SOME GUIDELINES FOR APPLYING ECOSYSTEM-SERVICES IN URBAN AND RURAL PLANNING.

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1. Introduction

This paper should be read as background information, giving more details behind the presentation *'towards a climate-proof ecopolis: plea for the lobe-city'* which I presented in Antwerp (Belgium) on Saturday 19th of December 2015 (Rebirth day initiative).

Cities are generally regarded as the cause of many ecological and social problems. Can they, in the future, also become the source of solutions? And if so, what are the best **strategy** and the best **urban model** for achieving these goals?

This paper presents some eloquent and inspiring examples of ecological residential neighbourhoods, ecoquarters, ecovillages and other green initiatives in European cities.

To conserve urban biodiversity, the **"lobe-city"** seems to offer the best prospects. This was developed as an urban planning model in the first half of the 20th century, in most cases as a reaction to the concentric growth of towns that was regarded as suffocating (GIELING, 2006). A lobe-city is characterised by blue and green fingers (wedges) in which one can find countryside-features penetrating deeply and separating densely built-up city-lobes from each other. Among others, the expansion plan for Köln (1927) in Germany and the "finger plan" for Copenhagen (1948) in Denmark were based on this concept. To varying degrees, the model of the "lobe-city" was also employed in the general plan to extend Amsterdam (NL-Amsterdam AUP, 1935) and in cities as Hamburg, Tübingen, Stuttgart, Berlin, Freiburg im Breisgau, Frankfurt am Main (Germany), Stockholm (Sweden) and many others.

This lobe-city model seems to be interesting, because the built-up areas can profit from important **ecosystem services** (HASSAN et al., 2005), produced in the blue-green fingers. One can think about lowering urban temperatures, maintaining the small water-cycles by moistening the air, producing oxygen and capturing CO_2, capturing particle air pollution, supporting conditions for recreation and food production (CSA, community supported agriculture), absorbing storm-water surpluses, carrying urban biodiversity etc.

1.1 The ecodevice model

Each ecological insight starts with the recognition that all human activities are depending on an intact biotic level: Humans need plants to feed them and to provide them with oxygen. But plants and animals need good abiotic ecological conditions such as water, sunlight, minerals in the soil, etc. That means that the abiotic sphere dominates the biotic one. Humanity obviously has a very vulnerable position in ecosystems.

Figure 1 illustrates this dependency clearly (SCHROEVERS, 1982).

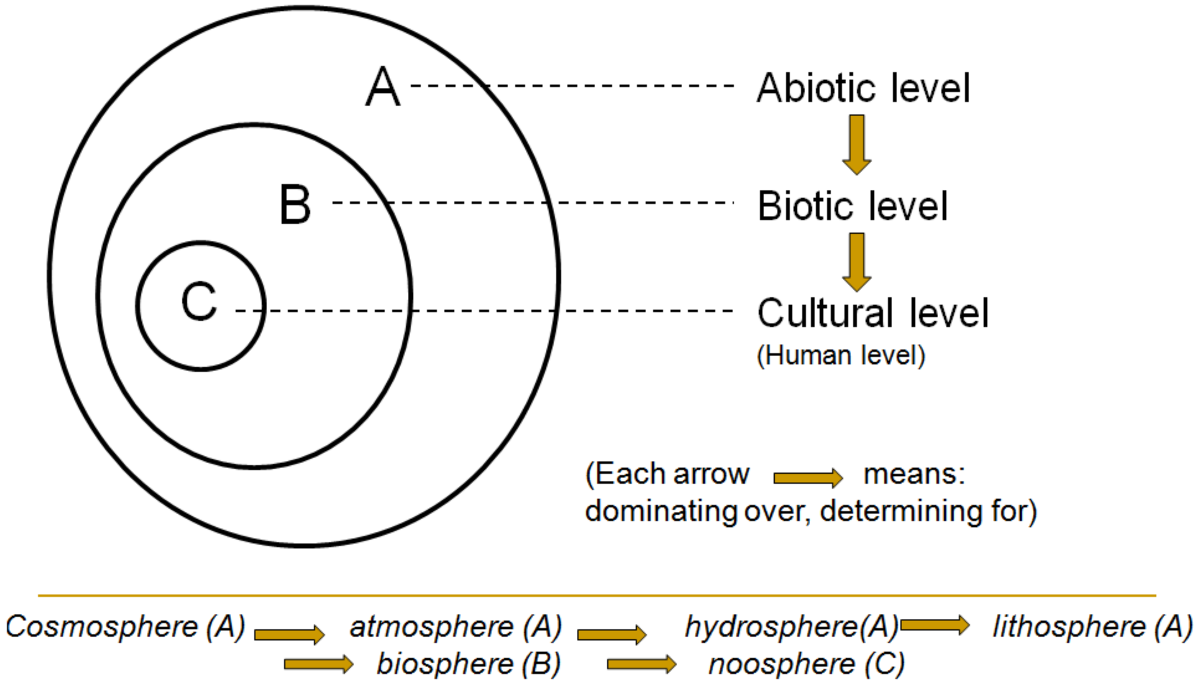


Figure 1 : Human activities depend on intact biotic and abiotic levels (SCHROEVERS, 1982).

Building cities has a lot to do with environmental problems. To point that out, the so-called ecodevice-model is very interesting. Van Wirdum and Van Leeuwen developed that model at the TUDelft (The Netherlands) for ecosystems (VAN WIRDUM, 1979), but it can also be used to illustrate the environmental impact of a city. One can see a building, a village or a city as a black box. At one side there is an input of energy, of water, of food, of building materials etc. At the other side there is an output of discharge-flows. (Figure 2).

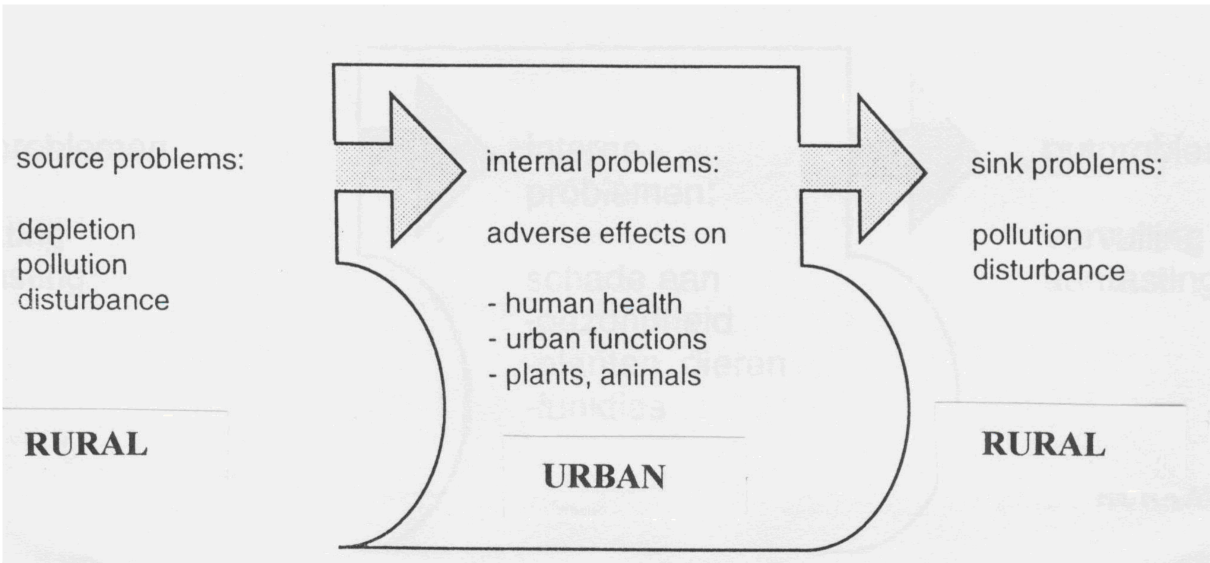


Figure 2 : The ecodevice model applied on urban environmental problems (TJALLINGII, 1996).

Supplying the city with building materials is causing **source**-problems in rural areas. This can cause environmental damage because of the extraction of materials such as gravel, which affects landscapes and nature. Exploiting the tropical wood has severe consequences for tropical rainforests. Supplying the city with water, energy and raw building materials can cause pollution and disturbance problems in rural areas. The larger extra supply-flows are, the bigger source-problems in rural areas will be.

Next there are **internal** problems within the buildings and within cities. These problems are dealing with damaging effects of used (building)materials on the health of inhabitants and of users of the buildings. Examples are the influence of asbestos, of formaldehyde-containing glues, of evaporating solvents or radon-gas etc. One can also think about internal city-problems such as increasing photochemical ozone levels (summer smog), traffic noise, dust causing local (sun)dimming-effects and winter smog, etc.

