Sustainable Architecture, Ecologically sound Urban/Rural Planning and Biodiversity: Thoughts about a climate-proof ecopolis.

Plea for the lobe-city.

Some guidelines for applying ecosystem services in urban and rural planning.

How blue-green networks within urban areas can improve biodiversity, city climate conditions and the urban water management.
How a judicious public-private mix can serve an ecologically sound water management and thus help to maintain and repair biodiversity in (European) urban areas.

Key words:

climate-proof urban and rural planning - ecopolis - lobe-city - urban biodiversity - ecosystem services.

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0 Summary

How to achieve a sustainable design for a city? What are the key elements? Here are at least two critical elements: 1. Green space which should surround the town and penetrating right into and through it. 2. Transport which should be planned to reduce dependence on the private car, through maximising public transport access, related to land use planning (Sir Peter HALL, 2006)

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

This paper presents a number of eloquent and inspiring examples of ecological residential neighbourhoods, ecovillages and green industrial parks in European cities.

The creation of a “semi-public common interior space” within the buildings, between buildings and in the green areas of residential neighbourhoods (through a judicious dosage of the public and the private) seems to be the **urban planning key** and strategy for solving both ecological and social problems. There is no doubt that when these green semi-public areas are inter-connected to form a blue-green network with the right ecological conditions, a surprisingly high biodiversity can be preserved in an urban environment.

Whether or not such an approach will strengthen the social diversity in urban areas depends, among other things, on the extent to which one resists the tendency to close these semi-public environments (that is, to privatise them) and to transform them into an urban eco-ghetto.

To conserve urban biodiversity, the **“lobe-city”** seems to offer the best prospects. This was developed as an urban 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). It is characterised by blue and green fingers (wedges) in which one can find countryside-features penetrating deep into the “lobe-city”. 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, Stuttgart, Berlin, Freiburg im Breisgau, Frankfurt am Main (Germany) and Stockholm (Sweden).

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.

In this paper we will focus on the theme ‘ecological sound urban *water* management’. That means that other very important topics, such as *waste* management, *traffic* management and of course *energy* management will not be tackled in detail here

1 Introduction

In September 2015; 193 governments have agreed on 17 Global Goals For Sustainable Development (SDG's). This is a UN-17-point plan to end poverty, to halt climate change and to fight injustice and inequality by 2030. The Global Goals are the biggest attempt in the history of the human race to make the world a better place. It is a to-do-list for the planet that will only be achieved if everyone plays their part (http://www.globalgoals.org)

Global goal 11 is dealing with sustainable cities and communities and aims to make cities and human settlements inclusive, safe, resilient and sustainable. In this paper we want to contribute to targets of this Sustainable Global Goal 11 (SDG 11), which can be found under http://www.globalgoals.org/global-goals/sustainable-cities-and-communities/

Figure 1 : 17 Sustainable Development Goals (SDG) of the UN, to strive to by 2030.

The aim of the ECOPOLISstudy of TJALLINGII (1992) was to find answers for the environmental problems of urban design on an international, a national and a local scale. The study was financed by the Dutch National Planning Institute and lead into a report titled: 'Ecologically Sound Urban Development'. In 1996 Tjallingii made out of his thoughts a doctoral thesis at the Delft University of Technology (TJALLINGII, 1996).

Meanwhile, this ecopolis-theory penetrated in a lot of study-reports: as a *guideline* to build an ecopolis in municipalities, as a *scientific hypothesis* and *thinking-framework* which reveals a lot of interesting research. But it's also a good *teaching model* to explain students and a wider public what a sustainable city (= ecopolis) is and how it can be accomplished.

In this presentation we explore the thoughts of Tjallingii and illustrate them with examples throughout European cities. We want to make clear that this ecopolis strategy (see onder) can inspire humanity to find ways to achieve Sustainable Development Goal 11.

1.1 The ecodevice model

Each ecological insight starts with the recognition that all human activities depend 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 2 illustrates this dependency clearly (SCHROEVERS, 1982).

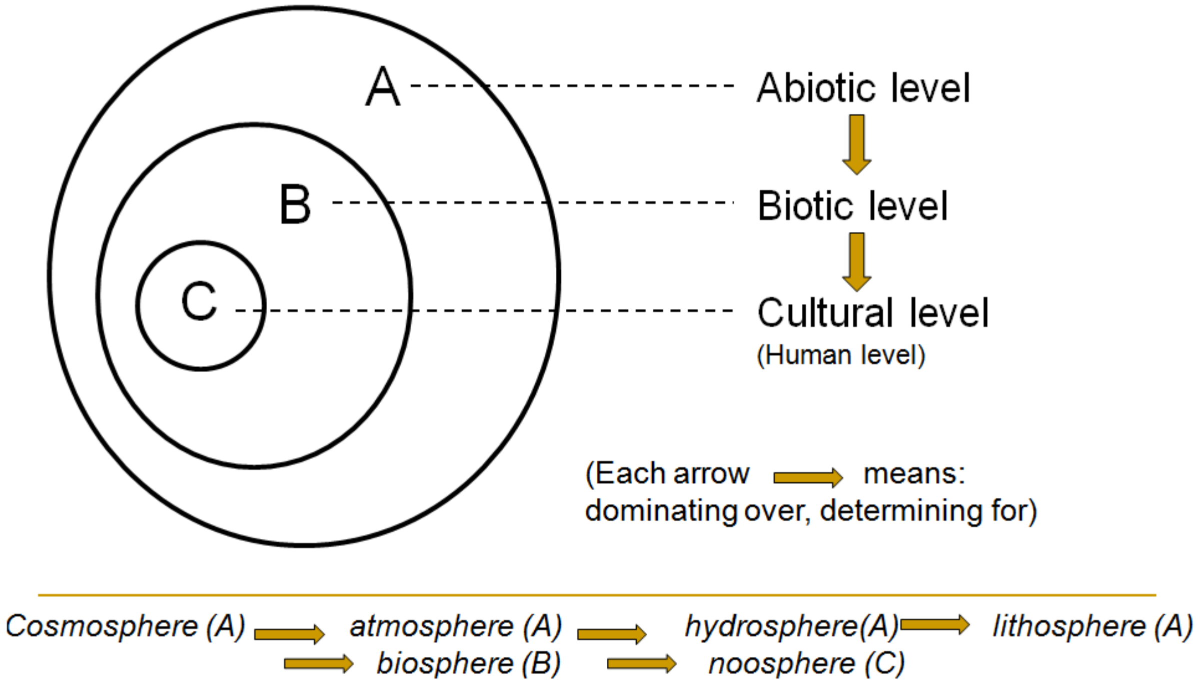


Figure 2 : Human activities depend on intact biotic and abiotic levels (SCHROEVERS, 1982).

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 3).

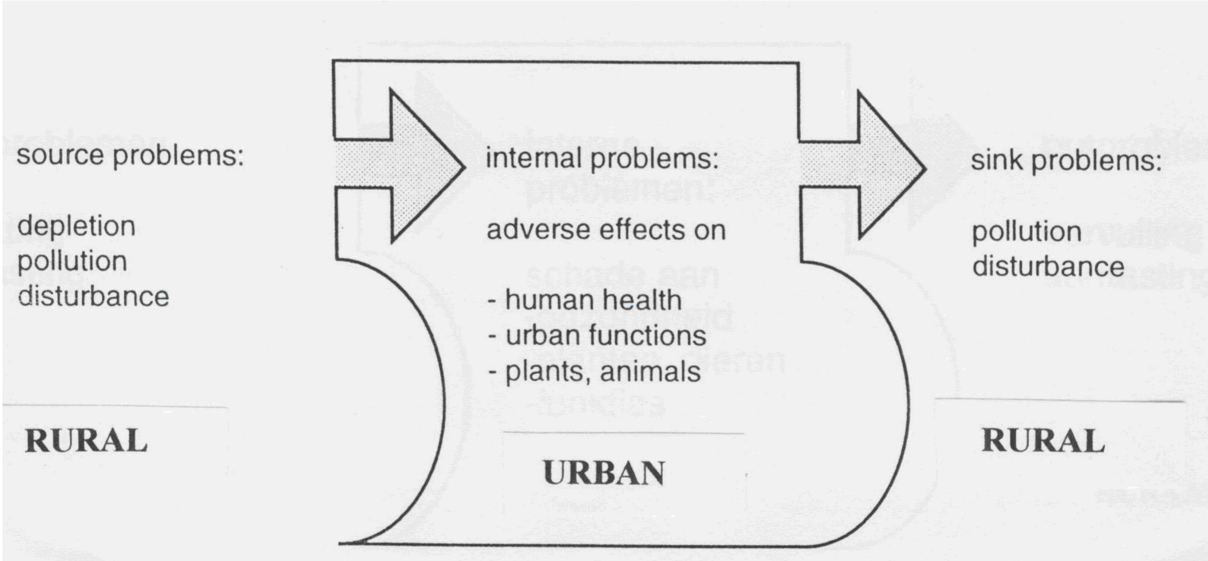


Figure 3 : The ecodevice model applied on urban environmental problems (TJALLINGII, 1996).

Moreover, it's clear that local causes may have global environmental consequences by shifting the effects in space and time (Figure 4): thus once again, think globally and act locally…

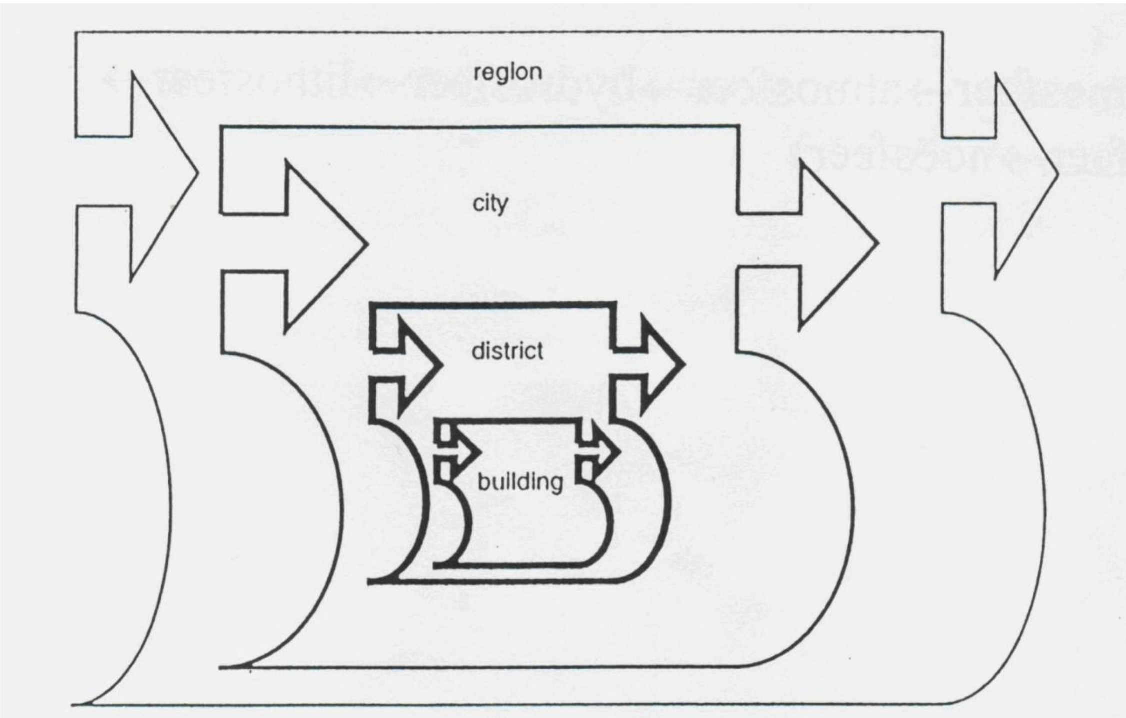


Figure 4 : Flow management at different scales (TJALLINGII, 1996).

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 The ecological footprint.

