplines and approaches have written about the aesthetics of sustainability. They have produced sensitive and thoughtful work sharing the view that aesthetics and beauty are essential attributes within the sustainability discourse, notwithstanding a noted absence.

Regarding landscape architecture, of particular relevance is Elizabeth Meyer's (2008) theoretical conception of sustainable landscape architecture and the **understanding of beauty as a means of transformative change, a vision shared by Kagan (2011), an expert in arts and culture.**

Meyer's "Manifesto Sustaining Beauty. The performance of appearance", aims to reinscribe the value of the visual – specifically beauty – and the prominence of aesthetic experience as promoters of transformative attitudes, intellectual and moral, toward the environment. She acknowledges the writings of Howett and Spirn in the 1980s as precursors in making the link between aesthetics and ecological design. Meyer argues that beauty and aesthetics matter in the sustainability discourse and that designed landscapes are necessary "to provoke those who experience them to become more aware of how their actions affect the environment, and to care enough to make changes" (2008, p.6). In addition, she states by "connecting the visual experience to the body and poly-sensual experience, […] immersive aesthetic experience can lead to recognition, empathy, love, respect and care for the environment" (2008, p.7).

Considering design as a cultural ecosystem service, Meyer states that designed landscapes have the essential ability of creating memorable places where human activities and ecological processes coexist. A good example is Crissy Field Park, in San Francisco, designed by George Heargreaves & Associates, where wildlife habitats are juxtaposed to human recreational areas. The experience of beautiful designed landscapes therefore, can promote mindfulness and restorative sensations in our psyche that, in turn, can inculcate environmental values and lead to the appropriation and care of place. It should be noted that the concept of beauty in sustainable landscape design is dynamic, not generic, and is related to the landscape's resilience and capacity of regeneration (Meyer, 2008). In summarising these ideas, "Beautiful sustainable landscape design involve the design of experiences as much as the design of form and the design of ecosystems. These experiences are vehicles for connecting with, and caring for, the world around us" (Meyer, 2008, p.18).

Similarly, Kagan (2011) argues the cultural dimension is foundational in understanding sustainability and reality because it moves from a static utopic conception to a more dynamic vision of sustainability. This is a "search process for dynamic balance", based on the comprehension of patterns that pervade and connect different aspects of reality (Kagan, 2011, p.66). According to Kagan (2011), sustainability relies on resilience and emergence, which encompass natural and cultural diversity and the capacity of learning from the unexpected. For him, openness to uncertainties is a key issue in understanding complexity, both for nature and for human society. Understanding reality means dealing with complexity, and the literacy of complexity involves understanding how natural and human systems – comprising social, cultural, political and economic aspects – respond to unpredicted transformations in themselves and their environments, as well as their ability to create new qualities to the whole and the parts. In other words, understanding reality and sustainable processes requires knowledge about how human and non-human living systems work and evolve (Kagan, 2011; Mang and Reed, 2012).

For this author, the aesthetic of sustainability facilitates the understanding of complexity. This is possible because of the principle of "autoecopoiesis", a term coined by Kagan (2011), pointing to the intelligent and sensible response of systems to disturbance. In other words, ecological aesthetics may help in re-activating the sense of connectedness with and belonging to nature, principles that existential knowledge, Eastern philosophical and religious traditions and some Western thinkers share and celebrate. This concept, as already mentioned, is likewise explored by Salingaros (2010; Salingaros and Masden, 2008), who enhance the idea of the 'seed of conservation' that relies upon the preservation of living forms that embed the structure responsible for providing neurological nourishment to human beings, once human evolution took place in living environments.

The arts and culture, in Kagan's view, may have a central role in re-establishing wholeness, the reflexive sensibility and connection between human and non-human systems, promoting sustainable and regenerative processes. He argues that two practices are relevant to the experience of aesthetics of sustainability: ecological art and, maybe surprisingly, the practice of everyday walking. Firstly, ecological art because it relates to the web of interrelationships of our environment; it engages with natural elements like water, wind and natural materials; informs the public about ecological dynamics and reclaims, restores and remediates damaged environments. Secondly, the practice of walking allows direct contact with nature and facilitates observation, recognition and learning; moving at slow pace facilitates contextual perceptions and supports social and political values dealing with public spaces; it is accessible to most human groups whilst offering experiences that enhance attention and foster serendipity because it is open to unexpected interactions (Kagan, 2011). Full experience with the environment therefore, can result in communication and participation. Similarly, Meyer notes in her Manifesto referring to design:

> It enables social routines and spatial practices, from daily promenades to commutes to work. It translates cultural values into memorable landscape forms and spaces that often challenge, expand and alter, our conceptions of beauty (2008, p.1).

Fig. 4: The everyday practice of walking. *(Photo M. Z. de Baro)*

Conclusion

The analysis of the sensitive and thoughtful views **of the a**uthors from different disciplines and approaches suggests that the aesthetics of sustainability and the new understanding of beauty are essential issues in the regenerative sustainability discourse. It seems to be common ground the appreciation of human innate affinities with beauty and nature, the perception of beauty as a catalyst of transformative change and the importance of sensory experiences through the practice of simple and daily habits leading to the appropriation and care of place.