Finally there are **sink**-problems caused by discharge-flows from urban areas towards the rural neighbourhoods. A dwelling produces wastewater, waste-gases and solid waste. Decisions by designing, made a long time ago by architects and urban planners, have great influence on the amount of waste produced later on. Decision-examples are the orientation of the house and the choice of (district?)heating-system, which have influence on emissions; or the insulation level which is important for the fuel-consumption and thus for emissions. Sooner or later buildings will be demolished, thus creating 'demolition waste'. Architects and urban planners should be aware of that, at the time of designing a building. So they can take into account measurements to decrease demolition-waste. Architects and planners can prevent a lot of environmental damage while designing.

So the ecodevice model is another way to illustrate the well-known concept of the ecological footprint of a city (WACKERNAGEL & REES, 1996).

1.2 Ecology: a holistic and process-based approach

Thinking about an **ecopolis** means starting with studying ecology as a scientific part of biology. Ecology is a synthesising scientific discipline, with a holistic approach. Ecology deals with relations between living organisms on the one hand. On the other hand, ecology is dealing with relations between organisms and their abiotic surroundings. Since the creation of ecology by Ernst Haeckel in 1866, scientific ecology has evolved very much (HAECKEL, 1866 in HUBLE, 1981). There are two well-known approaches of nature and ecology:

The first discourse is the traditional landscape-ecological approach in which city and nature are enemies; nature starts where the city ends. Nature is an object, a species or a nature-reserve. Biologists do not care about the city; they are experts dealing with conservation biology and wildlife management in green rural areas. Humans and nature are kept separate from each other. *Nature is an object which means nature is something to have, to protect or to lose…*

Luckily, a second discourse is emerging in which nature is seen as a process. Ecological laws and mechanisms are working always and everywhere, thus also within cities. (Rain)water, soil, climate are abiotic conditions, influencing organisms and organisms are influencing each other, also within cities. Urban city-planning and rural land-use planning are therefore working with nature and with the basic ecological processes. The aims of ecologically and socially sound urban planning and designing, are to create ecological conditions which are attractive for plants, animals and for human activities. Humans are part of nature. So this second discourse is focussing on processes. *Nature is a process, nature and ecology is something to do and to work with* (after TJALLINGII, 2000).

We conclude that ecologically sound urban and rural planning are taking natural processes as their point of departure. Creating the right conditions (patterns and processes, see 2.2) in order to restore biodiversity and social diversity in urban and rural areas, is the purpose of this sustainable approach.

1.3 Ecosystem-services

Ecosystem services (Figure 3) are defined as the benefits which humanity obtains from ecosystems, without paying for them. These include:

a. ***Provisioning** services* such as providing food, fuel, raw (building)materials, oxygen and clean water to humanity;

b. ***Regulating** services* such as flood-, climate-, erosion-, and disease control and water purification services ;

c. ***Cultural** services* such as spiritual, recreational, educational, and cultural benefits for humanity.

d. ***Supporting** services* such as nutrient cycling and soil formation that maintain and improve the conditions for life on earth (after HASSAN et al., 2005).

The carrying capacity of our planet for humanity is based on “provisioning services” , which have been increased by human interventions (such as: irrigation, fertilization,… for agriculture and forestry, etc.). These provisioning services depend entirely on the “supporting and regulating services” , which decreased enormously due to human impact (pollution, extinction,...). Humanity is relying on ecosystem services, but these services get damaged severely by human’s activities.

Figure 3 : some important ecosystem services (see HASSAN et al., 2005)

Ecosystem services deal with the benefits mankind gets (for free) from ecosystems, so there is clear link between ecosystem services (delivered for free by nature) and human economy. Pavan Sukhdev, the Deutsche Bank economist leading a European study on ecosystems, reported that we are losing natural capital worth between US$ 2 trillion and US$ 4 trillion every year, as a result of **deforestation** alone. Sukhdev arrived at this figure by estimating the value of the ecosystem services that forests perform (such as locking up carbon, feeding the local small and regional water-cycles, providing fresh water, etc.), and **calculating the cost of either replacing them technically, or living without them** [1].

A very interesting Western European case study is presented by MEIRE & VAN DIJCK (2014), describing the importance of restoring urgently ecosystem services in the basin of the river Scheldt in France, Belgium and the Netherlands. Indeed ecosystem services are of international importance and need an international approach. Ecosystems don't care about political boundaries. As human's economy and activities have, also ecology and ecosystem services have an international dimension.

2 Anthropogenic added dynamics: human activities versus biodiversity

2.1 Abiotic ecological conditions have to be designed in sustainable gradients

A diversity in abiotic conditions creates different habitats and therefore a diversity in fauna and flora (

Figure 1). But certain abiotic conditions are dominant and aggressive (e.g. polluted, salty, noisy, high dynamics, ...), while others are weak and vulnerable (e.g. clean, fresh, silent, low dynamics,...). Aggressive conditions easily affect the weak and vulnerable conditions, especially when aggressive conditions are situated (planned) on dominant positions (topographically higher, upstream, etc.) or when they are badly buffered (ROMBAUT, 1987 ; ROMBAUT & MICHIELSEN, 2005; ROMBAUT, 2011).

All over the planet, biodiversity is in general much higher in areas characterized by weak abiotic conditions, where 80% of the indigenous plant species grow. Only 20% of the species can grow in habitats characterized by dominant and aggressive abiotic conditions (WAAJEN, 1985). But those 20% of 'human-tolerant' species often occur in very large populations and in very high densities (pests!). Therefore, in order to achieve a sustainable variety of plants and animals in mainly aggressive environments (like cities), the ecological principle is to create sustainable gradients in abiotic conditions. Figure 4 points out how to design such a sustainable abiotic gradient, necessary for restoring or maintaining (urban) biodiversity

[1] https://www.ted.com/talks/pavan_sukhdev_what_s_the_price_of_nature#t-184853

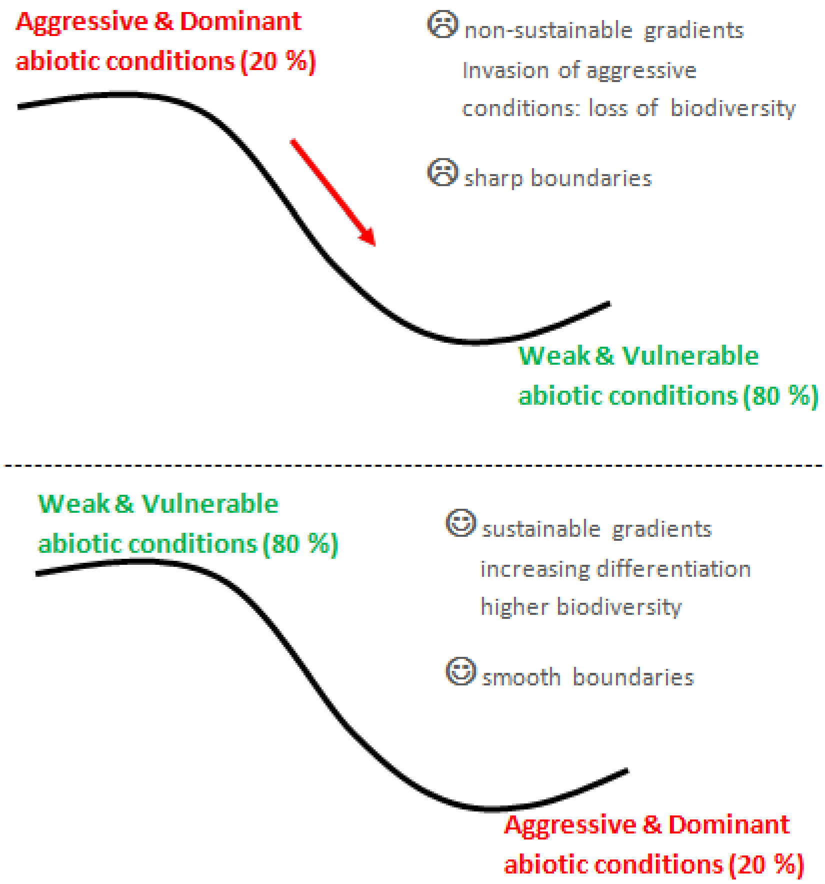


Figure 4 : Avoid the situation (above) of aggressive ecological conditions on a higher places (such as slopes, river springs, …) in landscapes. Strive for a sustainable gradient by design (under): more biodiversity over time will be the result, because 80 % of indigenous plant species depend on weak and vulnerable abiotic conditions. (ROMBAUT, 2011)

Suitable guiding models for the interconnection between the urban water system with the rural water systems can be found in STOWA (2000), in which the **connection model** (already presented by TJALLINGII, 1996: Figure 5) is applied. The connection model can be used to design a sustainable regional (urban/rural) water system. In this connection model the underlying ecological principle is to create a stable gradient by allowing water to **flow from clean to polluted**, from nutrient-poor to nutrient-rich conditions, from low dynamic to high dynamic areas.

There are two possibilities: a series connection and a parallel connection. In both cases, the aim is to find the best mutual adjustment between the water systems and the land use of different areas. Indeed, nature and leisure areas need the best standards for water quality, which has to do with the maintenance of clean, important ecological conditions both for biodiversity and for human health. In the connection model, residential areas are therefore located in the water system *upstream* from agricultural-industrial areas, but *downstream* from nature and leisure areas (TJALLINGII, 2005). All this means: taking into account so-called horizontal ecological relations (ROMBAUT, 1987 and ROMBAUT, 2011).