Our planet has a surface area of about 51 billion hectares, of which 14,5 billion is land. Not more than 8.9 billion hectares is productive area, the rest is non-productive land such as deserts or glaciers. More than 7 billion people are living on this planet [1], so there is about 1.8 ha of land available for every human being (WWF, 2005, 2010, 2014). WACKERNAGEL & REES (1996) developed an interesting tool to estimate the impact of economy on the environment: *'the ecological footprint'* (Figure 5). For many countries the researchers already calculated the cost of their economy and consumption in terms of impact on nature values and environmental damage. If you add all this, taking also into account the import and export data, the amount of surface a certain country needs becomes clear. The ecological footprint gives an indication of the additional surface (water + land) a country needs in other areas of the world. Of course one has to take into account the own surface and number of inhabitants [2].

[1] Since 2008, more than 50 % of them are living in urban areas. The UN predicts that by 2050 more than 70 % of people will live in cities, less than 30 % will live in rural areas. So solutions for sustainability have to be found within urban areas and cities.

[2] In an ecological sense, cities are as parasites for the surrounding rural areas. Rural areas deliver food, water, oxygen and they have to deal with waste discharges from the cities. So the ecological footprint of a population (city, region, country) is the total amount of water- and land surfaces (wherever on the earth) needed in a continuous manner to produce the needs of that population and to handle its waste discharges.

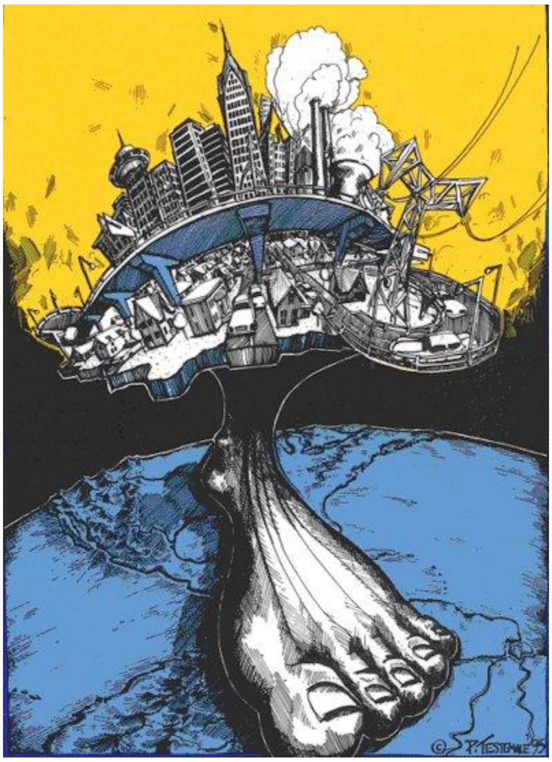


Figure 5 : The ecological footprint of a city is many times larger than the surface of the city itself (REES, 2004).

Of course one can calculate the footprint of smaller entities, such as cities [3] .In general, citizens have a smaller ecological footprint compared with people living in rural areas. European citizens use less cars and more public transport and live mostly in dwellings with better qualities than inhabitants of rural areas do (JUFFERMANS, 2006).

WWF (2010, 2014) calculated the ecological footprint of 148 countries. The modal inhabitant of Belgium/Luxemburg needs 8 ha/inhabitant, about the same as the USA. That is the fourth worst place in the ranking, around the world. Only the Arabic emirates, Qatar and Denmark have a worse footprint./inhabitant. Thailand has a footprint of about 2,2 ha/inhabitant. Haiti, Somalia and Afghanistan consume less than 0,5 hectares per inhabitant. If every human being on this planet would follow the American (Belgian) way of life, we should need three more planets (WACKERNAGEL & REES, 1996).

So, decreasing the ecological footprint to what is global acceptable could be a measurable long-term goal for the environmental policy. The living Planet Report (WWF, 2014) designs the future solutions: a transition to a zero carbon society through a new energy strategy (CAT, 2010) and an adaptation in diet through the reduction of our Western European and American meat consumption are the two main features.

[3] REES (2004) and ecolife (2008) calculated the ecological footprint of Brussels. The European capital depends on a surface that is 408 times larger than the geographical city-surface itself (about 72 times its own bio capacity), that means about 60 % of the total Belgian bio capacity. For London was the ecological footprint in 2000 about 293 times the city-surface (about 42 times its own bio capacity) or about twice the surface of the United Kingdom (Best Foot Forward Ltd 2002 in VAN ZOEST& MELCHERS, 2006)

1.3 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.

1.4 Ecosystem-services

Ecosystem services (Figure 6) 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;

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 (such as pollution, extinction). Humanity is relying on ecosystem services, but these services get damaged severely by human’s activities.

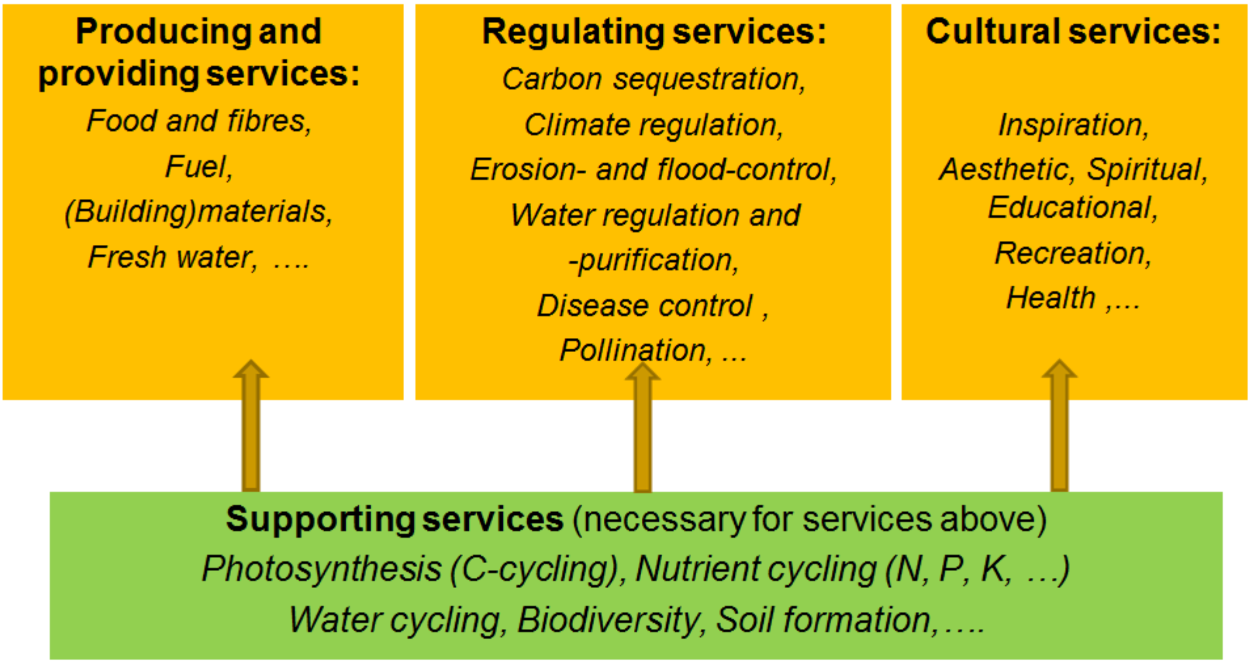


Figure 6 : Some important ecosystem services which nature is offering for free to our society (see HASSAN et al., 2005 ; MEIRE en VAN DYCK, 2014)

There is a clear link between ecosystem services 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 and regional water-cycles, providing fresh water), and calculating the cost of either replacing them technically, or living without them [4].

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.

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

2 Anthropogenic added dynamics: human activities versus biodiversity

2.1 Abiotic ecological conditions have to be designed in sustainable gradients

Diversity in abiotic conditions creates different habitats and therefore a diversity in fauna and flora (Figure 2).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 7 points out how to design such a sustainable abiotic gradient, necessary for restoring or maintaining (urban) biodiversity

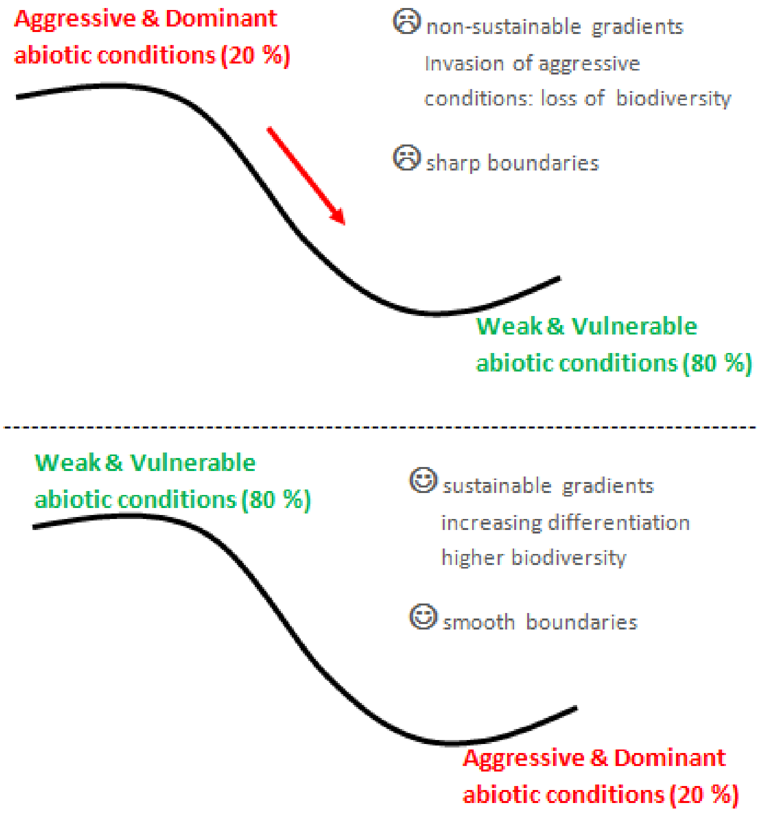


Figure 7 : Avoid the situation (above) of aggressive ecological conditions on a higher places (such as slopes, river springs) in landscapes. Strive for a sustainable gradient by design (under): more biodiversity over time will be the result, because 80 % of indigenous plant species depend on weak and vulnerable abiotic conditions. (ROMBAUT, 2011)

The balancing of urban and rural systems is essential in order to achieve sustainable gradients in both environments. For instance, the thoughtful interconnection between the urban and the rural water systems is very important. 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 8) 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. Nature and leisure areas need the best water quality for the support of both biodiversity and 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).

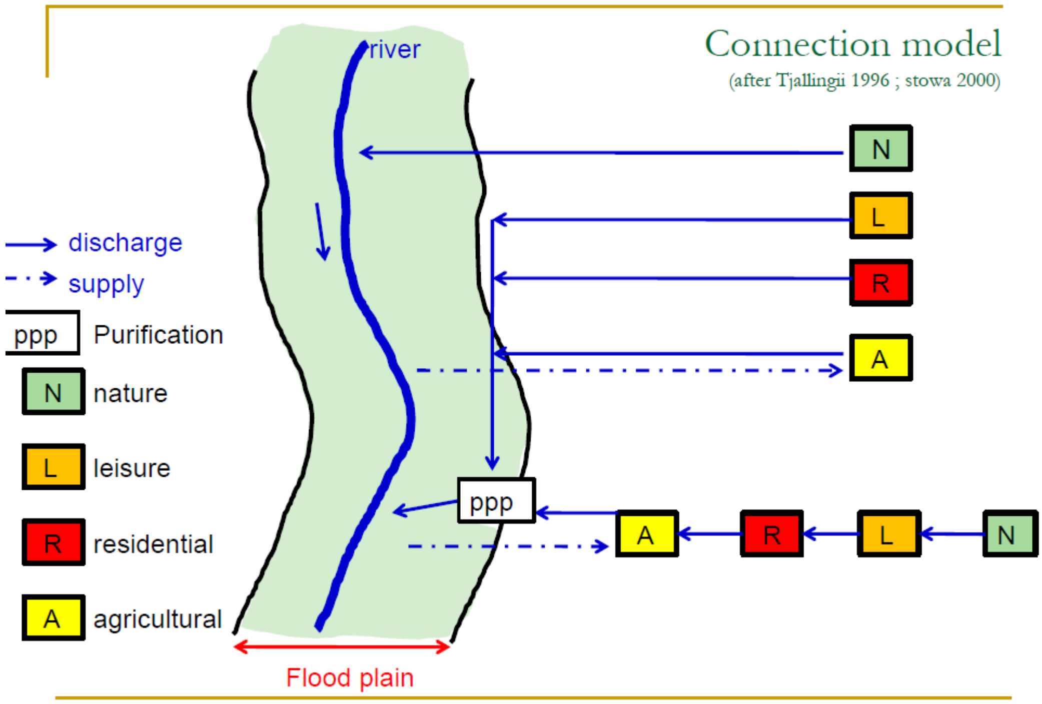


Figure 8: The connection model suggests an ecologically sound water-chain between rural and urban regions. (STOWA, 2000)

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). 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.