Aesthetic experiences and reflexive sensitivity are essential in (re)-connecting us to the world around us. Given current conditions, new skills are necessary for practitioners to design environments and art works that can promote experiences to engender awareness and care for the whole system. Ecoliteracy may help in recognising patterns that connect us with non-human beings and reveal inter-relationships that occur in the shared environment.

This new way of thinking about communities, how they are designed within the natural environment and understanding the symbiotic relationship, presupposes sensible approaches and new skills for design practitioners to fulfil the needs of sustainable regenerative urban design practices.

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Appendix B

Regenerating Cities through Living Architecture Collaboration

POSTER PRESENTED AT THE 2ND INTERNATIONAL SKYRISE GREENERIES CONFERENCE. SINGAPORE, NOVEMBER 2013.

Appendix C

Core principles of Regenerative Development and Design

Regeneration as a level of work

Regeneration is the inherent capacity within any open living system to "changing into something different and better, as well as to bringing about a thorough moral change or improvement "(Hes and du Plessis, 2015, p.111). Levels of work is a framework to assess the evolution of living systems. It comprises two orders: Existence (where the system currently is) and Potential (where the system could be but is not being achieved yet) with two levels each, Operate and Maintain within Existence, and Improve and Regenerate levels within Potential. A living system needs to work at all the four levels for improving its health and capacity for evolution. If the system remains just at the Existence order, it means that it increases efficiency and maintains effectiveness, but undermines efforts to improve or regenerate the system, e.g. green buildings. If the system evolves into the Potential order, it has increased its creativity and potential in relation to larger systems (Hes and du Plessis, 2015).

Development and design

According to Mang and Reed (2012b, p.3), regenerative development and design is an emergent distinctive field within ecological sustainability that *"marks a significant evolution in the concept and application of sustainability"*. The regenerative approach aims to design human systems that not only can diminish impact on or reverse degeneration of natural environments but also generate mutual benefits and co-evolution (Mang and Reed, 2012b).

Development and design are two different but synergistic elements of a paired relationship. Development informs design solutions to the issues that place and proposed project are bringing, they need to be partners; it also builds capability and scope of commitment of the parts involved aiming to transform them into co-designers and stewards of those solutions. In other words, regenerative development looks for development of the potential in the system. Regenerative design employs strategies and technologies to design self-renewing systems in which design interventions occur (Mang & Reed, 2012a; Hes and du Plessis, 2015). An example of this are Curitiba's urban acupunctures described in Chapters 6 and 8.

Place as a core

Place is the most relevant starting point for regenerative practitioners in order to understand patterns and processes that have shaped and are shaping the place in both the natural ecology and the local culture. A deep understanding of place as a whole re-locates it to its core position in human life, whilst creating an emotional bond that facilitates ownership along with the interest in caring for the development of strong local communities (Mang and Reed, 2012a; Beatley, 1997, 2004). When working on a project, regenerative methodology considers *place* not only the area occupied by the project itself, but also the neighbouring ecosystems, allowing connectivity and regenerative benefits to ripple through the region. Mang and Reed (2012a, p.26) define the foundation of this approach in these terms: "Regenerative development and design mean the reconnection of human aspirations and activities with the evolution of natural systems – essentially co-evolution".

From the regenerative development and design perspective, place is considered an organising core principle for all design disciplines regarding the built environment. It allows realigning the understanding of and relationship to the natural environment and local culture, creating a harmonious blend in a geographical context by understanding patterns and processes that have shaped and are shaping the place in both the natural ecology and the local human activities.

Considering communities and places as living systems, the concept of purpose is always present. Understanding place and discovering its purpose is essential for regenerative development and design because it expands the opportunities for co-evolution, which enable the potential of the system to regenerate (Mang &Reed, 2012a).

Pattern literacy

It is a deep understanding of how living systems work. It is penetrating into the organised complexity of nature and the cultural systems that compose a place, through decoding patterns of relationships. By recognising these relationships, designers can discover how systems existing on place organise and sustain themselves "and even what their evolutionary potential may be", determining how their designs can harmonize with and contribute to the site's health and evolution (Hes and du Plessis, 2015, p.118). This pattern literacy process enables the shift from dominance to intimacy with nature, because it allows a deep understanding of how it works. Examples of pattern literacy are permaculture and indigenous wisdom.

Power of story

Stories are ancient ways of preserving and communicating knowledge, they are also ways of relating people in time and space, to their places and to both their ancestors and future generations. They create collective identity and are providers of meaning; they put together loose pieces of information and make wholes full of significance. They help creating the 'big picture'.

Stories create the narrative relating all parts involved in the process, in terms of place, development, design, all stakeholders, outcomes and their interrelationships. They are powerful in deepening understanding and envisioning potential (Mang and Reed, 2012b; Hes and du Plessis, 2015).

Potential

The concept of place also embeds the notion of potential, defined as the "inherent capacity of growth, development or coming into being" (Mang and Reed, 2012b, p.18). All living systems have potential, thus, so does place as a living system. Potential rises from the uniqueness of place. A regenerative project, building or development seeks to contribute to the integrity, life and viability not only of the site where it is located but to the larger system in which it is nested (Mang and Reed, 2012b; Hes and du Plessis, 2015).