

## Formulating the principles of an eco-city

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**ABSTRACT:** Over 50% of the world's population now lives in cities and urban areas. These large communities provide both challenges and opportunities for environmentally-conscious developers, and there are distinct advantages in defining further and working towards the goals of sustainable cities. A sustainable city should be able to feed itself with minimal reliance on the surrounding countryside and power itself with renewable sources of energy. The crux of this is to create the smallest possible ecological footprint, and to produce the lowest quantity of pollution possible, to use land efficiently; compost used materials, recycle it or convert waste-to-energy. An eco-city is a city designed with consideration of environmental impact, inhabited by people dedicated to minimisation of required inputs of energy, water and food, and waste output of heat, air pollution and water pollution. The various aspects of this principle include education and training for all in sustainable urban development, technical training and up-skilling, research, exchange of experiences, knowledge dissemination through research publications about sustainable design city theory.

### INTRODUCTION

Economy, ecology and social cohesion are the pillars of a sustainable city. These must be in balance and, therefore, require an integrated approach. Dialogue is the basic principle for achieving this for Local Agenda 21 [1]. Cities have become the focal points of these components as major consumers and distributors of goods and services. However, many cities tend to be large consumers of goods and services, while draining resources out of the external regions that they depend on. As a result of increasing consumption of resources and growing dependencies on trade, the ecological impact of cities extends beyond their geographic locations. It has been recognised that the concept of sustainable development is an evolving, debatable term.

Sustainable urban management should challenge the problems both caused and experienced by cities, recognising that cities themselves provide many potential solutions, instead of shifting problems to other spatial levels or shifting them to future generations. The organisational patterns and administrative systems of municipalities should adopt the holistic approach of ecosystems thinking. Integration, cooperation, homeostasis, subsidiarity and synergy are key concepts for management towards urban sustainability [2]. Existing tools developed in relation to environmental action need to be extended to address the economic and social dimensions of sustainability.

Sustainable management of natural resources requires an integrated approach to closing the cycles of natural resources, energy and waste within cities. The objectives of such an approach should include minimising consumption of natural resources, especially non-renewable and slowly renewable ones; minimising production of waste by reusing and recycling wherever possible; minimising pollution of air, soil and waters; and increasing the proportion of natural areas and biodiversity in cities. These objectives are often easier to achieve on a small scale, which is why local ecological cycles can be ideal for introducing more sustainable policies for urban systems. Local government, therefore, plays a crucial role.

Sustainability is strongly linked to socio-economic aspects of cities. There is a need for the EU and Member States to create the conditions in which businesses can profit by operating in more environmentally-sound ways. Regional and local authorities should explore ways of creating employment through environmental measures, encourage better environmental performance in existing businesses and encourage industry to adopt an ecosystems approach.

Authorities should strengthen the well-being of the population and promote equality and social integration by ensuring that basic services and amenities, education and training, health care, housing and employment are available to all [3]. Resisting recent trends of ignoring environmental and social risks while concentrating on accumulating material wealth requires changes to the underlying values in society, as well as to the basics of economic systems.

Urban regeneration should be used to meet goals of sustainable development through the recycling of previously developed land or existing buildings, the retention of green field sites and protection of countryside and wildlife. Detailed sustainability objectives, including the establishment of ecological links, improved accessibility, energy efficiency and community participation, should also be pursued. The sustainable city process is about creativity and change. It challenges traditional government responses and seeks new institutional and organising capacities and relationships. This article identifies the intertwined principles for achieving Green Urbanism.

## GREEN URBANISM

Green Urbanism is a conceptual model for zero-emission and zero-waste urban design, which arose in the 1990s, promoting compact energy-efficient urban development, seeking to transform and re-engineer existing city districts and regenerate the post-industrial city centre. It promotes the development of socially and environmentally sustainable city districts. The holistic concept of an eco-city is shown in Figure 1.