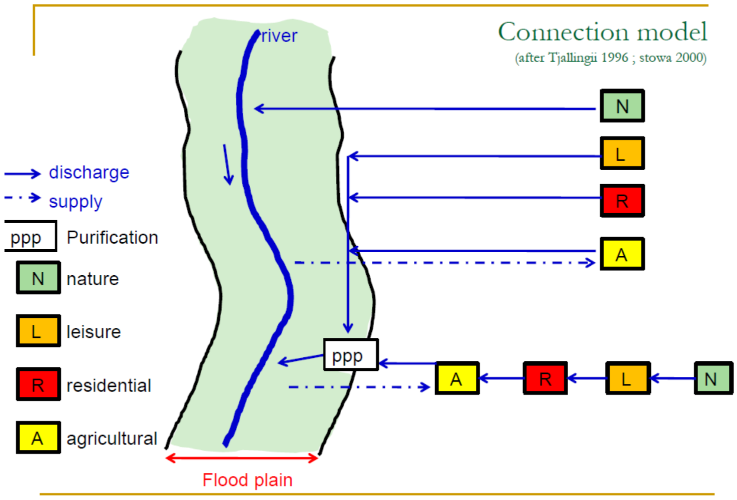


Figure 5: The connection model suggests an ecologically sound water-chain between rural and urban regions. (STOWA, 2000)

2.2 About processes as the cause of patterns (VAN LEEUWEN, 1966)

The *gradually change* (increase or decrease) of one or more environmental conditions *in space* is called **'a gradient'** (e.g. moisture gradient from wet to dry, salt-gradient, nitrogen-gradient, etc.). Following the genetic tolerance optimum of organisms , and also as a consequence of competition, every single species finds its own grow optimum along the gradient within a landscape. So sustainable gradients in abiotic conditions guarantee species-rich, small-scaled biodiverse communities.

The influence of abiotic (non-living) ecological conditions often varies also over time (e.g. climatic variation, day-night rhythm, tidal rhythm along the coast, etc.). Such a *variation in the time* is called **'the dynamics'**. In general, local species can resist these local natural fluctuations and so, the local communities are stable over time (apart from natural succession).

Species growing together in the same community (forest, heath and moorland, dunes, …) have similar requirements for their abiotic environment (pattern) but also for the temporal dynamics at that place (process).

With the publication of his Relation Theory in 1966, VAN LEEUWEN added a deep understanding in the landscape ecology discipline. He studied the relation between time (process, dynamics) and space (pattern, gradients). The Relation Theory explains clearly that processes are dominating patterns: A process (time) is the cause; a pattern (space) is the consequence. This means that temporal aspects dominate spatial ones.

VAN LEEUWEN concludes that **high dynamic processes result over time in boring, uniform pioneer-landscapes and poor biodiversity. Low dynamic and stable processes result over time in increasing biodiversity in attractive climax communities with huge biodiversity.**

This explains scientifically why human's activities (which are mostly high dynamic processes, spreading aggressive dominant ecological conditions) usually are affecting vulnerable and weak ecological conditions over time, which is then followed by decreasing biodiversity and is ending with boring uniform landscape patterns.

The practical consequence is that next to sustainable abiotic patterns (see 2.1), also ecological processes should be taken into account in sustainable urban and rural planning. Sustainable blurred gradients not only have to be designed gentle and correctly (Figure 4), they also need an ecologically sound long-term management, e.g. taking into account the different stages of natural succession. Choosing the right and stable (long-term) management techniques will lead to a more biodiverse pattern. Haying, pruning and hewing (= taking away biomass and thus leading to mineral-impoverishment), extensive grazing, are measures that will result (over time) in very different biotopes with a large biodiversity. Although a lot of experience in nature management techniques is developed in a rural context, this kind of ecology-based management is also applicable in urban green areas and urban gardens.

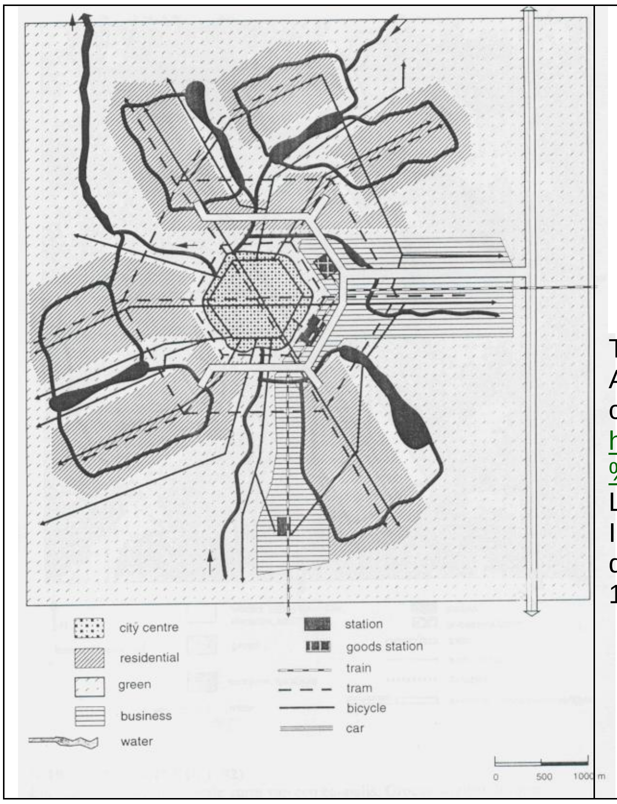
Urban biodiversity is often still very low. We already explained (see 2.1) that a first important reason for that is the dominance of aggressive ecological conditions in urban areas. Large waste deposits, dirty sewer systems, food and mineral storages, etc. are optimal habitats for very few species (20%). Moreover, areas that could contain more kinds of species are often not only badly designed (**pattern**) but often also badly managed (**process**). The same aggressive species always benefit from cutting the lawn too often, using too many biocides, too much manure, pollution, etc.: biodiversity decreases. That's another reason why populations of few ‘human-tolerant’ species (20 %; such as nettles, rats and doves) will increase and often become real pests within urban areas.

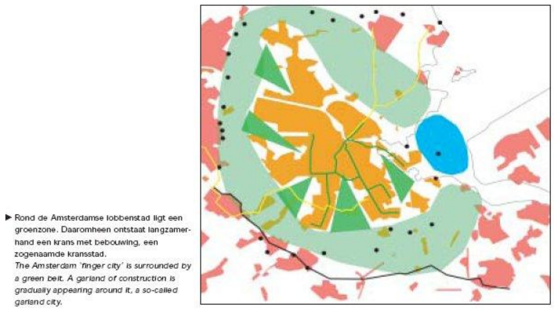
Designing and creating a varied abiotic environment (pattern) followed by a well fitted nature-friendly way of management (process) is the best guarantee for a very rich, spontaneous flora and fauna, also within urban green areas and that for an reasonable cost. Reasonable, because the traditional intensive high dynamic green management is more expensive than ecologically sound low-dynamic extensive green management techniques (HERMY, 2005). Ecologically sound green management needs less labour. The money savings can then be used for the environmentally friendly maintenance of the stony city centre, since the maintenance of e.g. cycling paths and footpaths, without using pesticides, is more labour intensive. So on average, employment is maintained. (VASTENHOUT, 1994).

3 The Lobe city

In literature [2], a discussion is going on for a long time on the best form of a sustainable city. Is a compact city the best shape for an ecopolis ? Studying these problems, TJALLINGII (1992, 1994, 1996) concludes that the **'lobe-city'** probably is the best form for an 'ecopolis' (Figure 6). For the city centre a closed hexagon (pentagon) is the best form, in terms of costs of investing in infrastructure and management costs. The edge of the city needs a lobed structure. The lobe-city characteristically has **blue-green wedges (= fingers)** between the built-up lobes. Those blue-green fingers have to be connected with the ecological (blue-green) infrastructure through the rural area (Natura-2000).

[2] Well-known is the compact-city debate: How sustainable is compact and how compact is sustainable ? Uncontrolled spreading of the city (urban sprawl) is harmful for rural areas. But building in the scarce open green space within the city to make the city more compact is not a good idea either. The citizen loses green within walking-distance and moreover, the solution of the water problems of the city needs large blue-green infiltration areas very close to the city-centre (see WILLIAMS et al, 2000 ; JENKS et al., 1996 ; JENKS & DEMPSEY, 2005 ; DAVOUDI et al. 2009).