Abiotic (non-living) ecological conditions often vary also over time (e.g. climatic variation, day-night rhythm, tidal rhythm along the coast). Such a *variation in the time* is called **'the dynamics'**. In general, local species can resist these local natural fluctuations and therefore , 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 of their abiotic environment (pattern) but also for the temporal dynamics (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*.

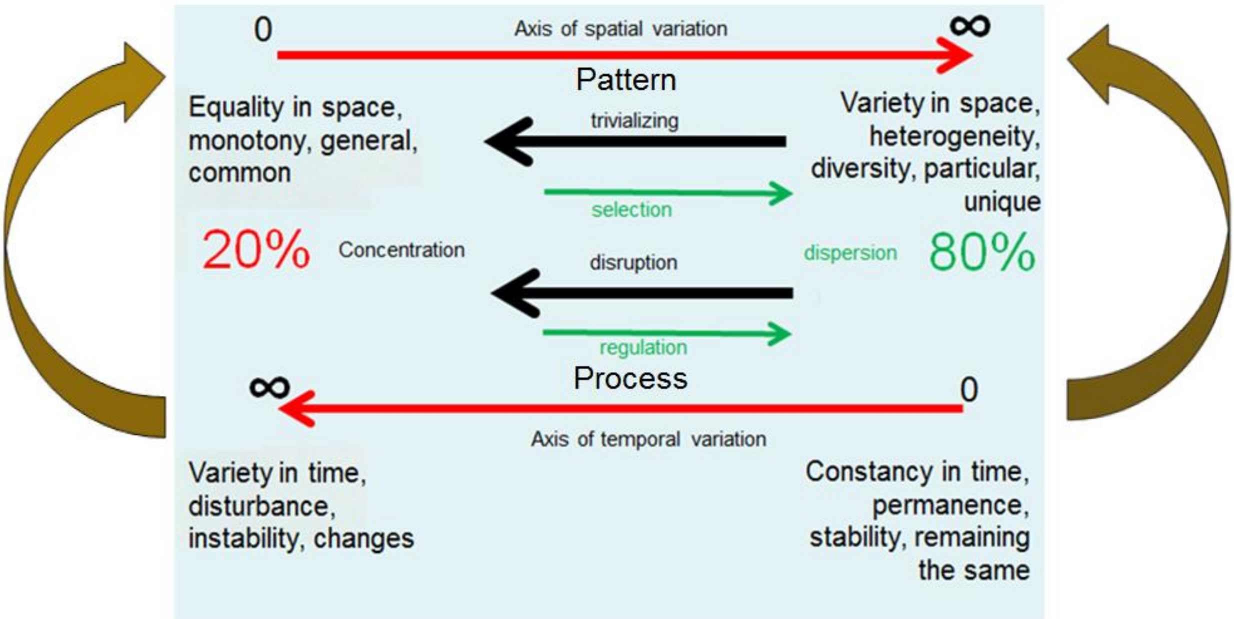


Figure 9 : Visualisation of the relation theory (VAN LEEUWEN, 1966, after VAN DER MAAREL & DAUVELLIER, 1978)

Figure 9 is visualising the theory: Processes (below) are dominating and determining patterns (above) (brown arrows).
This means that **disruption** of processes (black arrow below, to the left) is preceding **trivializing** of landscapes and a collapse of biodiversity (black arrow above, to the left,). The consequence is **concentration, extinction** and **convergence**: few species (20%), few vegetation types, poor biodiversity, **Instability**. Shifts to the left are easy.
This means also that **selection** (green arrow above to the right) without first **regulating** the management processes (green arrow below, to the right) is meaningless. Selection and regulation work in the same direction of **dispersion, restoration** and **divergence**: many species, different vegetation types, rich biodiversity. **Stability**. Shifts to the right are difficult.

The practical consequence is that next to sustainable abiotic patterns (see boven), 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 7), 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 boven) 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. Three main strategic decision fields: the ecopolis-strategy.

The ecopolismodel (TJALLINGII, 1994,1996) provides good tools to evaluate the ecological conditions of a country, a region or a city. It distinguishes three fields of decisions on activities. In an ecopolis one has to decrease **flows,** such as energy, traffic, water and waste. In an ecopolis one has to create attractive **areas** that have a good urban quality. But one must realise that both aims can only be realised when people want to cooperate: there is a need for **participants**, for **actors**. Sociology thus, coupled with ecology. These three fields must be present together in each plan towards a sustainable city. Figure 10 and Figure 11 (ROMBAUT, 2006 ; DUYVESTEIN, 1996).

Three main strategic decision fields:
The ecopolis strategy

- Management of **FLOWS**: *the responsible city*

  E.g.: energy, water, traffic, waste,…

- Management of **AREAS**: *the living city*

  Providing quality to urban (semi-) public areas
  Attracting different people and different lifestyles
  = social diversity
  And a variety of plants and animal
  = biodiversity

- Management of **ACTORS**: *the participating city*

  An ecopolis cannot be accomplished without the co-operation of the local residents and the citizens.

These three main decision fields must be treated together and integrated by a multidisciplinary team
All this is the subject of the ECOPOLIS-model
(TJALLINGII 1992,1994,1996)

Figure 10 : In an ecopolis one tries to decrease the flows (water, energy, waste and traffic), to improve the ecological quality of urban neighborhoods. Both aims need good co-operation of the citizens (ROMBAUT, 2006)

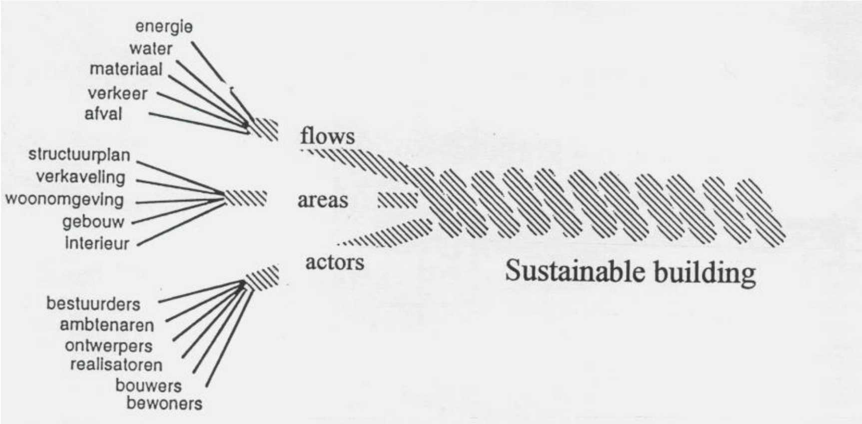


Figure 11 : In an ecopolis, caring for flows, areas and actors is needed, at the same time. If one fails to do, ecologically sound urban development is impossible. (DUYVESTEIN, 1996).

3.1 Sustainable (water)flow-management (the responsible city).

As a consequence of large supply flows and discharge flows in and out the urban areas, lots of environmental problems occur in rural areas. Often, urban problems are solved by increasing large extra supplies and discharges. So pumping extra water out of rural areas solves shortage of water within the cities, but this leads to drought problems in nature reserves. Cities have to stop enlarging flows and have to stop shifting away the problems to rural areas and to coming generations. Cities must take their responsibilities and must therefore diminish flows of water, energy, traffic, materials and waste. Less input and output cause fewer source and sink problems. Responsible cities do care for rural areas; they do reduce their ecological footprint, for their own sake.

As an example we will handle the **water-chain** in this presentation. An ecological strategy seeks to improve the retention of clean rainwater within the cities. So the introduction of a separated sewer system (one for rainwater, one for wastewater) is demanding infiltration-areas for the rainwater. The more the city re-uses rainwater and retains it within the city, the less drinking water has to be pumped out of rural areas. On the other hand it's clear that urban nature and biodiversity require water and require surface too. A better water-chain management is good for nature both in rural and in urban areas. Moreover, the storage of peak-amounts of water within the cities will decrease pollution caused by overflow problems in sewage treatment stations.

We already referred to the **connection model** (already presented by TJALLINGII, 1996, Figure 8) to be used to design a sustainable regional water system.

Suitable guiding models for residential areas (sensu strictu) can also be found in STOWA (2000), the infiltration model and circulation model (already presented by TJALLINGII, 1996) are applied. Key words are retention and infiltration of clean rainwater in urban regions. The general **'keep clean (rain) water longer'** principle leads to a cascade-like approach. Wadis are very useful to reach that aim (Figure 12 ; Figure 13) A wadi [5] is an Arabic word, which means dry river valley in deserts: Those valleys contain water in the scarce rainy periods, most of the year they are dry. The same with wadis, designed in urban areas, which are only filled with water in rainy periods. Wadis can be very useful in urban regions to infiltrate water. A lot of experience is sampled in Germany (ecoquarters *Schüngelberg'* and *Kuppersbusch*, city of Gelsenkirchen, in German wadis are called 'Mulden-Rigolen-Systeme') and in the Netherlands (ecoquarter *Ruwenbos* en *Oikos*, city of Enschede). Wadis can be combined very well with green structures within city quarters. Of

[5] In Dutch w.a.d.i. stands for ***w***ater ***a***fvoer ***d***oor ***i***nfiltratie: evacuation of water by infiltration.

course there are a lot of other infiltration techniques available, such as underground infiltration caissons.