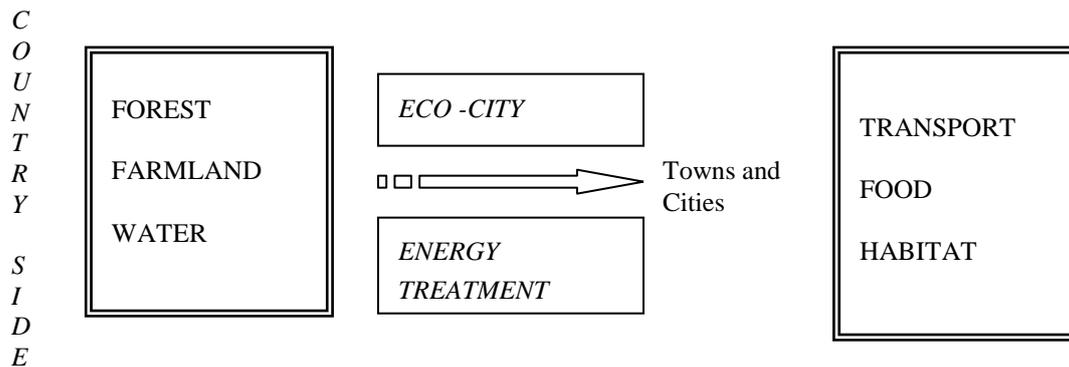


Figure 1: The holistic concept of an eco-city: a balanced relationship between the urban area and the rural area.

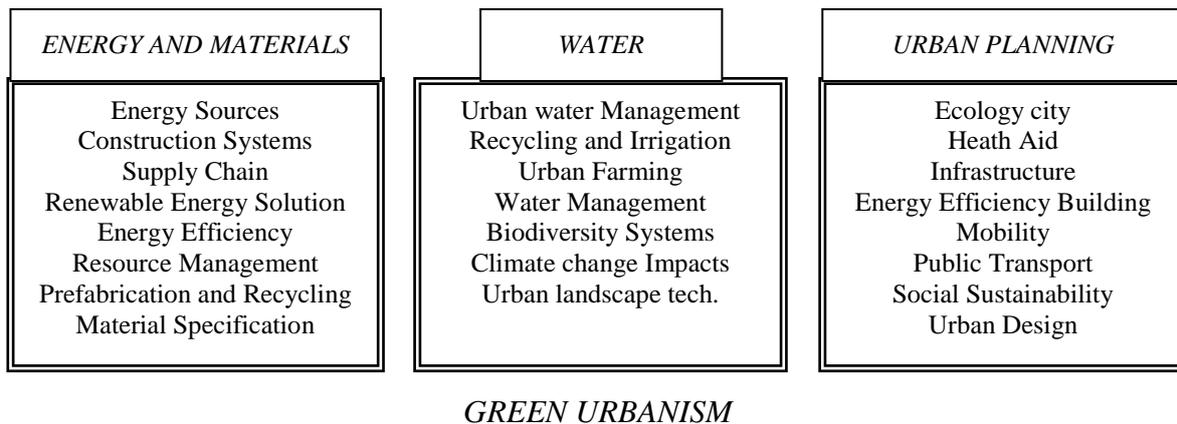


Figure 2: The three pillars of Green Urbanism.

Green Urbanism is by definition interdisciplinary; it requires the collaboration of landscape architects, engineers, urban planners, ecologists, transport planners, physicists, psychologists, sociologists, economists and other specialists, in addition to architects and urban designers. Green Urbanism *makes* every effort to minimise the use of energy, water and materials at each stage of the city's or district's life-cycle, including the embodied energy in the extraction and transportation of materials, their fabrication, their assembly into the buildings and, ultimately, the ease and value of their recycling when an individual building's life is over [4].

Today, urban and architectural design also has to take into consideration the use of energy in the district's or building's maintenance and changes in its use; not to mention the primary energy use for its operation, including lighting, heating and cooling. The three pillars of Green Urbanism are shown in Figure 2.