Top:
Amsterdam (The Netherlands): example of a lobe-city.
http://www.dro.amsterdam.nl/Docs/pdf/PLAN%201%202006.pdf
Left:
In a lobe-city, blue-green fingers are penetrating deep between built-up city lobes (TJALLINGII, 1996)

Figure 6 : The lobe-city (TJALLINGII, 1996)

Through the **blue-green fingers**, a lot of rural **ecosystem services** can be brought into the city: possibilities for urban agriculture (community-supported agriculture, CSA) and for restoring biodiversity next to the city-centre; possibilities for storage and infiltrating of (rain)water that runs off out of the impermeable city. Storing storm water in blue-green fingers close to the cities can avoid flooding of the built-up areas and of rural areas downstream of the city. The blue-green fingers are attractive for citizens to cycle and to walk very close to their dwellings. Moreover, blue-green fingers have a good influence on the city-climate: tempering the urban heat-island effect, restoring small local water-cycles and providing humidity in hot seasons (www.epa.gov/heatisland) (Figure 7). In the blue-green wedges, some extensive low dynamic green urban functions such as graveyards, children's farms, vegetable gardening for citizens, some sport and leisure infrastructures, etc. might be planned. When one is designing a good pattern (gradients) and one is thinking about an ecologically sound management process (see 2.2), the nature-values and also the social values of those green wedges can be huge.

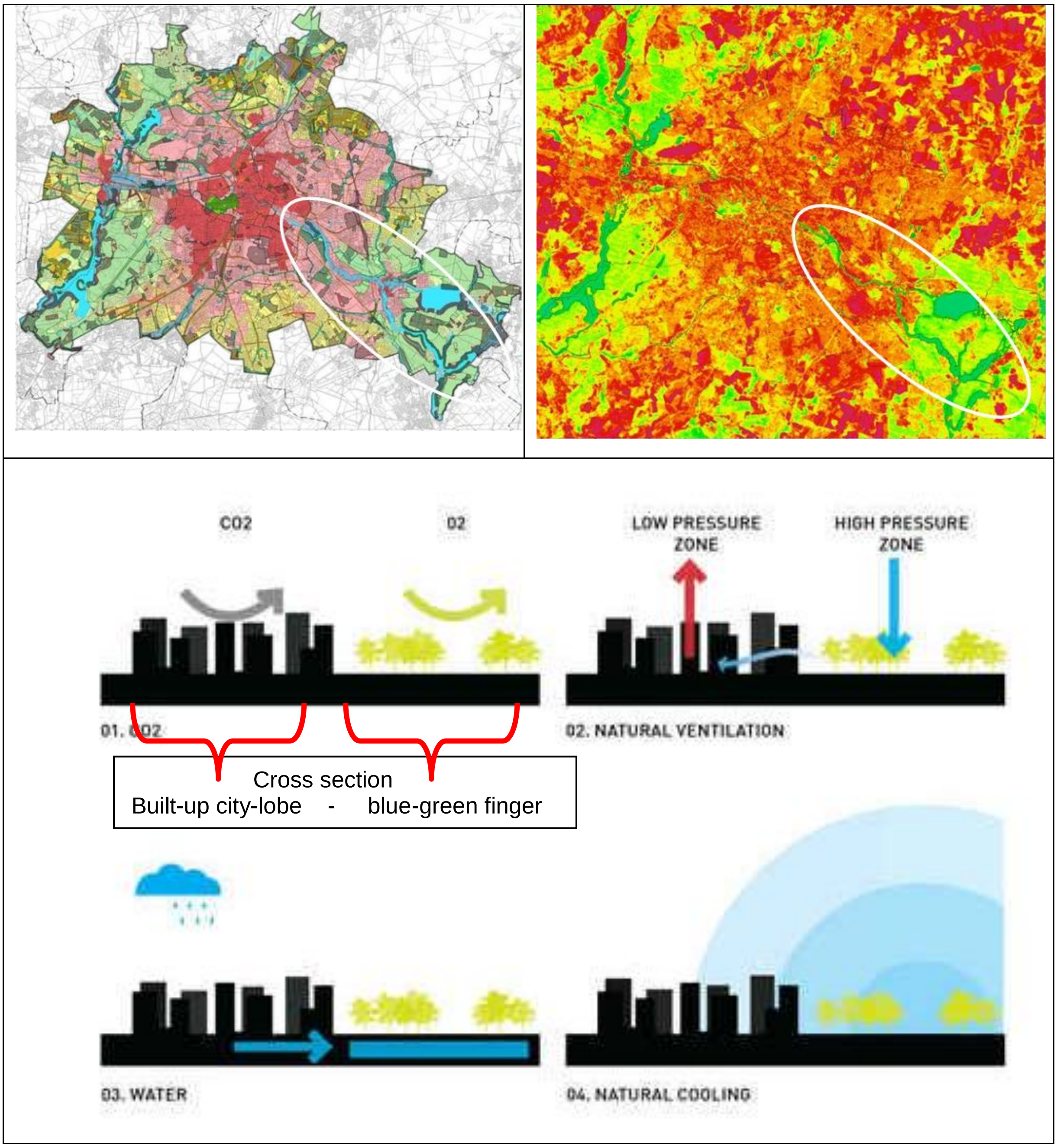


Figure 7: Blue-green fingers have an interesting impact on urban climate, as a lot of rural ecosystem services can be brought into the city. The built-up areas have a higher temperature, thus a lower air pressure than blue-green areas. Blue-green fingers remain colder. Air transport by convection from green areas towards the city keeps lobe-cities cooler and brings more humidity. The pictures show Berlin (Germany). On the upper left picture the blue-green areas are clearly visible. The infrared picture (upper right) shows the differences in temperature (CLOOS, 2006). This is an illustration of the urban heat-island effect: building materials such as concrete, bricks and paved tracks get warmer than blue-green areas (HERMY, 2005).

Other ecosystem services are mentioned in the cross-section of a built-up city lobe and a blue-green finger: production of O_2 and absorption of CO_2 and dust, natural ventilation, infiltration of run-off water and natural cooling (http://www10.aeccafe.com/blogs/arch-showcase/2011/06/18/masterplan-%E2%80%9Cjuzne-centrum%E2%80%9D-in-brno-czech-republic-by-chybikkristof-associated-architects/)

Accepting a cycling-maximum of 15 (to 20) minutes to the city-centre (central train and bus station), the length of **the built-up city lobes** can be about 2500 (- 3000) meters. TJALLINGII (1996) proposes 600 meters for the width of the lobes, in order to keep the green areas within walking distance of the citizens. To set up a payable public transport system, dwellings in the city-lobes must be built more densely, in contrast with the suburban context of garden cities. There is a lot of interesting study work been done about how to raise densities without losing quality and living comfort [3]. Enough people should be living within a walking distance from bus or tram stops. The central axes of the lobes need very comfortable, affordable and frequent public transport systems (also during the night). Best is a light-rail system on the ground level (both underground metro or sky-train systems are too expensive). All this means a city lobe has a surface of around 2500 (-3000) x 600 m² which is around 150 (180 ha) [4].

In a lobe-city the water-chain carries the green fingers, the (public)traffic-chain carries the built-up lobes. Designing high densities of dwellings is important for setting up payable public transport but also for the introduction of District Heating and Cooling (see 3.1.2). The EU also advocates the lobe city, presenting the mobility component in the fingerplan of Copenhagen as a good example of sustainable urban planning. In EU (2003:23) we find: *Transport can be considered as a derived demand of the wish to perform activities and land-use describes the spatial distribution of activities. The linkage between land-use and transport is widely recognized and a growing number of cities are developing integrated land-use and transport plans. Good examples of integrated policies are the fingerplan-structure in Copenhagen (Denmark) and the integrated land-use, landscape and transport planning in the Greater region of Stuttgart (Germany)*. Indeed, both examples (Copenhagen and Stuttgart) are based on a lobe-city approach (ROMBAUT, 2009).

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[3] The creation of a “semi-public common interior space” within the buildings, between buildings and a well thought public-private gradient in the green areas of building blocks in residential neighbourhoods seems to be the urban planning key and strategy for raising densities without losing quality and living comfort. We cannot elaborate this theme here but we refer the reader to ROMBAUT, 2008 ; ROMBAUT & HEUTS, 2010 ; ROMBAUT (2011) for more details.

[4] With a density of minimal 50 dwellings/ha, 7500 (9000) dwellings in a city lobe, a lobe-city contains up to 100.000 (130.000) inhabitants. Further expansion of the city is best organised along the axes of public transport around the railway stations, as a string of beads (TJALLINGII, 2005).