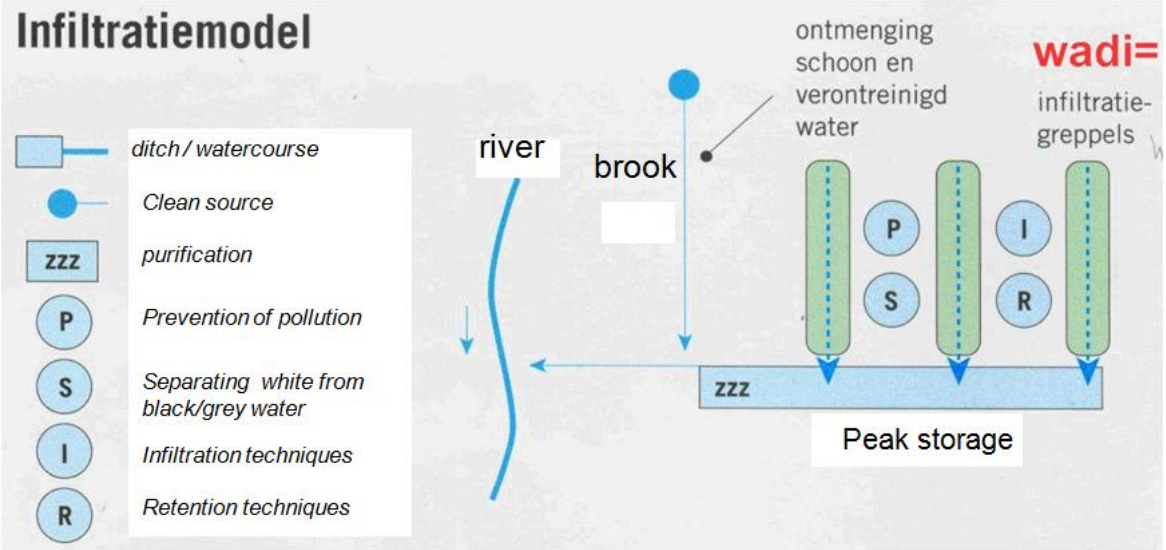
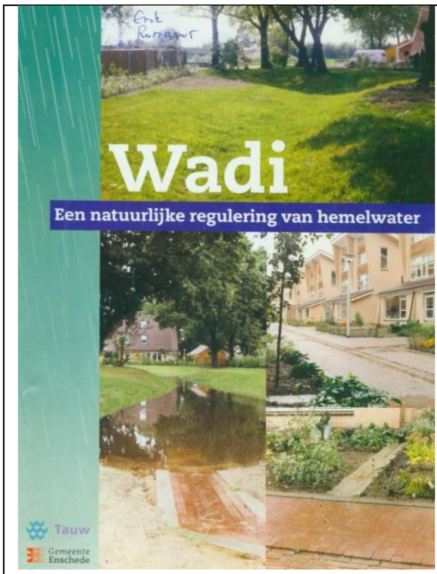


Figure 12 : The infiltration water model is suitable within urban regions in upland situations (STOWA, 2000)

 Enschede (The Netherlands). wadi's in the ecoquarters *Oikos* and *Ruwenbos* http://www.eschmarke-online.nl/index3.htm	 Culemborg (The Netherlands). Wadi in the ecoquarter *EVALanxmeer.* *Picture Erik Rombaut*

How a wadi works: infiltration of separated rainwater in soils, avoids problems in water treatment plants (municipality Enschede & TAUW, 1999).


Hundested, Torup (Denmark). Infiltration pond in the ecoquarter *Dyssekilde*. *Picture Erik Rombaut*


Malmö (Sweden). Green roofs, permeable parking and wadi's in the ecoquarter *Augustenborg. Picture Erik Rombaut*


Gelsenkirchen (Germany). wadi's in the ecoquarter *Schüngelberg*. *Picture Erik Rombaut*


Helsinki (Fin.). Wadi in the ecoquarter *Eco-Viikki*. *Picture by Erik Rombaut*


Helsinki (Fin.). Playground for children with rain water in the eco-quarter *Eco-Viikki*. *Picture by Erik Rombaut*

Figure 13 : Wadis and how they help to infiltrate clean rainwater in urban regions.

PERLMAN & MILDER (2005: 208) put it like this: *'design storm water management systems that mimic natural ones, by treating and infiltrating water on-site (rather than piping it away), using natural vegetated systems for treatment and infiltration and integrating storm water management with landscape design'.*

In relatively flat built-up urban zones in lowland areas (polders), surface water can be circulated (several times) before it is drained further down. That is shown in the circulation model:

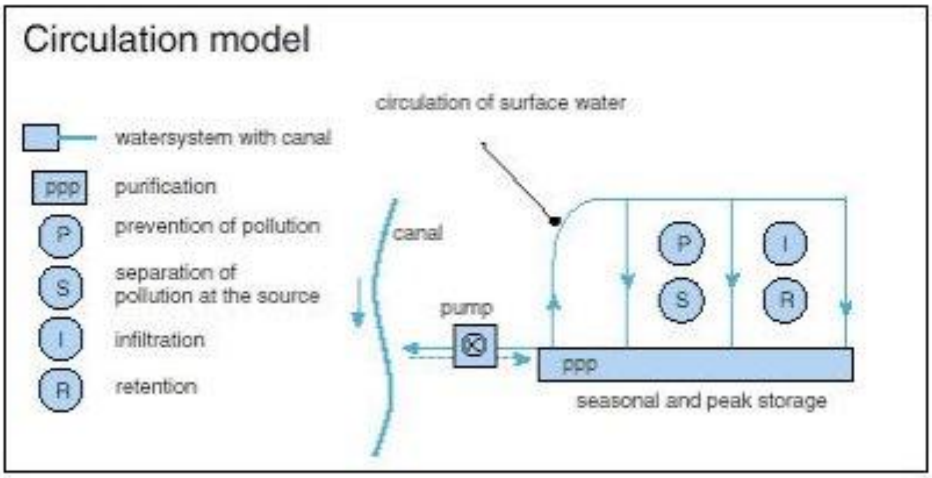
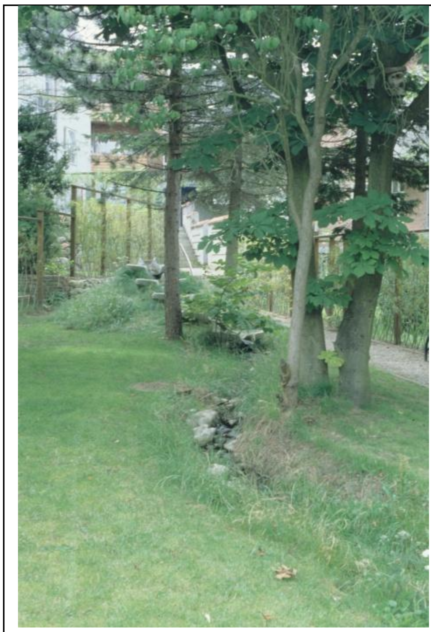


Figure 14 : The circulation water model is suitable within urban regions in rather flat situations (STOWA, 2000)

The underlying ecological principle is to **use the area's own water resources optimally** by retaining the water and purifying it within the urban system. Retention includes seasonal storage, i.e. retaining rainwater in the winter, when surpluses can be expected, so that the saved water can be used during summer shortages. These clean surface waters can be used as a design element in the urban region (Figure 15) STICHTING RIONED (2003) describes 20 projects of designing with rainwater in the Netherlands. LONDONG & NOTHNAGEL (1999) focus on German examples and CHAIB (1997) on the French situation.

Alphen aan de Rijn (The Netherlands). Infiltration pond in the ecoquarter *Ecolonia.*
Picture Erik Rombaut

Gelsenkirchen (Germany). Infiltration zone in the ecoquarter *Kuppersbusch.*
Picture Erik Rombaut



Kolding (Denmark). Urban renewal project in *Fredensgade/Hollandervej* area. A semi-public common garden is created in the middle of the building blocks. *Picture Erik Rombaut*

Malmö (Sweden). Designing with rainwater in the ecoquarter *Västra Hamnen.*
Picture Erik Rombaut

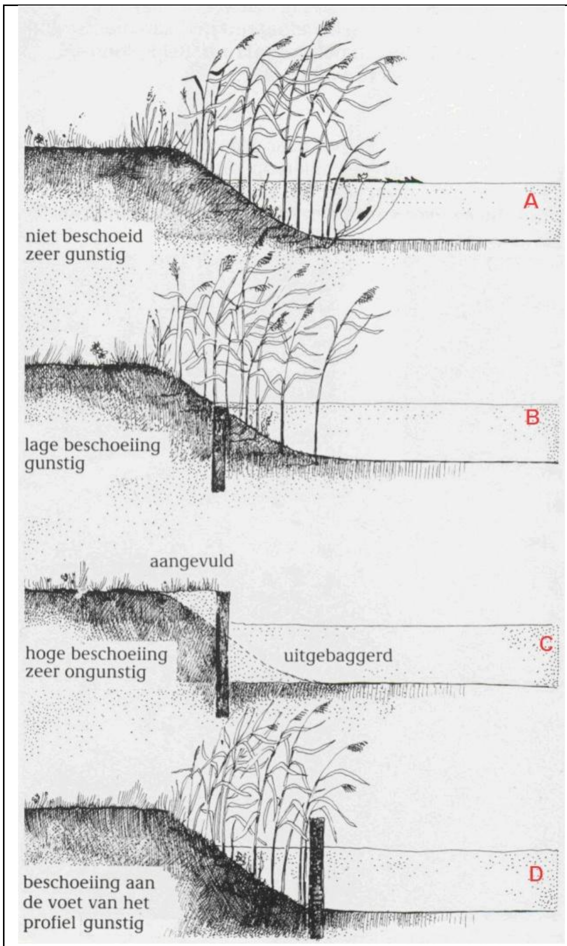
Figure 15 : Some pictures of good examples of designing with rainwater in urban areas in European cities.

3.2 Sustainable urban areas (the living city)

Cities have to be attractive to live in, for people, but also for many plants and animals. Using local ecological potentials can be helpful to restore the right ecological conditions to attract people of very different ages and very different lifestyles but also to provide an identity to the city as a whole. Urban ecosystems are living, there is a need for very different areas and qualities to give rise to a social-diversity and bio-diversity.

Lots of people (especially families with children) escape from cities because cities don't fit to them (Figure 44) .But also the biodiversity of plants and animals is very low within cities. We already explained the reason for that : the appearance of dominating ecological conditions in unsustainable gradients (boven). Moreover: areas that could contain more kinds of species are not only badly equipped and designed for (**pattern**) but also badly managed (**process**). The same aggressive species always benefit from cutting the lawn too often, using too many biocides, too much manure, etc. Large waste deposits, sewer systems, food storages, etc. are just optimal habitats for very few organisms. That's the reason why populations of these species (like nettles, rats and doves) can increase and become real pests within urban areas. We explained all this, because of the Relation Theory, explained boven 2.2. Using pesticides of course is not advisable because that only focuses on the effects, not on the causes of the problems.

Designing and creating a various 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 areas, and that for an attractive low cost (Figure 16) .(see also ROMBAUT, 2011).



Designing slopes in a gradual manner (A) instead of making them very steep (C) is better for waterfowl and marsh plants, also within urban areas. If there is a need to protect the riverbanks against damaging (by passing ships) one can choose for solution B or D (permeable bank protection). So breeding zones for all kinds of animals (fish, amphibians,…) can be created or conserved in this gently gradient (ANONIEM, 1982)

Culemborg (The Netherlands). The designing of a very gently water-land gradient in the eco-quarter EVA*Lanxmeer* creates nice living areas for people and appropriate abiotic conditions for different plants and animals
Picture Erik Rombaut

Arnhem (The Netherlands). Very high biodiversity is created in the city park *Presikhaaf*, using gradients in combination with a suitable ecological management.
Picture Erik Rombaut

Figure 16 : Designing gently gradients creates conditions for biodiversity and for attractive residential areas.

3.3 *Sustainable organisation (the participating city)*

3.3.1 Introduction

Urban problems such as vandalism, noise pollution and refuse dumping are connected to a lack of involvement by citizens with their environment. This can be due to ignorance. But more important is the organisation of the urban society, which does not call on commitment of citizens, sometimes even counteracts it. There is no ecopolis possible on an urban social mess. Strategies will have to be developed to increase the co-operation of citizens to a sustainable neighbourhood. Without this co-operation, neither a sustainable flow management nor the creation of attractive urban areas can be reached. One must think of strategies towards various lifestyles and types of business (target group policy). Of course good information of the citizens is a condition sine qua non (Figure 17). Furthermore the best strategy is one that rewards the participants, not necessary financial, but by creating for and with them an attractive daily environment. Punishing people if they are not participating the process is not the best strategy. The aim is to create a participating city.

Malmö (Sweden). Rainwater from roofs, streets and parking is infiltrated in the ground in the ecoquarter *Augustenborg* is showed on this poster all over the city. *Picture Erik Rombaut*

's Hertogenbosch (The Netherlands). Two years before the water system in the quarter *'De Vliert'* was renewed, an information centre was set-up in the middle of the quarter, to inform people in order to get coöperation of all the citizens. *Picture Erik Rombaut*

Gelsenkirchen (Germany). Information panel to inform the residents about the purpose of the new wadi's in the ecoquarter *Kuppersbusch*. *Picture Erik Rombaut*

Walloon region (Belgium). Information about the ecologically sound management of roadside green areas, which are mown less frequent to restore biodiversity. *Picture Erik Rombaut*

Figure 17 : Information is the first condition to get cooperation from residents.