Over the last thirty-five years or so, an international debate on eco-city theory has emerged and has developed as a relevant research field concerning the future of urbanism and the city itself. One such school is Technical Utopianism (a technological idealism that relied on the quick *techno-fix*, as expressed, for instance, in the work of Archigram). The idea is that technology, human needs and environmental concerns should be considered an integral part of architecture [5]. Probably no historian before had so systematically explored the impact of environmental engineering and services on the design of buildings. Other early significant writing on Green Urbanism has come from Lewis Mumford and Jane Jacobs - although they did not call it Green Urbanism. Design for an *Energy-conscious Future*, and the *Solar City*

Charter the field of sustainable city theories and climate-responsive urbanism has constantly been expanded [6]. An important contribution was a programmatic manifesto for designing and constructing longer-lasting buildings [7].

More recent theories for *Compact Cities* and *Solar Cities* encapsulate the visions based on the belief that urban revitalisation and the future of the city can only be achieved through *re-compacting* and using clearly formulated sustainable urban design principles [8][9]. These principles for achieving Green Urbanism have to be clearly defined and adjusted to an era of rapid urbanisation, especially, in the Asia-Pacific region. In the 21st Century, one is working in an entirely new context, for which one needs new types of cities. As noted by Ulrich Beck, the people have arrived in *a new era of uncertainty*, where energy, water and food supply are critical. *We live in a world of increasingly non-calculable uncertainty that we create with the same speed of its technological developments* [10].

In 1972, in its study *Limits of Growth*, the *Club of Rome* formulated the negative effect of sprawl and over-consumption of resources. Today, one knows that uncontrolled development is a damaging exercise and that urban growth should occur in existing city areas rather than on green field sites. Younger people no longer desire to live in the endless suburbs, but have started to re-orientate themselves back to the city core, mainly for lifestyle reasons [11]. However, as several recent studies of inner-city lifestyles reveal, an increase in consumption can be part of the inner-city renaissance, which often enlarges the ecological footprint of the urban dweller (e.g. research by the Universities of Vancouver and Sydney on the effect of higher population density and increase in lifestyle gadgets owned by urban dwellers).

At the end of the 20th Century, Tokyo, Sao Paulo, Mexico-City, Mumbai, Calcutta, Shanghai and Beijing have grown to become endless urban landscapes. They are new types of mega-cities, which express an impossibility of orderly planning and strategic regulation. *Whatever happened to urbanism?* One finds emerging Green Urbanism theory for the 21st Century, which aims to transform existing cities from fragmentation to compaction. Eco-city theory focuses on adjusting the relationship between city and nature.

Leading sociologists and urban theorists are exploring wider areas, such as globalisation, urban sustainability, ecology, network systems, information and communication technologies, and other related fields. Solar cities in Linz-Pichling (Austria), Freiburg-Vauban and the Solar District Freiburg-Schlierberg (Germany), Hanover-Kronsberg (Germany), Stockholm Hammarby-Sjöstad (Sweden), the *BedZED Development* in Sutton (South of London, UK), and the green district EVA Lanxmeer in Culemborg (The Netherlands) represent some of the built milestones in sustainable urban development at the beginning of the 21st Century.

The Swedish city of Vaexjö has been very successful in reducing its CO<sub>2</sub> emissions and by 2015 will be entirely independent from fossil fuels. The industrial park in Kalundborg (Denmark) is often cited as a model for industrial ecology, while the City of Waitakere, in the Western part of the greater Auckland urban region, is New Zealand's first eco-city. In the meantime, *Sustainability Science* has emerged as a conceptual and theoretical basis for a new planning paradigm.

Today, one can probably recognise two major breaks in the continuous development of cities. The first is connected to the introduction of the car, which made possible an entirely different, dispersed city model (the de-compacted *Functional City* of the 20th Century). The second, the full awareness of problems posed by climate change and consumption of fossil fuel, is of equal importance and just as far-reaching, raising the possibility of entirely new city models and typologies that are likely to emerge: Green Urbanism [12]. Cities can and must become the most environmentally-friendly model for inhabiting our earth. It is more important than ever to re-conceptualise existing cities and their systems of infrastructure to be compact, mixed-use and polycentric cities.