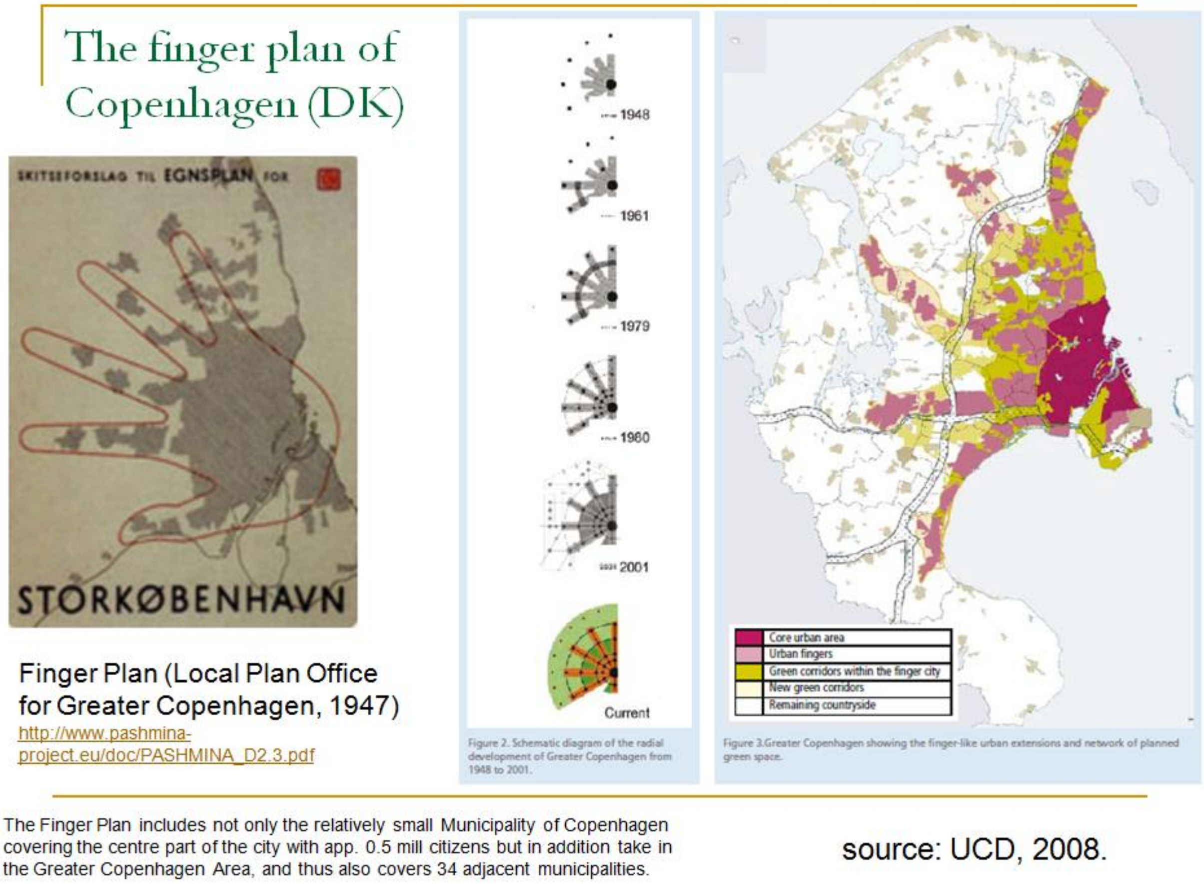

Figure 8 : The fingerplan of Copenhagen, capital of Denmark. (1,5 billion inhabitants)

In a lobe-city, the strategy of the two networks is applied (S2N) (TJALLINGII, 2005): Within the blue-green fingers all the *low dynamic activities* are concentrated such as foot paths and cycle lanes, city farming, low dynamic leisure and recreation activities, nature, ponds for the infiltration and retention of storm water, cemeteries, some sports infrastructure, ... Within the built-up city lobes all the *high dynamic activities* are planned, such as industrial activities, trade services, mass recreation, … The residential areas are situated in-between. The two networks create a good position for residential land-use in the middle, with free access to both the slow lane and the fast lane. Notice in Figure 9 that conventional agriculture is regarded as a highly dynamic activity, which is better linked to the industrial area rather than to the blue-green zone.

So it all boils down to the design of contrasts, close to each other and linked with the basic ecological laws and principles, as explained in 2.1 and 2.2. Just as the (public) traffic network supports the fast lane of high dynamic social and economic life, water networks support the slow lane of leisure and nature.

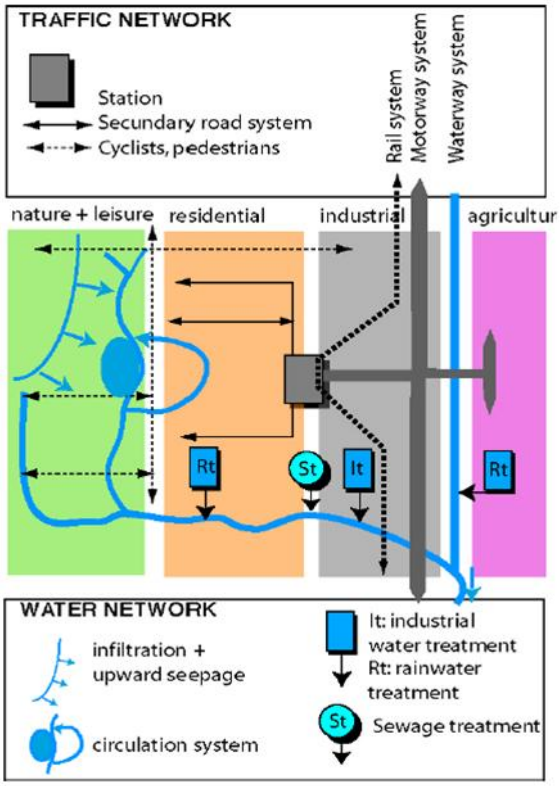

Figure 9: The two networks' strategy (S2N, TJALLINGII, 2005)

3.1 The Lobe city versus the garden-city: compactness versus energy and mobility

3.1.1 The lobe-city versus the garden-city

In fact the **lobe-city concept** is another way to fill in the ideas of Ebenezer HOWARD, which were an answer on the social problems in industrial cities in the United Kingdom at the end of the 19th century. HOWARD (1898, 1902) presented with his 'three magnets' theory a new concept: **the garden-city**. He wanted to wed 'city' and 'country', by placing houses in 'yards'. The advantages of urban and rural areas were combined in so-called 'new-towns' (LAGROU, 2000). Each lot has its own house surrounded by a private garden. The main critique on this large lot zoning in the garden cities is the *lack of density*, (often less than 25 inhabitants/ha, see Figure 10) which is the main reason why public transport systems are due to fail and all other public services are very expensive:

Scattered dwellings (urban sprawl) are difficult and expensive to connect to sewer systems, and to all kinds of public services. Garden-cities produce environmental and mobility problems. In North America, the Broadacre City plans of Frank Lloyd Wright (1958), in which everyone could afford to have a house on an acre of land, and get there by car (or helicopter!), were the seeds of an intellectual and aesthetic justification for urban sprawl (REGISTER, 2002). Streets were designed in an endless grid. The gridiron layout (streets usually north-south, east-west oriented) was criticized by FISHMEN (1990), in his criticism on 'America's new city': *The grid is boundless by its very nature, capable of unlimited extension in all directions... it is destroying the freedom of movement and access to nature that were its original attraction…… the 'new city' has an urban form that is too congested to be efficient, too chaotic to be beautiful and too dispersed to possess the diversity and vitality of a great* *city... no one can find the centre of a new city and its borders are even more elusive... in the old central cities, the jobless have moved in, the jobs have moved out...*

Uncontrolled expansion of broadacre cities ends with unliveable suburbs such as Los Angeles, a city of almost 100 km². A US-study (*the cost of Sprawl(1974))* gathered data from all over the US and compared impact of density on schools, fire and police services, government facilities, roads and utilities. Up to 50 % less investment costs and up to 44% less energy costs were found in higher-density communities. Unfortunately, the American government did ignore the message, and now, decades later, the shape of cities in America and most of the rest of the world is worse than ever (REGISTER, 2002: 111-112).
Indeed, the situation in many European cities and regions is not better as is explained in EEA (2006). Suburbanisation of houses, and more recently of economic activities, has caused ribbon development (so-called 'roadscapes'), building in the outskirts and a spreading of building in the countryside in many European countries too.

The ribbon development has choked public (bus)transport in always bigger traffic jams. Another problem has to do with traffic unsafety, especially for children. When every single house in a traditional suburban garden city has its own garage and parking, this means that cycling children might encounter a dangerous car on each access lane to each individual garage. There is a crossroads at the level of every single detached house. So introducing common car parking areas enhances traffic safety in child-friendly ecoquarters.

Moreover, the huge gardens surrounding each house mean a separation between neighbours. One can only meet the neighbours at the entrance of the yard, driving by car to the house. In garden cities social loneliness is a real danger, neighbours are far away, the private green is insulating people from each other. In contrast, lobe cities combine urban and rural qualities very close to each other in a completely different way, as we explained earlier. The (semi)public blue-green fingers between the dense built-up lobes are connecting people to each other. Social benefits are guaranteed.

3.1.2 Compactness versus energy

Figure 10 makes it very clear: the energy consumption of huge 'new-towns' in North America, Canada and Australia (built-up in the 20th century based on cheap fossil oil, individual mobility with private cars) is much higher, compared with medieval and dense European and Asian cities. The exponential relation has a bend around a density of about 75-125 inhabitants per hectare. That seems a density which enables payable, viable public transport.