3.3.2 Participation in private building communities (citizen building groups) in Germany.

The idea of a private building community is simple. Private families or private persons agree together to realize their ideas of building, living and working within the city, in common. In the nineteen nineties this German cooperation model arose in the municipality of Tübingen as well as in Freiburg im Breisgau. Traditionally the city is developed either by private builders often in new-towns (garden cities), or by big building companies. The last often work with a lack of flexibility, transparency and often in a very expensive way.

De municipality of Tübingen did want to attract also families with lower incomes to live within the new city expansions [6]. All the realised projects are the result of initiatives of so-called 'privaten Baugemeinschaften'. The municipality of Tübingen stimulated the formation of such building groups by organising so called *building markets*. These are meetings of interested partners, finding each other such as families, singles, elderly, small entrepreneurs gathered to develop a project together. When their project was accepted, an appropriate allotment was awarded to the building group. So the diversity of the building groups (different social groups and generations) is reflected in the different scale and typology of the projects. So a virtually organically grown city quarter arose, not stereotyped as often when built up by promoters (Figure 18). Through the establishment of participation in a common project in a very early phase, the future neighbours learned to know each other even before the building started. An important advantage of this building group formula was the fact that the prices were up to 20 % cheaper than it would have been without cooperation (SOEHLKE in GAUGGEL, 2007). Moreover, the traditional aversion of citizens against living in densely occupied city quarters, does not exist (or is not so obvious) amongst members of a private building community.

Indeed, in the new ecodistricts, the municipal service for city renewal established a high density of dwellings. During the development of these quarters, the aim was to mix residential areas with suitable working places and recreation/leisure possibilities. Small offices, businesses, cafés, restaurants and local shops are situated on the ground floor. The higher stories have a residential function. In the Loretto quarter live 170 inhabitants/hectare and work 80 to 90 employees/ha. In the French quarter live 240 inhabitants/hectare and 50 to 60 working places per hectare are created (SOEHLKE, 2008). Moreover there has been chosen for a mixed development of private projects and public municipal projects and also for a mixture of renovation and new buildings. E.g. old military barracks were renovated and got a new function for co housing projects, for elderly, for foreign families, students (Figure 19)

These high citizens' densities could be reached, because these new city quarters are developed as a city lobe, following the principles of the lobe-city (see onder). The well thought-out mixture of functions results in lively city quarters. But as we will explain later onder, these well-thought mixing of functions has also many advantages in terms of district heating piping networks in combination with the cogeneration of heat and power. The consequence of all this is a huge decrease of energy-demands (carbon-footprint).

[6] Up to 1991 an area of about 60 ha south of the city centre of Tübingen was occupied by the French army. After the withdrawal of the French troops, the huge area was given back to the German state and then sold as a bargain to the municipality of Tübingen. The municipality gave the area a residential function and organised a design competition for this French Quarter. By 2012 around 6500 new inhabitants and around 2000 working places, will be realised. Two eco quarters already are built up: the Loretto-areal and the French Quarter.

Freiburg in Breisgau (Germany). A private building community (or citizen building group) is a group of families realising together one project. *Picture Peter Boogaerts*

Tübingen (Germany). By mixing different forms and scales of projects proposed by the different building groups, the new city quarter *French Quarter* seems to be organically grown.
Picture Erik Rombaut

Tübingen (Germany). In the eco quarter *French Quarter* living and working are mixed. *Picture Erik Rombaut*

Tübingen (Germany). In the eco quarter *Lorettoareal* renovation projects are mixed with new buildings.
Picture Erik Rombaut

Figure 18 : Tübingen (Germany) is stimulating so-called private building communities (=citizen building groups).

These eco-projects in Tübingen got a lot of international attention and appreciation. Tübingen got the German price for urban development (Deutsche Städtebaupreis ,2001) and the European Urban and Regional Planning Award 2002.

Meanwhile other initiatives with private building groups emerged all over Germany (GAUGGEL, 2007), and recently also in Switzerland, Austria and The Netherlands. More information about participation through citizen building groups is published in ROMBAUT (2008c)

4. Building stones for an ecologically sound urban development.

4.1 The lobe-city.

Sustainable urban development is far more than sustainable building. Moreover, most of the gains for the environment can be achieved before building has even started. The location of the project and the development of the urban plan are important for the environmental impact (SEV/Novem, 1996, ADRIAENS, 2005). A green building which cannot be reached by public transport and which is constructed far away from the city-centre is a missed opportunity, for it demands unfriendly behaviour of the inhabitants.

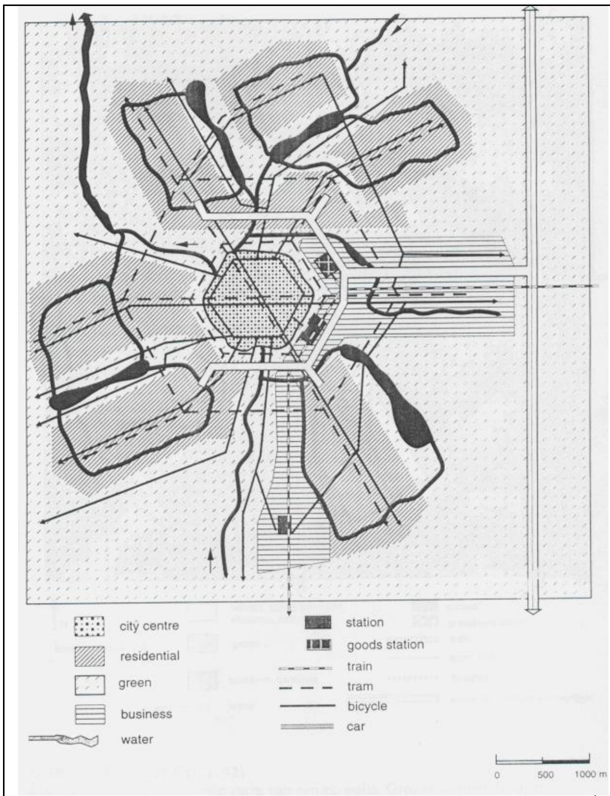
In literature [7], a discussion is going on for a long time on the best form of a sustainable city. Is a compact city the best shape for an ecopolis ? Studying these problems, TJALLINGII (1992, 1994, 1996) concludes that the **'lobe-city'** probably is the best form for an 'ecopolis' (Figure 19). For 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).[8].

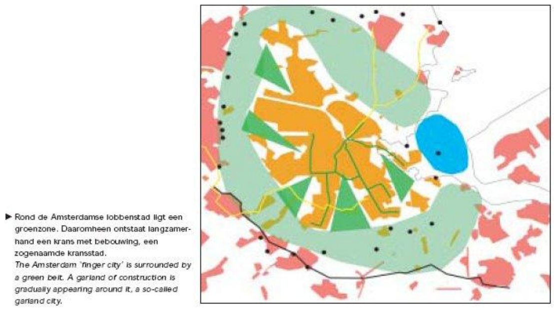
Through these **blue-green fingers**, a lot of rural **ecosystem services** (see boven) can be brought into the city: possibilities for urban agriculture (community-supported agriculture, CSA) and for restoring biodiversity next to the city-centre; possibilities for storage and infiltrating of (rain)water 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 20). 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 boven), the nature-values and also the social values of those green wedges can be huge.

[7] 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).

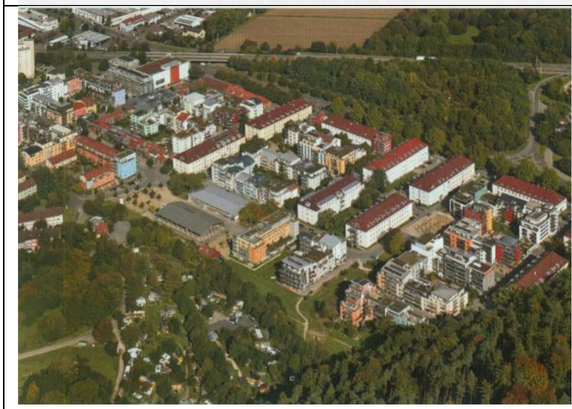
[8] The Natura 2000 network is based on two European directives: the birds directive (79/409/EEG) and the habitats directive (92/43/EEG) both aiming to preserve European biodiversity and forcing member-states to plan a network of nature reserves crossing national boundaries, for conservation purposes http://ec.europa.eu/environment/nature/home.htm (ROMBAUT, E. & K. MICHIELSEN, 2005)

Of course there is a need for more research to look carefully whether green wedges close to dwellings in tropical and subtropical regions always are safe in terms of wildlife. One can imagine citizens in south Asia, Africa or south America being anxious living too close to dangerous wildlife. The European situation is quite different, for dangerous animals for example are rarely living close to cities. Further social and biological research on this topic is needed.





Top:
Amsterdam (The Netherlands) as a lobe-city example
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)



Tübingen (Germany). In the compact built-up city-lobe *Französisches Viertel (French Quarter)* live 240 inh/ha and 50 to 60 labour places. Blue-green fingers are nearby.

Tübingen (Germany). The urban fringe of the city-lobe *Französisches Viertel (French Quarter*).
Picture Erik Rombaut

Figure 19 : A lobe-city is probably the best form for an ecopolis. In a lobe-city the water-chain carries the green fingers, the (public)traffic-chain carries the built-up lobes (TJALLINGII, 1996).

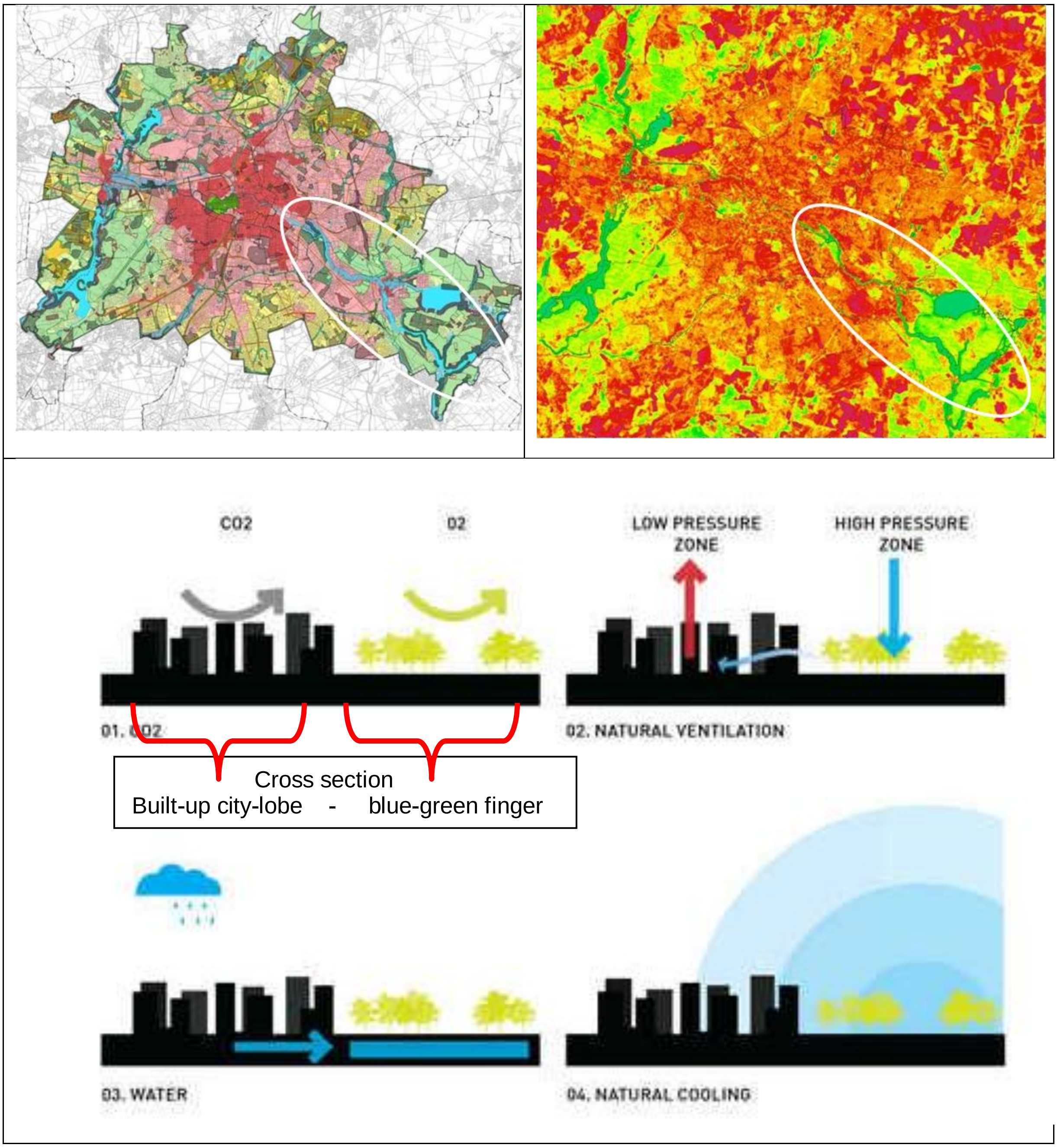


Figure 20 : Blue-green fingers have an interesting impact on urban climate, as a lot of rural *ecosystem services* can be brought into the city. The built-up areas have a higher temperature, thus a lower air pressure than blue-green areas. Blue-green fingers remain colder. Air transport by convection 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/)