## SUSTAINABLE MATRIX

Principles of Green Urbanism consist of:

*Climate and context:* Every site or place has its own unique individual conditions in regard to orientation, solar radiation, rain, humidity, prevailing wind direction, topography, shading, lighting, noise, air pollution and so on. One can use the buildings' envelope to filter temperature, humidity, light, wind and noise. Due to the different characteristics of every location, each city district has to come up with its own methods and tailored strategies to reach sustainability and to capture the spirit of the place. Each site or city is different and the drivers for re-engineering existing districts will need to understand how to take full advantage of each location's potential, and how to fine-tune the design concept to take advantage of local circumstances. As an aim, all urban development must be in harmony with the specific characteristics, various site factors and advantages of each location and be appropriate to its societal setting and contexts (cultural, historical, social, geographical, economic, environmental and political). In future, all buildings will have climate-adapted envelope technologies, with facades that are fully climate-responsive.

*Renewable energy for zero CO<sub>2</sub> emissions:* The supply of oil will last less than the life-expectancy of most buildings. The local availability of a renewable source of energy is the first selection criterion for deciding on energy generation. In general, a well-balanced combination of energy sources can sensibly secure future supply. A necessary aim is also to have a distributed energy supply through a decentralised system, utilising local renewable energy sources. This will

transform city districts into local power stations of renewable energy sources, which will include solar PV, solar thermal, wind (on- and off-shore), biomass, geothermal power, mini-hydro energy and other new technologies. Some of the most promising technologies are in building-integrated PV, urban wind turbines, micro CHP and solar cooling. Energy-efficiency programmes are not enough. Too often one finds that savings from energy-efficiency programmes are absorbed by a rise in energy use. Genuine action on climate change means that coal-fired power stations cease to operate and are replaced by renewable energy sources. High building insulation, high energy-efficiency standards and the use of smart metering technology is essential, so that if a part of an office building is not in use, the intelligent building management system will shut down lights and ventilation.

*Zero-waste city:* Sustainable waste management means turning waste into a resource. All cities should adopt nature's zero-waste management system. Zero-waste urban planning includes reducing, recycling, reusing and composting waste to produce energy. All material flows need to be examined and fully understood, and special attention needs to be given to industrial waste and e-waste treatment. One needs to plan for recycling centres, for zero landfill and *eliminating the concept of waste* and better understanding nutrient flows. Waste prevention is always better than the treatment or cleaning-up after waste is formed. Some other systems that need to be put in place are: the remanufacturing of metals, glass, plastics, paper into new products needs to be a routine (without down-grading the product); waste-to-energy strategies are needed for residual waste; and an *extended producer responsibility* clause is needed for all products. Essentially, the population needs to become (again) a *recycling society*, where it is common that around 60 to 90 per cent of all waste is recycled and composted.

*Water:* In general, reducing water consumption, finding more efficient uses for water resources, ensuring good water quality and the protection of aquatic habitats must be achieved. The city can be used as a water catchment area by educating the population in water efficiency, promoting rainwater collection and using wastewater recycling and storm water harvesting techniques (e.g. solar-powered desalination plants). Storm water and flood management concepts need to be adopted as part of the urban design, and this includes storm water run-offs and improved drainage systems and the treatment of wastewater. An integrated urban water cycle planning and management system that includes a high-performance infrastructure for sewage recycling (grey and black water recycling), storm water retention and harvesting the substantial run-off through storage, must be a routine in all design projects. On a food production level one needs to investigate the development of crops that need less water and are more drought resistant.

*Landscape and urban biodiversity:* A sustainable city takes pride in its many beautiful parks and public gardens. This pride is best formed through a strong focus on local biodiversity, habitat and ecology, wildlife rehabilitation, forest conservation and the protecting of regional characteristics. The sustainable city also needs to introduce inner-city gardens, urban farming/agriculture and green roofs in all its urban design projects (using the city for food supply). It needs to maximise the resilience of the eco-system through urban landscapes that mitigate the *urban heat island* effect, using plants for air-purification and urban cooling. Further, the narrowing of roads, which calms traffic and lowers the UHI effect, allows for more (all-important) tree planting. Preserving green space, gardens and farmland, maintaining a green belt around the city, and planting trees everywhere (including golf courses), as trees absorb CO<sub>2</sub>, is an important mission. In all urban planning, one needs to maintain and protect the existing eco-system that stores carbon (e.g. through a grove or a park), and plan for the creation of new carbon storage sites by increasing the amount of tree planting in all projects. The increase in the percentage of green space as a share of total city land is to be performed in combination with densification activities.