Moreover, higher urban densities provide opportunities towards common systems for energy supply. Many ecoquarters have chosen for district heating systems, which is a proven technology that is wide spread in Scandinavian and eastern Europe (and Russia). The principle is simple: build a small scaled plant for the cogeneration of heat and power (CHP) in the middle of the city quarter, dimensioned on the heat demand of the quarter (Figure 11). The CHP plant uses a primary energy source to produce electricity. The primary energy source often is natural gas, but it also might be renewable sources such as organic waste (biomass) as in the eco quarter Munksøgård (Roskilde ,DK) or in the eco quarter Vauban (Freiburg, D). The heat which is co-produced (normally about 60 %) is transported through hot water pipes to the dwellings. A heat exchanger permits every dwelling to adjust its own thermal comfort. By using this central city-heating system, the energy yield of the energy plant grows to more than 80 %. The reason is the simultaneous production of electricity and the waste heat, which is re-used directly very close to the power plant, in the surrounding buildings. Of course the higher compactness of dwellings and the density of inhabitants, the better the efficiency of this kind of energy supply will be. So building blocks and densely built-up city-lobes of the lobe-city, are ideal to connect on a district heating system.

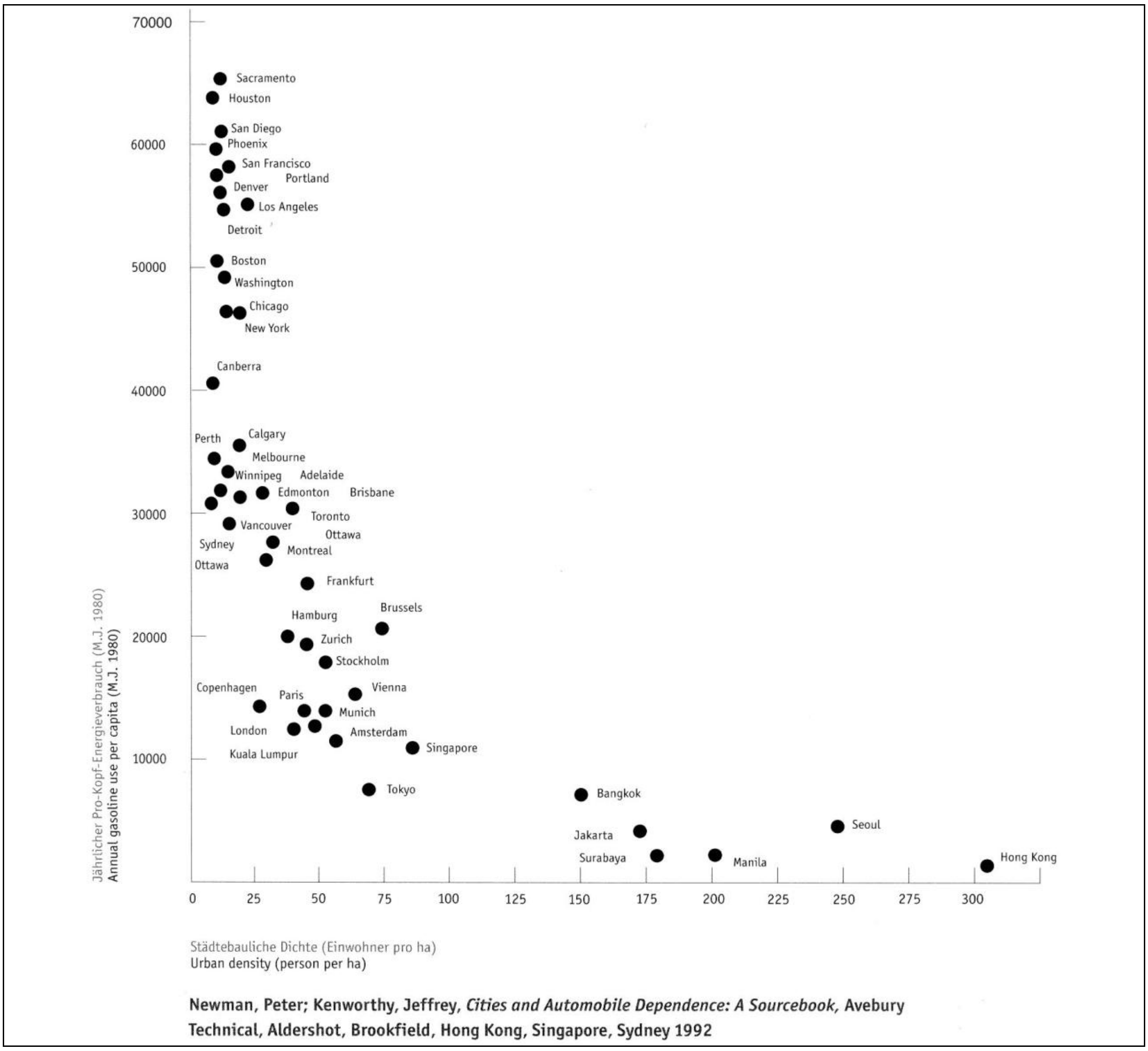

Figure 10 : There is an amazing exponential correlation between urban density in cities and the energy consumption.

All this means that shifting away from the suburban (American) model with single detached dwellings surrounded by a private garden (the urban sprawl) is urgently needed. The broad-acres city expansion model from Frank Lloyd Wright which started in North America will end in a catastrophe, while *cheap fossil energy is ending*. Both the transport in such a car-based urban planning model (the urban grid) and heating and cooling of the dwellings will become extremely expensive and is contributing to climate change. Unfortunately, this '*American way of life*' is being copied all around the world.

In densely built-up city-lobes the dwellings can also be cooled collectively, during hot seasons using the same district piping network as used in cold seasons for heating the houses. Denmark is the world leader in District Heating and Cooling Technology, with over 70% of Danish buildings receiving heating and hot water via District Heating (80% of which comes from surplus energy sources). http://www.youtube.com/watch?v=-0V5OMS4kzw&feature=endscreen&NR=1

It's clear that we found here a very powerful argument for **mixing functions in ecoquarters**. During summer season the heat demand from dwellings is low (especially when they are well insulated). That means that the yield of the CHP risks to decrease. So when amongst the dwellings also other heat demanding activities are mixed (such as small offices, businesses, cafés, restaurants and local shops, swimming pool, hospital, wellness centre, ...), more heat (hot water) can be valorised. That's another very important argument to get rid of the old-fashioned CIAM-ideas, which made a plea for separating residential areas from industrial areas and from leisure areas [5].

Freiburg (Germany). This is the CHP energy plant of the eco quarter *Vauban,* burnt with waste wood (biomass). The Electricity is sold to the common grid; the (waste) heat is used for the district heating network.
Picture Erik Rombaut

Tübingen (Germany). In the middle of the eco quarter *Loretto-areal*, there is a CHP energy plant, providing the district heating system with hot water. *Picture Erik Rombaut.*

Figure 11 : CHP plants in some European cities.

[5] Le congrès international d'architecture moderne (CIAM, 1928-1959) was an international think tank of modernists in architecture and urban planning. Their Athens Charter (1933) put that problems within cities could be resolved by a strict functional segregation and by housing people into huge apartment blocks, scattered in green areas. These ideas were widely adopted by city planners rebuilding Europe after the 2nd world war, although by then, some CIAM planners were already doubting about some of the concepts. These old ideas, leading towards huge mobility problems, are rejected nowadays and a lot of cities luckily mix living, working and recreation.

3.1.3 The need to mix functions: congruent findings from ecology and sociology.

It is very important indeed to emphasize once more that an ecopolis will not be achievable without getting rid of the old-fashioned CIAM-ideas (see footnote 5), which made a plea for separating residential areas from industrial areas and from leisure areas (ideas on which in so many countries, spatial planning was based on). It doesn't need an expert to foresee huge traffic-problems neglecting this function-mix. Moreover we just explained also the link of mixing functions, with district heating and cooling (3.1.2). The lobe-city gives a good answer to these challenges.

From the ecological point of view, the advantages of this mixing-functions-and-higher-citizens'-densities discourse is clear. But what is striking, is that also from sociological side, the findings are congruent.

Doug Saunders in his bestseller book ' arrival city ' (SAUNDERS, 2010) is formulating similar conclusions. His ideal arrival neighborhood is densely built-up, situated in or near the city-centre, has a wide variety of functions (with many and cheap buildings for homes, shops, small businesses, etc.). Such 'arrival areas' can then function as an emancipation machine, as locations for transition, integration and social rising. If not, such neighborhoods might fail and degenerate into resorts of alienation, extreme poverty, social unrest and (religious) extremism,…

Saunders says explicitly, that the ideas of the famous French architect Le Corbusier and of the 'Congrès international d'Architecture Moderne (CIAM)', (see footnote 5) are not compatible at all with the ideal urban arrival neighborhoods.

Also in the United States these insights are growing fast. Transit-oriented development (TOD) is a type of community development that includes a **mixture** of housing, office, retail and/or other amenities integrated into a **walkable** neighborhood and located within a half-mile of quality **public transportation** (http://www.reconnectingamerica.org). Reconnecting America believes it is essential that TOD creates better access to jobs, housing and opportunity for people of all ages and incomes. Successful TOD provides people from all walks of life with convenient, affordable and active lifestyles and create places where children can play and parents can grow old comfortably.