The lobe-city model was developed in the first half of the 20^{th} century. To varying degrees, this model was used in Denmark for the “fingerplan” in Copenhagen (Denmark, Figure 22) (1948), the general plan to extend Amsterdam (NL Figure 19) (1935) and in cities such as Hamburg, Köln (1927), Berlin (Figure 20), Stuttgart, Tübingen (Germany) and Stockholm (Sweden).

Accepting a cycling-maximum of 15 (to 20) minutes to the centre (central train and bus station), the length of **the built-up city lobes** can be about 2500 (- 3000) meters. Tjallingii proposes 600 meters for the width of the lobes, in order to keep the green areas within walking distance of the citizens. In order to set up a payable public transport system, dwellings in the city-lobes must be built more densely, than usually is done in suburban context of garden cities. Enough people should be living within a walking distance from bus or tram stops. The central axes of the lobes need very good, 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). Business areas are located also in lobes, mixed with dwellings, next to railways (and motorways). All this means a city lobe has a surface of 2500 (-3000) x 600 m^2 which is around 150 (180 ha). 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 stations, as a string of beads (TJALLINGII, 2005). Earlier we have mentioned the interesting citizens’ densities reached in the ecoquarters of Tübingen (see boven). Raising densities was also the aim in the Beddington zero fossil energy development in London (Figure 21). Designing high densities of dwellings is important for setting up payable public transport but also for the introduction of District Heating and Cooling, as we will explain later (see onder Later in this paper we will discuss how higher densities can be designed without losing residential quality (see onder)

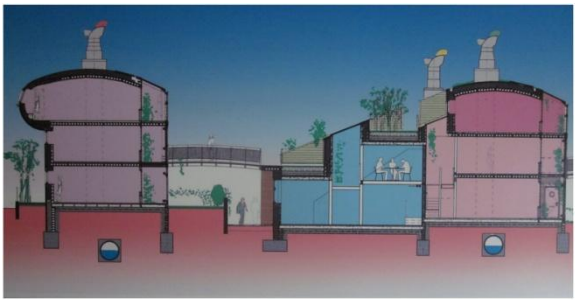


Figure 21 : London (UK): Density (and compactness) of dwellings in Beddington zero fossil energy development (BedZED) is higher than in traditional garden-cities. The developer moved away from the traditional single detached houses towards more density.

In a lobe-city the water-chain carries the green fingers, the (public)traffic-chain carries the built-up lobes. With this model, Tjallingii shows the way out of the compact-city discussion. Citizens can benefit both: there is green in the neighbourhood as well as good public transport and the city centre (with the central station) is in cycling distance from the dwellings. 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 Figure 22 and Stuttgart) are based on a lobe-city approach (ROMBAUT, 2009b).

Copenhagen (DK)

1947 and 2007 Finger Plans

Historically, the Copenhagen suburbs have been developed according to the **Finger Plan** from 1947 which intends for the suburbs to develop as fingers along commuter rail lines separated by green wedges.

The finger plan of Copenhagen (DK)

Finger Plan (Local Plan Office for Greater Copenhagen, 1947)
http://www.pashmina-project.eu/doc/PASHMINA_D2.3.pdf

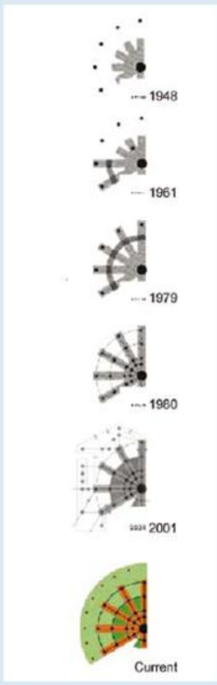


Figure 2. Schematic diagram of the radial development of Greater Copenhagen from 1948 to 2001.

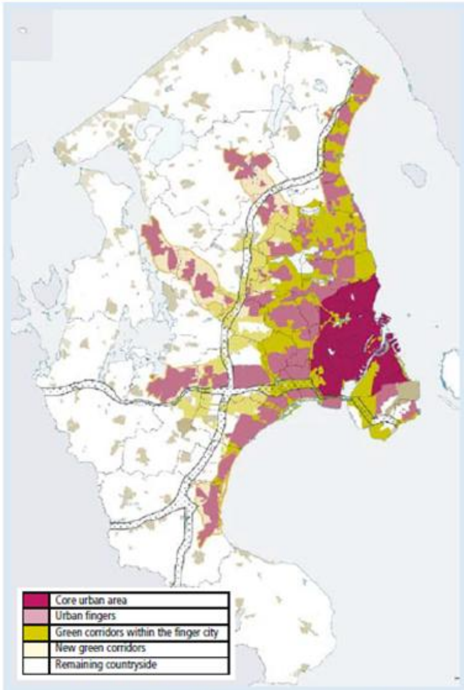


Figure 3.Greater Copenhagen showing the finger-like urban extensions and network of planned green space.

The Finger Plan includes not only the relatively small Municipality of Copenhagen covering the centre part of the city with app. 0.5 mill citizens but in addition take in the Greater Copenhagen Area, and thus also covers 34 adjacent municipalities.

source: UCD, 2008.

Figure 22 : The fingerplan of Copenhagen, capital of Denmark. (1,5 billion inhabitants)

Also in Helsinki (Finland), the designers of the ecoquarter *eco-viikki* opted for blue-green fingers. (Figure 23*)*, in which water overflows are infiltrated or slowly evacuated and in which local biodiversity is supported.

Figure 23 : Helsinki (Fin.). The blue-green fingers are carrying biodiversity into the dwelling neighbourhoods of the eco quarter eco-viikki. The overflow of rainwater is infiltrated and evacuated very slowly. Pictures by Erik Rombaut.

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 24 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 boven .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.

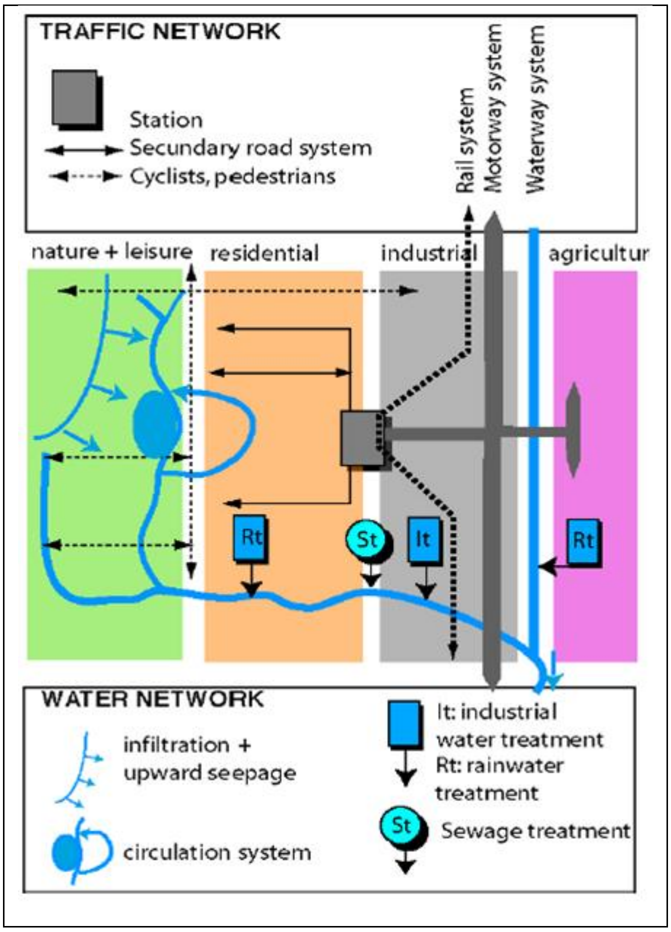


Figure 24 : The two networks' strategy (S2N, TJALLINGII, 2005)

4.2 Need for a public-private gradient to restore biodiversity and social cohesion.

4.2.1 Public-private gradient in the green urban areas (the gardens)

Also in the inner city, a lot of unexpected opportunities can occur to restore biodiversity, combined with finding solutions for environmental problems. An interesting example can be studied in the city of Kolding (Denmark). This municipality found a solution for the infiltration of rainwater and the purification of black and grey water in a marsh plant purification system, located in a glass pyramid. The urban renewal project in *Fredensgade/Hollandervej* area turned out successfully, because the area needed for the project was found by combining a part of each private garden into a bigger **semi-public inner garden** (KENNEDY & KENNEDY, 1998, Figure 15).

In a lot of European ecoquarters the creation of a semi-public green area from the beginning of the designing process seems the key for success (Figure 25). In a growing number of ecologically sound city-quarters and building blocks, the inhabitants buy and own an inner green area in common.

In these ecoquarters with a common central green area, also a lot of sociological problems can be solved[9]. Residents often are involved with the designing and the management of these common gardens. In this context it's interesting to mention the Dutch idea of a 'neighbours-nature-garden'. These are (semi-) public gardens which are maintained by local residents, based on ecological principles. One of the first initiatives arose in 1979 in Utrecht (The Netherlands; PEELS, 1993): de Bikkershof is today a quite nice example of how such a nature-garden can be started up and managed. The advantages for the municipalities are clear: economising costs; local residents are actively involved in policy and there is an increasing social control in (semi)public green areas. This is a good example of combining flow-management, creating urban quality and participation. These were the three pillars of the ecopolis strategy (see boven)

In Kolding (Denmark), local residents open their common garden for the public during daytime and offer the citizens a nice green area. For that reason the municipality decided to maintain the common inner garden by the official park staff. A very nice consequence is the creation of shorter attractive cycling and walking possibilities. Short-cuts like these through the built-up areas can stimulate people to walk or to cycle in the inner city. In the eco quarter EVALanxmeer (municipality of Culemborg, NL) an agreement has also been made between the residents association and the municipality. In the agreement is pointed out which part of the management will be done by the residents and which part by the staff of the municipal park service. This strategy is strengthening social cohesion amongst the residents (ADRIAENS, 2005 ; KAPTEIN, 2008).

The designing of a well thought **public-private gradient in the green areas** is **the second key** [10] towards higher citizens' densities, without losing quality in residential city-lobes. Every family has its own private garden, but is also co-owner of the common garden. Especially for families with younger children, these insights are very attractive. It seems a way to stop the flight from cities of young families, moving to suburban and rural areas.