*Sustainable transport and good public space:* It is important to identify the optimal transport mix that offers inter-connections for public transport and the integration of private and public transport systems. Some ideas here include: eco-mobility concepts and smart infrastructure (electric vehicles); integrated transport systems (bus transit, light railway, bike stations); improved public space networks and connectivity, and a focus on transport-oriented development. The transport sector is responsible for causing significant greenhouse-gas emissions. To combat this effect the population needs to change their lifestyles by, for example, taking public transport, driving the car less or car-pooling. Alternatively, people can ride a bike or walk, if the city district has been designed for it. People want a city district, which is well-connected for pedestrians, a city with streetscapes that encourage a healthy, active lifestyle and where residents travel less and less by car.

*Local and sustainable materials:* The various aspects of this principle include: advanced materials technologies, using opportunities for shorter supply chains, where all urban designs focus on local materials and technological know-how, such as regional timber in common use. Affordable housing can be achieved through modular prefabrication. Prefabrication has come and gone several times in modern architecture, but this time, with closer collaboration with manufacturers of construction systems and building components in the design phase, the focus will be on sustainability. One needs to emphasise green manufacturing and an economy of means, such as process-integrated technologies that lead to waste reduction. It is more environmentally friendly to use lightweight structures, enclosures and local materials with less embodied energy, requiring minimal transport. Success in this area will increase the long-term durability of buildings, reduce waste and minimise packaging.

*Density and retrofitting of existing districts:* Consideration will need to be given to better land-use planning to reduce the impact of urban areas on agricultural land and landscape; to increasing urban resilience by transforming city districts

into more compact communities and designing flexible typologies for inner-city living and working. Special strategies for large metropolitan areas and fast-growing cities are required. Public space upgrading through urban renewal programmes will bring people back to the city centre. This will need some strategic thinking about how to use brown field and grey field developments and also the adaptive reuse of existing buildings. Re-modelling and re-energising existing city centres to bring about diverse and vibrant communities requires people to move back into downtown areas. In the compact city, every neighbourhood is sustainable and self-sufficient; and uses energy services company principles for self-financing energy efficiency and in all retrofitting programmes.

*Green buildings and districts:* New design typologies need to be developed at low cost and longer lasting functionally neutral buildings must be produced. One needs to apply facade technology with responsive building skins for bioclimatic architecture, to take advantage of cooling breezes and natural cross-ventilation, maximising cross-ventilation, day-lighting and opportunities for night-flush cooling; one needs to focus on the low consumption of resources and materials, including the reuse of building elements; and design for disassembly. It is important to renew the city with energy-efficient green architecture, creating more flexible buildings of long-term value and longevity. Flexibility in plan leads to a longer life for buildings. Technical systems and services have a shorter life-cycle. This means, first of all, applying technical aids sparingly and making the most of all passive means provided by the building fabric and natural conditions. Buildings that generate more energy than they consume, and collect and purify their own water, are totally achievable. One needs to acknowledge that the city as a whole is more important than any individual building.

*Liveability, healthy communities:* Land use development patterns are the key to sustainability. A mixed-use (and mixed-income) city delivers more social sustainability and social inclusion, and helps to repopulate the city centre. Demographic changes, such as age, are a major issue for urban design. It is advantageous for any project to maximise the diversity of its users. Different sectors in the city can take on different roles over a 24 hours cycle; for example, the Central Business District is used for more than just office work. In general, one wants connected, compact communities, for a liveable city, applying mixed-use concepts and strategies for housing affordability, and offering different typologies for different housing needs. To this end, one needs affordable and liveable housing together with new flexible typologies for inner-city living. These mixed-use neighbourhoods (of housing types, prices and ownership forms) have to avoid gentrification and provide affordable housing with districts inclusive for the poor and the rich, young and old, and workers of all walks of life, and also provide secure tenure (ensuring *ageing in place*). Housing typologies need to deal with demographic changes. Mixed land uses are particularly important as it helps reduce traffic. Master plans should require all private developments to contain 40 to 50 per cent of public (social) housing, and have it integrated with private housing. By integrating a diverse range of economic and cultural activities, one would avoid mono-functional projects, which generate a higher demand for mobility. Green businesses would be supported through the use of ethical investments to generate funding. The question is: how specific or adaptable should buildings be to their use?