Our conclusion is clear: The lobe-city concept is a spatial translation of this so-called *Transit-Oriented Development*. Also the American so-called *New-urbanism* movement is going this way, making a plea for shifting away from the suburban model with single detached dwellings with a private garden.

3.2 The lobe-city versus concentric expanded cities: urban biodiversity

A lobe-city has a very long urban fringe between the built-up lobes and the blue-green fingers. That is opposite to a so-called compact city, overtime expanded in a concentric way, which has a very short circumference. Further concentric expansion of compact cities leads to unliveable situations such as in the city of Athens (Greece, Figure 12): the rural areas are far away from the centre, the richer citizens try to escape from the centre to the outskirts, closer to the green: social segregation is occurring.

Athens (Greece). A big compact city, expanding in a concentric manner, surrounded by mountains is vulnerable for summer smog (city heat island effect), threatening the health of people and the cultural heritage. *Picture Erik Rombaut*.

Amsterdam (The Netherlands). The blue-green network in the lobe-city of Amsterdam creates nice living conditions for people and has a good influence on city climate conditions (www.dro.amsterdam.nl)

Figure 12: Problems of compact cities such as Athens cannot occur in lobe cities such as Amsterdam.

The longer the urban fringe, the better an ecopolis can be achieved. Citizens are rewarded with an attractive neighbourhood: rural and urban conditions both are very close to their dwellings. This strategy leads to the maximum of citizens living in attractive neighbourhoods.

It is well-known that the biodiversity of the city fringe is often much higher than in the stony and sealed city centre. (

Figure 13; Gent, HERMY, 2005). But also in the adjacent rural areas which are often occupied by intensive agricultural land, there is less biodiversity left, than in the outskirts of the cities (HONNAY et al. 2003). For a lot of wild plants and animals the intensive use of both the centre of the cities and of the surrounding agricultural areas is a problem. That has also been recently (VANGESTEL, 2011) demonstrated by research on the House sparrow in Europe (Figure 14).

City fringes are often used less intensive and show a huge spatial variety, the so called ‘patchiness’, which is related with species diversity (VAN ZOEST & MELCHERS, 2006). Because of the lower densities of dwellings and the presence of green (especially urban gardens and green corridors) urban fringes offer a good connectivity for biodiversity (as in the lobe-city of Stockholm, e.g. MORTBERG & WALLENTINUS, 2000).

However, edge effects from the (high dynamic) city lobes often can be too strong for the conservation of (low dynamic) high-quality nature in the urban blue-green fingers. Therefore, it still remains (of course) very important to conserve big natural *rural* entities. The lobe-city can then play an important role in the connection of these bigger rural high quality natural entities with the city and the citizens, through the urban blue-green fingers.

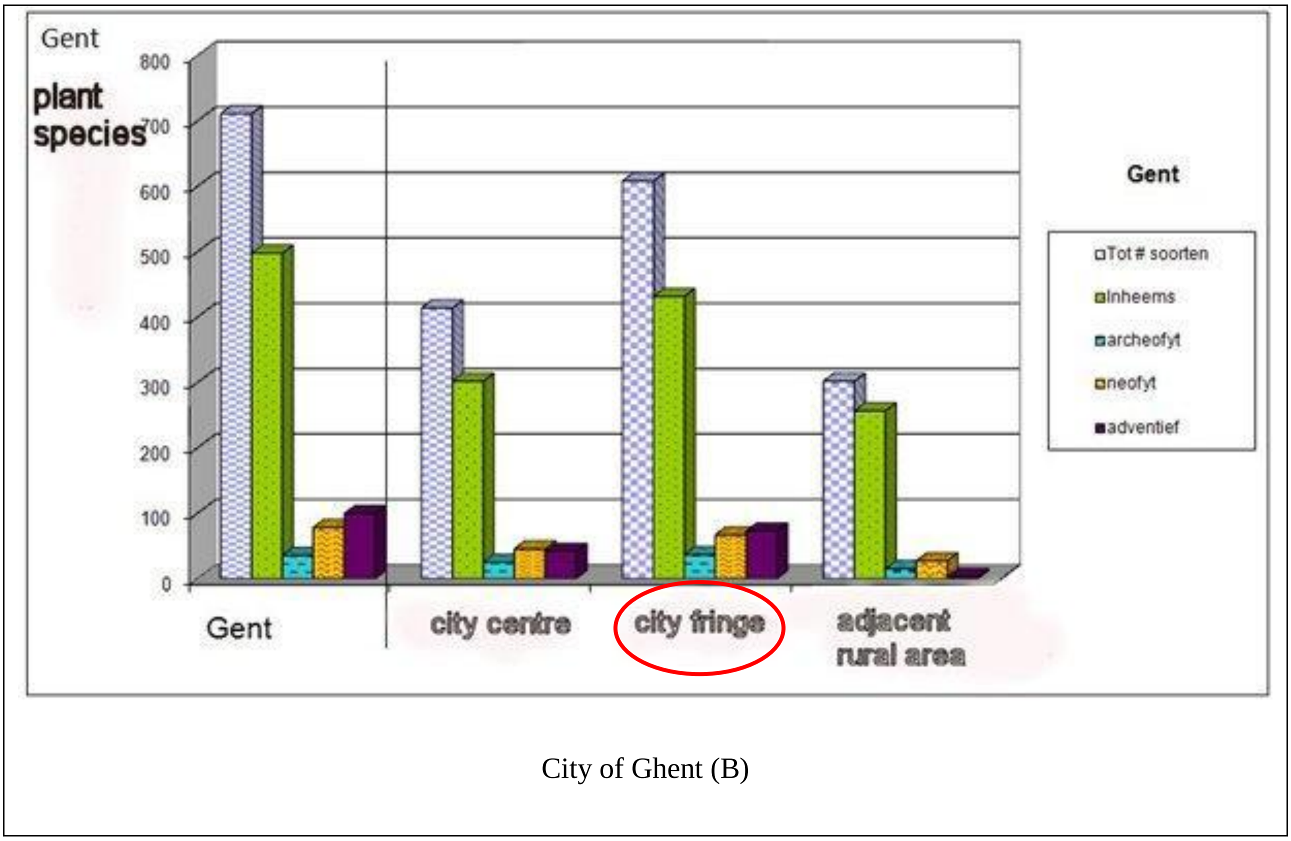

Figure 13 : City fringes often carry more biodiversity , not only in comparison with the city centre but also with the adjacent rural agricultural areas. Example of Ghent (B, HERMY, 2005)

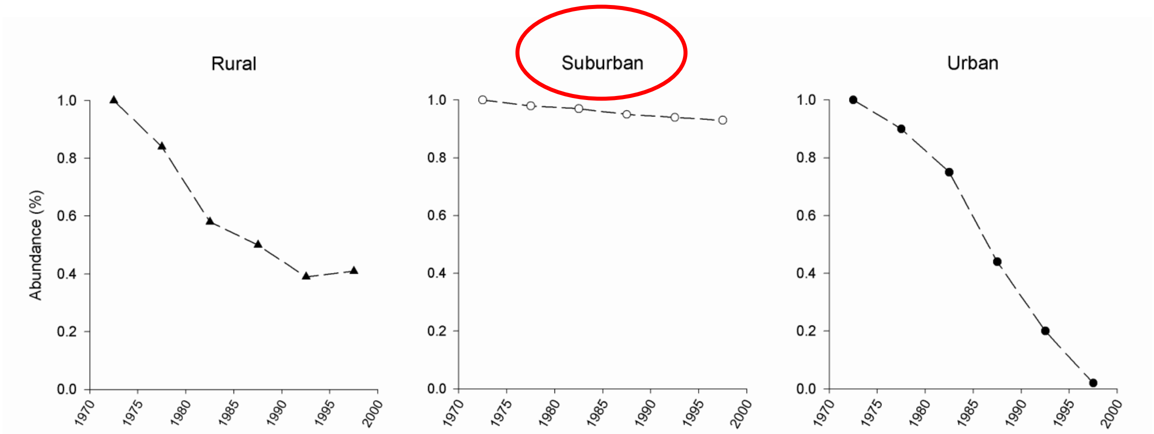

Figure 14 : Population trend of house sparrows (1970-2001) in some <u>urban</u> (London, Glasgow, Edinburgh, Dublin and Hamburg), <u>suburban</u> (Stockton, Crewkerne, Guisborough en Sandhurst college in Sussex) and <u>rural</u> (common bird census counts in England) areas in Europe

Also here the steep population decrease in the stony sealed and paved city-centers is obvious (urban) but also in the agricultural areas (rural). Only in the suburban city fringes, the population remains quite stable up till now.

(DE LAET, 2007 in VANGESTEL, 2011).

It is therefore no coincidence that SUNSETH & RAEYMAEKERS (2006) found the largest amount (and surface) of Natura-2000 areas in Berlin en Copenhagen. Of course, because these are lobe-cities (see <u>Figure</u> 15).