Malmö (Sweden). Semi-public inner garden in the ecoquarter *Västra Hamnen.*
Picture Erik Rombaut

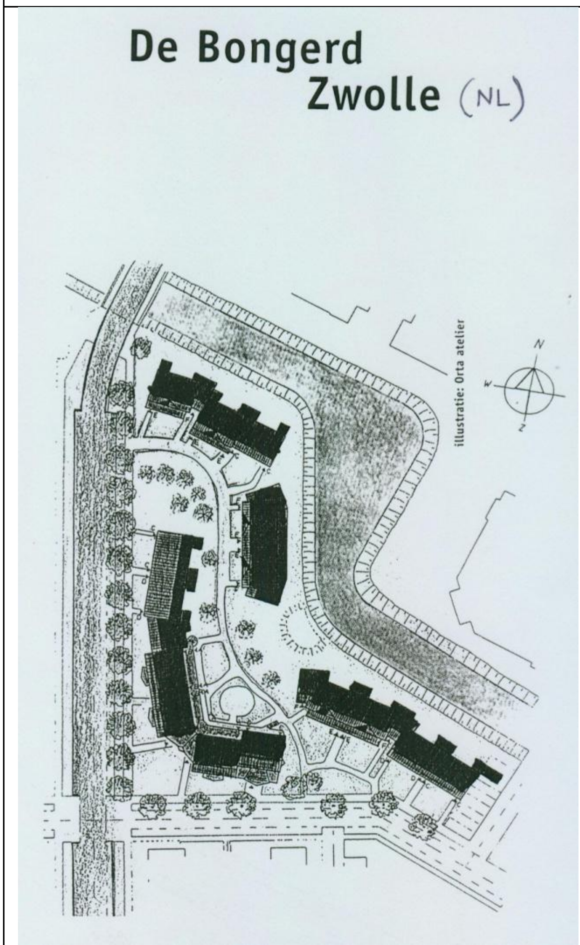
Westerlo (Belgium). 13 social low energy dwellings (social housing company 'De Zonnige Kempen' are built up around a semi-public area..
Picture Erik Rombaut

[9] In city quarters with green areas, there are 15 % less children with obesitas. Dutch Alterra-researchers link this with the possibilities children have in those city districts, to play and to move. The presence of green areas triggers children moving and playing more (elektronische beleid.flits natuurpunt nr 144 dd. 31/10/06)

[10] The first key was the introduction of private building groups (see 3.3.2 Participation in private building communities (citizen building groups) in Germany.) in which the traditional aversion of citizens against living in densely occupied city quarters, does not exist (or is not so obvious).

Culemborg (The Netherlands). Semi-public areas within building blocks in the ecoquarter *Lanxmeer*. *Picture Erik Rombaut*

Zutphen (The Netherlands). Central common garden in the Ecoquarter *De Enk.*



Zwolle (The Netherlands). Ecoquarter *'De Bongerd'*

Zwolle (The Netherlands). View on the small private gardens, surrounded by a semi-public area in ecoquarter *'De Bongerd'*. *Picture Erik Rombaut*

Culemborg (The Netherlands). Semi-public area in ecoquarter *Lanxmeer*. *Picture Erik Rombaut*

Culemborg (The Netherlands). View in a semi-public area in ecoquarter *Lanxmeer*. *Picture Erik Rombaut*

Figure 25 : Some examples of the creation of semi-public green areas (gardens) in European ecoquarters.

Whether or not such an approach will strengthen the social diversity in towns depends, among other things, on the extent to which one resists the tendency to close these semi-public environments (that is, to privatise them) and to transform them into an urban **eco-ghetto**. In the ecoquarter *Hedebygade* in Kopenhagen (Denmark) and in *Västra Hamnen* in Malmö (Sweden), local residents closed their inner gardens with big fences (Figure 26 :). Subjective feelings of a lack of safety are the origin of this asocial behaviour, but one can imagine big fences and surveying cameras also contribute to those unquiet feelings. Of course this is not the way towards an ecopolis with benefits for the whole population, for all citizens. On the contrary, this leads towards further segregation of social groups and towards city green only accessible for the happy few. Some municipalities counter this asocial behaviour by offering the quarter public services (maintenance) in exchange for accessibility.

Utrecht (The Netherlands). Semi-public garden *'De Bikkershof'* is open for the public in daytime and creates a nice green inner-city park.
Picture Erik Rombaut

Malmö (Sweden). Local residents fenced their common gardens in ecoquarter *Västra Hamnen* *Picture Erik Rombaut*

Copenhagen (Denmark). Fences make the inner green areas inaccessible for the public in the *Hedebygade* project. *Picture Erik Rombaut.*

Figure 26 : Creating urban eco-ghettos leads to further segregation of social groups and towards city green only accessible for the happy few.

4.2.2 Public-private gradient inside the buildings and between the buildings

In a growing number of European eco quarters one is designing also a well thought gradient between public and private inside the buildings (Figure 27 :).

A nice example one can find in the ecoquarter Munksøgård (Roskilde, DK). Different neighbourhoods are built up around the central organic farm. Each neighbourhood contains an amount of private dwellings around a semi-public garden ; each of those has also a semi-public building. In those buildings some facilities are provided with focuses on specific groups of inhabitants such as elderly people, youth, families, …

Roskilde (Denmark). The different neighbourhoods of the ecoquarter *Munksøgård* are planned around a public central organic farm. Each neighbourhood has its own semi-public building with facilities for different groups of inhabitants.
Picture by Erik Rombaut

Roskilde (Denmark) Neighbourhood in the ecoquarter *Munksøgård* In the background the private dwellings are situated, in the foreground left the semi-public building.
Picture by Erik Rombaut

Kolding (Denmark). Common car ports with a photovoltaic energy plant on the roof, built in the semi-public parts of this urban building block.
Picture by Erik Rombaut

Roskilde (Denmark). Semi-public zone with a common bike parking in the ecoquarter *Munksøgård.*
Picture by Erik Rombaut

Culemborg (The Netherlands). Everyone is welcome in the public urban farm, adjacent to the eco quarter *EVALanxmeer*.
Picture by Erik Rombaut

Freiburg (Germany): Common bike parking in the ecoquarter Vauban. *Picture by Erik Rombaut*

Figure 27 : In a growing number of eco quarters, semi-public buildings are designed, with a lot of different functions.

There is a lot of experience about dealing with such semi-public buildings or parts of buildings in the so-called ecovillages. Het Global Ecovillage Network (GEN) gathers these initiatives (www.gen-europe.org) : The German ecovillage *Sieben Linden* (Municipality of Poppau, D; Figure 28 :) has a central community house with the reception, central kitchen, guest dormitories, library and lecture rooms for courses and educational projects. The ecovillage has about 90 ha of common owned land. Partly it is a woodland providing building materials and fire wood. Another part is the common vegetable garden and orchard. About 75 % of the food needed for the 120 inhabitants in a year is cultivated organically, the rest is bought in a local organic farm.

 Poppau (Germany): Central community house with kitchen, library, guest rooms and lecture rooms in the ecovillage *Sieben Linden*. In the foreground a common ecological swimming pond.. *Picture by Erik Rombaut*	 Poppau (Germany): Common wood stock and a collective photovoltaic plant in the ecovillage *Sieben Linden.* *Picture by Erik Rombaut*
 Poppau (Germany): Compost toilet and shared washing machine in the ecovillage *Sieben Linden.* *Picture by Erik Rombaut*	 Poppau (Germany): By using compost toilets the surface needed for the plant purification system can be minimised (only grey water) in the ecovillage *Sieben Linden*. *Picture by Erik Rombaut*

 Poppau (Germany): Common vegetable gardens in the ecovillage *Sieben Linden. Picture by Erik Rombaut*	 Poppau (Germany): Amphitheatre in the common garden of the ecovillage *Sieben Linden. Picture by Erik Rombaut*

Figure 28 : Common facilities in the green areas and inside the buildings of the ecovillage Sieben Linden (Municipality of Poppau, Germany.)

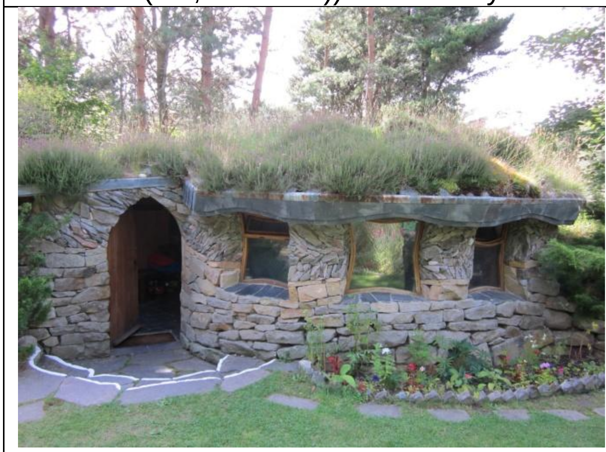
Growing food is the aim in a lot of eco- initiatives such as in the Finish project *eco-viikki* (Figure 29 :), close to Helsinki. Fruit trees were planted through the area and there are a lot of possibilities growing vegetables by the inhabitants.

Figure 29 : Helsinki (Fin.). In the quarter Eco-Viikki , a lot of space is intended for gardening by local inhabitants.

Another nice example can be found in the Scottish ecovillage of Findhorn (www.ecovillagefindhorn.org ; Figure 29). There also, a lot of common used infrastructure has been built.

Findhorn (UK, Scotland)): community centre.

Pictures by Erik Rombaut



Findhorn (UK, Scotland): common meditation room, from outside and….

… from the inside

Figure 30 : In the ecovillage of Findhorn (Scotland) a lot of common used infrastructure with very different functions has been built.

There is a growing number of projects in which designers are creating a public-private gradient within the buildings itself (Figure 31 :). A good example is the seniors home 'Het Kwarteel' in the ecoquarter EVALanxmeer (Culemborg, the Netherlands) in which a part of the building has a lot of common facilities such as a bike parking, guest rooms and a cafeteria. In the social housing project Werdwies (Zürich, Switzerland), the ground floor is reserved for common used facilities such as a nursery, ateliers and a laundry. These common areas became the meeting places of the project, just like, a long time ago, the central laundry in the medieval and antique village was important for the social cohesion. Also in the Finnish eco-quarter eco-viikki (Helsinki), common laundries and sauna's are designed in order to minimize the energy and water consumption. Though the average building cost is about 5 % higher than a conventional comparable Finnish dwelling, water and energy consumption are about 30 % less, which of course leads to an attractive lower ecological impact (www.skanska.com).

In a lot of car-free eco-projects also the car-parking's and the bike-parking's are designed for common use for the inhabitants (Figure 27)

Zürich (Switzerland). The social housing project *Werdwies* (architect Adrian Streich, 2007) was build according to the Swiss minergie-eco standard.
Picture by Erik Rombaut

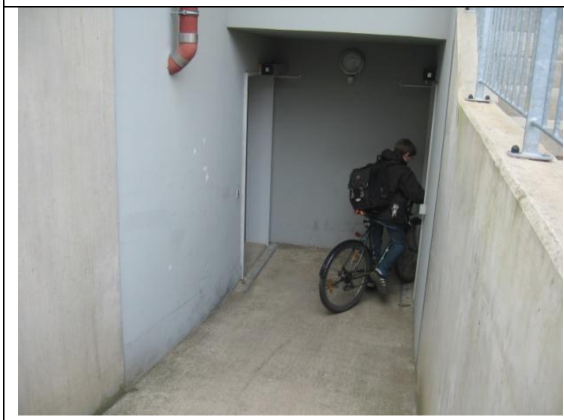
Zürich (Switzerland). On the ground Floor a lot of common functions are designed, for example this common laundry, stimulating social cohesion in this *Werdwies* project. *Picture by Erik Rombaut*

(Culemborg, The Netherlands). Senior home 'Het Kwarteel' in the eco quarter *EVALanxmeer* with a lot of common used facilities …
Picture by Erik Rombaut

…. in the darker round part of the building
Picture by Erik Rombaut

Figure 31 : Also within the buildings a well thought public-private gradient is designed. The common used facilities are of a great diversity.