*Cultural heritages:* All sustainable cities aim for air quality, health and pollution reduction, to foster resilient communities, to have strong public space networks and modern community facilities. This is the nature of sustainable cities. Each city has its own distinct environment, whether it is by the sea, a river, in a desert, a mountain; whether its climate is tropical, arid, temperate, etc; each situation is unique. The design of the city will take all these factors into consideration, including materials, history and population desires. New ideas require affordable and flexible studio space in historic buildings and warehouses. Cities will grow according to the details and unique qualities of localities, demographic qualities of the populace, and the creativity of the authorities and citizens. The aim of a city is to support the health, the activities and the safety of its residents.

*Urban governance and leadership:* Good urban governance is extremely important if one wants to transform existing cities into sustainable compact communities. It has to provide efficient public transport, good public space and affordable housing, high standards of urban management; and without political support change will not happen. City councils need strong management and political support for their urban visions to be realised. They need strong support for a strategic direction in order to manage sustainability through coherent combined management and governance approaches. A city that leads and designs holistically, that implements change harmoniously, and where decision-making and responsibility is shared with the empowered citizenry, is a city that is on the road to sustainable practices. In balancing community needs with development, public consultation exercises and grassroots participation are essential to ensuring people-sensitive urban design and to encouraging community participation. Citizens need to participate in community actions aimed at governments and big corporations, by writing letters and attending city-council hearings. Principles of Green Urbanism, based on an integrated action plan should include measures to finance a low-to-no-carbon pathway; implementing environmental emergency management; introducing a programme of incentives, subsidies and tax exemptions for sustainable projects that foster green jobs; eliminating fossil-fuel subsidies; developing mechanisms for incentives to accelerate renewable energy take-up; implementing integrated land-use planning; having a sustainability assessment; and certification of urban development projects.

*Education and knowledge:* Primary and secondary teaching programmes need to be developed for students in subjects such as waste recycling, water efficiency and sustainable behaviour. Changes in attitude and personal lifestyles will be necessary. The city is a hub of institutions, such as galleries and libraries and museums, where knowledge can be shared. Sufficient access to educational opportunities and training for the citizenry must be provided, thus, increasing

their chances of finding green jobs. Universities can act as *think tanks* for the transformation of their cities. The developed education approach also needs to redefine the education of architects, urban designers, planners and landscape architects. Research centres for sustainable urban development policies and best practice in eco-city planning could be founded, where assessment tools to measure environmental performance are developed and local building capacity can be studied.

## CONCLUSIONS

Green Urbanism has to become the norm for urban developments. The problem of urban design is far more complex. Designing a city requires holistic, multi-dimensional approaches, and the adaptation of strategies to a unique context each time: the integration and combination of qualitative and quantitative knowledge. The construction and demolition sector has a particularly urgent need to catch up with other sectors in better managing its material and waste stream, and increasing the focus on reusing entire building components at the end of a building's life-cycle. Increasing the economic value of recycled commodities, such as rare metals in e-waste, metals, paper, glass and plastics remains an area for future development and investment.

Achieving sustainable materials flow in cities and *zero waste* remains difficult and requires continued and combined efforts by industry, government bodies, university researchers and the people and organisations in our community. It will be essential to continue to reduce wasteful consumption and to promote the cyclical reuse of materials in the economy by maximising the value of our resources to make resource recovery the common practice. The objective must be to reconcile the scarcity of our natural resources with the almost *infinite* quantities of waste produced by cities and industries, which one must unfailingly recover. One must find ways of doing more with less. Principles of Green Urbanism are practical and holistic, offering an integrated framework, encompassing all the key aspects needed to establish sustainable development and encouraging best practice models.

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