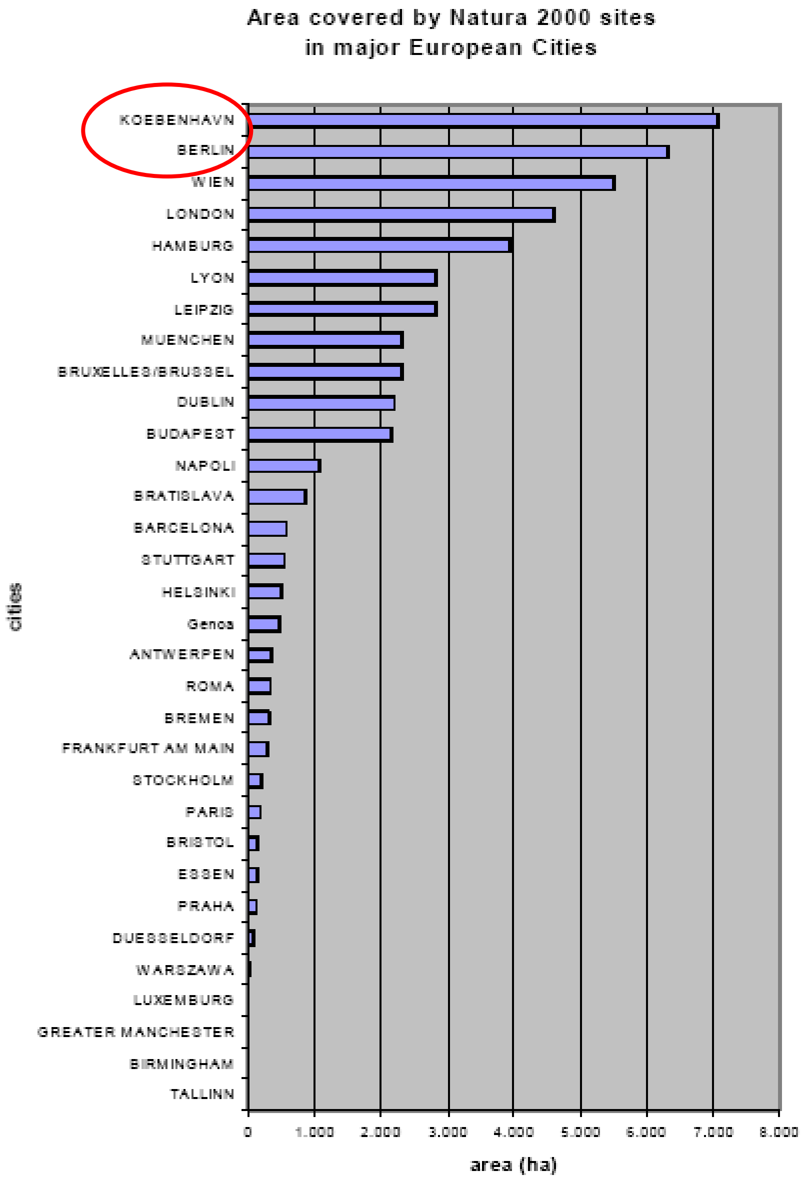

Figure 15 : The lobe-cities of Copenhagen and Berlin have the largest amount of urban Natura-2000 areas (from SUNDSETH & RAEYMAEKERS, 2006)

Designers of rural areas and urban designers have to meet each other in this urban fringe and have to search together to a mutual adjustment of the (water)plans. Unfortunately the urban fringe is under urban pressure, so it is time scientific attention is given to the design and management of the contact zones between urban and rural areas. This discourse is developing: e.g. the international congress in Ghent (B) which was devoted to the problems of the urban fringe (ROMBAUT, 2001).

4 Conclusion. Towards climate proof urban development with the lobe-city.

4.1 Building stones for an ecologically sound urbanisation

4.1.1. Water

a. Take all the measures that are necessary on the building level to decrease the water-flow Design them water-neutral: make full use of rain water indoor.
b. Design storm water management systems that mimic natural ones, by treating and infiltrating water on-site (rather than piping it away). Introduce therefore a separate sewer-system. Retain clean white rainwater and use it for designing infiltration infrastructure such as ponds, wadi's, re-open canals and rivers where possible. Design nature-friendly water systems in the city (slopes and river banks). Restore the local small water-cycles: evapotranspiration helps a lot to cool the city down.
c. Take into consideration decentred purification plants: use marsh-plant-filters. Do respect water catchment areas and flooding-areas: don't build there but combine them with urban **blue-green fingers** in the **lobe-city** or with Natura-2000 networks in rural areas.

4.1.2. Energy

d. Design carbon-neutral on the building level to decrease the energy-flow and to get rid of central fossil fuel energy-plants and nuclear power plants.
e. Use renewable energy as much as possible: take into consideration sun collectors and photovoltaic panels, wind energy, local biomass, biogas, small scaled hydro-power, combined generation of heat and power (CHP) for district heating and cooling. Take measures on urban and city-quarter level: raise densities, introduces compact building, roof-orientation to the sun, district-heating infrastructures such as heat exchangers, etc.
f. If there is still some need for fossil energy, choose for natural gas. Strive towards CO_2 neutral cities (e.g. planting new forests).

4.1.3. Traffic

g. Take all the measures that are necessary on the building level. Restrict the number of parking areas and use parking places double (day-night), concentrate long term parking places out of the quarter, create bicycle sheds close to working places and shops en create sanitary facilities (showers,…) for cyclists that come to work, to school, to shop, etc.
h. Build a **lobe-city** to minimise distances to the green areas and to public transport axes. If possible, avoid underground public transport systems, give public transport car-free bus/streetcar lanes.
i. Prevent need for transport by mixing urban functions. Stimulate car-sharing, decrease noise pollution by traffic and create pedestrian areas. Stimulate the use of public transport, walking, cycling also by building special infrastructures without conflicts with private car infrastructures. Shift away from the suburban model with detached houses and private gardens: raise densities.

4.1.4. Raw materials and waste

j. Take all the measures that are necessary on the building level to decrease the waste-flow. Use natureplus (www.natureplus.org) labelled products.

k. Choose for friendly materials for timbering, sewer systems, paving tracks etc. Prevent poisonous materials. Stimulate (central) composting, implement the principle *waste equals food* (cradle to cradle).
l. Prevent building and demolishing-waste and do separate waste. Develop an urban plan to avoid waste and to set up a network to handle waste e.g. in recycling centres, repair cafés and second hand shops. Stimulate sharing goods with each other.

4.1.5. Fauna en flora, landscape, ecosystem services.

m. *PATTERNS*. Use existing blue-green structures that can be found in both in the old city centre as in new city-extensions and connect them to the rural ecological network (Natura-2000). Create sustainable gradients (wet/dry; high/low, etc.). Use water systems and rivers as carriers of a blue-green network in the **green wedges through the lobe-city**. Think of greening facades, wallflowers, endogenous trees and shrubs, green roofs and nature friendly riverbanks to link to this blue green urban network, in which urban gardens of course play a major role.
n. *PROCESSES*. Choose for an ecologically sound green management. Choose very carefully the most appropriate processes in order to create the most interesting patterns. Patterns are the consequence of processes. Management such as mowing and making hay, keeping wet, extensive grazing, … often create and maintain a wide biodiversity also within cities. Stimulate community supported urban agriculture (CSA). Restore as much as possible all kinds of **ecosystem services**.

4.2 Towards climate proof urban development with the lobe-city

Climate proof urban development will be the main challenge of the 21st century (ROMBAUT, 2008b). A growing amount of scientific reports gives compelling evidence for the ongoing serious climate changes with effects on rising global temperatures, on precipitation (wetter in wintertime in large parts of northern and western Europe) and on see level rising (IPCC, 2014). In urban regions, the rising global temperatures will be strengthened by the local urban heat-island effect. The exceptionally warm and dry European summer of 2003 was responsible for 35,000 extra deaths across Europe as a result of heat stress, bad air quality and high levels of air pollutants such as ozone, especially in urban regions (WWF, 2008). So cities urgently have to be adapted to climate change, the transition towards an ecopolis is urgently needed [6]. Lobe cities have major advantages for this transition:

A lobe city has better features helping to avoid further future climate changes. Lobe cities have a high dwelling-density in the city-lobes which enables good public transport systems and district heating and cooling systems. So lobe cities can minimise the CO_2 emissions more easily than garden cities and concentric compact cities can.

Moreover, a lobe-city has better features helping to mitigate the effects of climate change than a compact city has, because of better possibilities to benefit from ecosystem services. Massive blue-green fingers between the built-up compact city lobes provide possibilities for infiltrating rainwater and for storing storm-water. This enhances abiotic conditions for wildlife and urban biodiversity. Through convection from the blue-green wedges, cooler and humid fresh air can enter into the urban zones, cooling them down and tempering the growing risks of urban heat stress, reducing the city heat island effect. This enhances living conditions for humans, in a global warming world. Moreover a lobe-city is an adequate planning model for finding a mutual adjustment between urban and rural areas.

It all has to do with applying ecosystem-services in urban and rural planning, with looking to nature as something to work with. Indeed, working and planning *against* nature is doomed to fail….

[6] http://www.knowledgeforclimate.nl/urbanareas/climateproofcities_finalreport

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