In the German city of Köln, the car free city quarter 'Stellwerk 60' is a nice example of a bike friendly design, even on the building level. There are central car parking facilities at the edge of the quarter. Each building has a common-used bike parking in the cellar, which can be reached using the slopes. Bike parking is everywhere and there is even a common bicycle pump on the central square in the district (Figure 32 :).



In Köln (D) the car free city quarter 'Stellwerk 60' has been designed very bike friendly: all builidngs are provided with common used bike parkings which can easily be reached, using the slopes..

Figure 32 : Designing a car free city is asking for measures on every level: the building, the city quarter and the city level.

In the ecovillage Keuruu (Finland), all these principles are consistently applied: each family lives in a private separate dwelling. But there is also a community house with a kitchen, library, meeting rooms, sports infrastructure and guest rooms. Moreover there is a common vegetable garden and close to the lake there is a common sauna. So within the buildings as well as in the green areas, there is a well thought gradient between public and private areas of the ecovillage (Figure 33 :). That is the case in a lot of ecovillages (www.gen-europe.com).

Keeruu (Fin.). View on the central place of the ecovillage Keuruu.
Picture by Erik Rombaut

Keuruu (Fin.). In the 'community house' of the ecovillage there is a library, which can be used by inhabitants as well as visitors of the village.
Picture by Erik Rombaut

Keuruu (Fin.). Some other common facilities in the community house of the ecovillage.
Picture by Erik Rombaut

Keuruu (Fin.). Masonry heater in a meeting room of the ecovillage.
Picture by Erik Rombaut

Figure 33 : The ecovillage Keuruu (Finland) is dealing with a carefully thought gradient between public and private areas, inside the buildings, between the buildings as well as in the green areas.

4.3 Blue-Green-buildings

Recently in some projects there even have been blue-green networks designed on the level of one (big) building. So the eccentric Austrian artist F. Hundertwasser became very well-known with his ideas to get more colours in the inner city of Wien (AT). He proposed to replace some apartments in sky scrapers by roof-gardens and plants in the facades of the building. He redesigned the plans for a waste incinerator and got attention in the whole world with his Hundertwasser house.

In his book 'Nature and the city', TIMMERMANS (2001) makes a plea for urbanisation as an instrument for nature conservation policy. His main idea is that ecological conditions within urban areas often are better than in rural areas, because of intensive agriculture activities poisoning the rural areas (see also onder). For the maintenance of biodiversity, he expects more from cities then from rural areas. He describes ecological high (building)structures with their own (rain)water system. With the rainwater the air is moistened and air quality within the building is kept healthy. Outside the building (but also inside) rainwater helps to create good conditions for biodiversity. City-nature has to become part of designing buildings and of urban design. But therefore buildings have to be designed in a nature-friendly manner.

Green roofs offer a lot of opportunities for more nature in the (inner) city. In Scandinavia those roofs are used for centuries because of insulation. But they also are important for a sustainable rainwater management. Rainwater is not piped away anymore through the sewer system, but kept in the roof substrate and evaporated by the plants. Green roofs have an influence on local micro-climate conditions (e.g. temperature, moisture.). Of course they can be attractive for all kinds of organisms such as butterflies (TEEUW, 2000), even in the city centre.

So what first started with extensive *Sedum*-green roofs and roof gardens (as on the ING bank office Amsterdam) now grows further with ideas of blue-green networks on whole buildings. Those buildings show some similarities with mountains. Rainwater is kept as long as possible on the building and transported very slowly, as the melting water from a mountain slowly finds its way to the valleys. These ideas are implemented in some nice projects of the famous German architect J EBLE (2006).

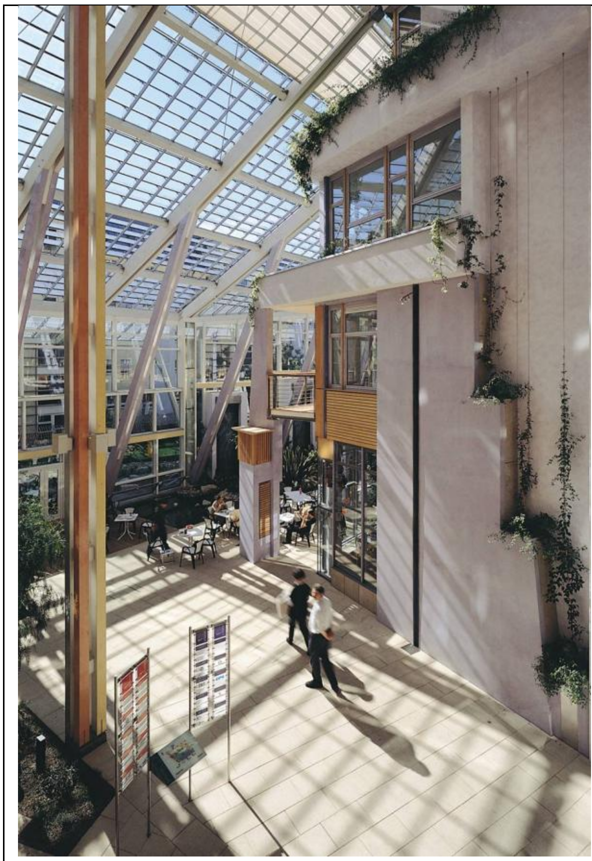
It's clear that one major advantage has to do with cooling down local temperatures, both within the building as in its surroundings. Once again, introducing blue-green buildings is designing with *ecosystem services* (see boven). In this case designers are using the evapotranspiration of green zones as a cooling infrastructure on the building level. We already made a plea to do the same on the city scale, introducing blue green fingers within a lobe-city context (see boven).

Hovden (Norway) In Norway new dwellings often have a green roof. *Picture Erik Rombaut*

Eidfjord (Norway). New sustainable architecture near the national park Hardangervidda in Norway.
Picture Erik Rombaut

Westerlo (Belgium) The province of Antwerp built a demonstration project Kamp C, about sustainable buildings on a former military area.
Picture Erik Rombaut

Westerlo (Belgium). In the library of Kamp C, literature on sustainable urban and rural planning can be found.
Picture Erik Rombaut

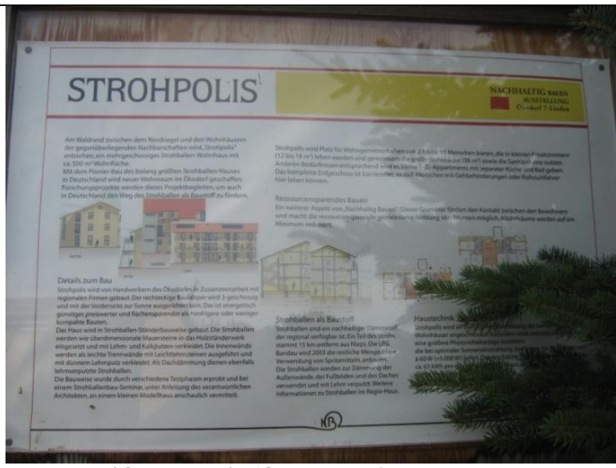

Nüremburg (Germany). Green building designed by Joachim Eble. (EBLE, 2006)


Wien (Austria). Hundertwasser house in the city centre of the Austrian capital.
Picture Erik Rombaut.


Amsterdam (The Netherlands). Roof garden on the ING bank office. (*Picture Johan Heirman).*


Amsterdam (The Netherlands). Designing with rainwater on the roofs of the ING Bank office.
(*Picture Johan Heirman)*

Poppau (Germany): Community house 'Strohpolis' built with straw in the ecovillage *Sieben Linden*.
Picture Erik Rombaut



Poppau (Germany): 'Strohpolis' in the ecovillage *Sieben Linden*.
Picture Erik Rombaut

Paris (F): Quai Branly (*Picture Erik Rombaut)*

Paris (F): Quai Branly (*Picture Erik Rombaut)*

Milano (Italy): Bosco Verticale
The landscape architects Emanuela Borio and Laura Gatti working with Stefano Boeri designing Bosco Verticale in Milano (It)
http://thelandscape.org/2014/09/01/bosco-verticale-milan-the-next-step

Figure 34 : Blue-green buildings in some European cities.

4.4 Green industrial areas

All theories and principles explained in this presentation are also applicable on industrial urban areas. First of all it's necessary to get rid of the old-fashioned CIAM [11]-ideas, which made a plea for separating residential areas from industrial areas and from leisure areas. That kind of planning system has led us towards the well-known huge mobility problems. Luckily, many cities nowadays choose for mixing functions. Only then cycling and walking are realistic alternatives for individual cars. For the ecological sound zoning principles we refer to the connection model we explained boven.

Interesting initiatives can be studied in Trier (Germany): In the Petrisberg project living (passivhouse dwellings) and working (renovation of old military buildings into factories) are combined (www.petrisberg.de). In Esch-sur-Alzette (Lux) one can find another inspiring project in which leisure (concert hall), living (a lot of dwellings), studying (some research centres from the university) are combined on an old brownfield (arbed/arcelor company), with very impressive green structures through the project (by the Dutch planner Jo Coenen & Co. www.agora.lu ; Figure 35 : .

Trier (Germany). Wohnen und arbeiten auf dem Petrisberg (www.petrisberg.de)
Picture Erik Rombaut

Esch-sur-Alzette (Lux). www.agora.lu
Picture Erik Rombaut

Figure 35 : Mixing functions (living, working and recreation) is the guideline in these projects.

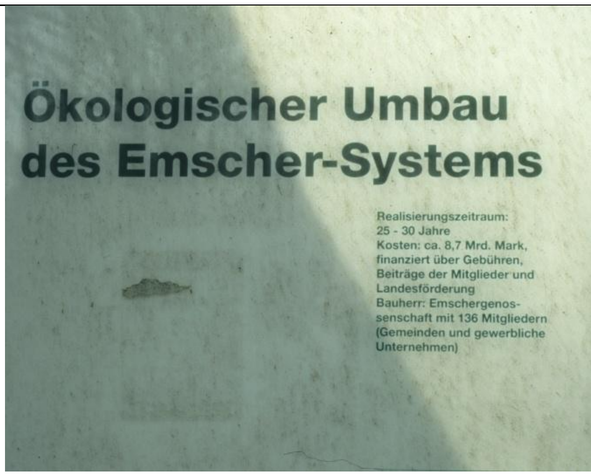
But there is more that can be done. A lot of experience is gathered to improve biodiversity in industrial areas. JANSONIUS, T & P. JACOBS (2005) describe 12 examples in The Netherlands. Analysing them points out that - as we explained for residential areas (2.2) - biodiversity is served by good patterns (blue-green networks) and by the right ecological management processes. Nice examples can be found in the German Emscher region (Ruhrgebiet (Germany), where old brownfieds are cleaned and turned into green nature and leisure areas and even in residential zones (LONDONG & NOTHNAGEL, 1999 ; LATZ, 2006). Also the renovation of Ford's River Rouge factory in Dearborn (Michigan US),

[11] 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 (such as ***Le Corbusier***), 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.

of the Herman Miller Factory (US) and some Chinese urban projects in preparation, all from MACDONOUGH, W & M. BRAUNGART (2002) are famous green initiatives. Waste equals food is the guiding principle of those remarkable designers. That means all products and buildings should be designed in such a way, that after use when they are demolished, all so called waste-products can be re-used or can be decomposed in useful components for nature.

A next interesting initiative is taken in the Danish municipality of Kalundborg. About 20 different factories are working together to decrease energy consumption and waste discharges. This is accomplished by using each other's material, energy- and waste-flows (JACOBSON, 2002).It's interesting the concept 'symbiosis' is borrowed from biology science to specify what is achieved [12].

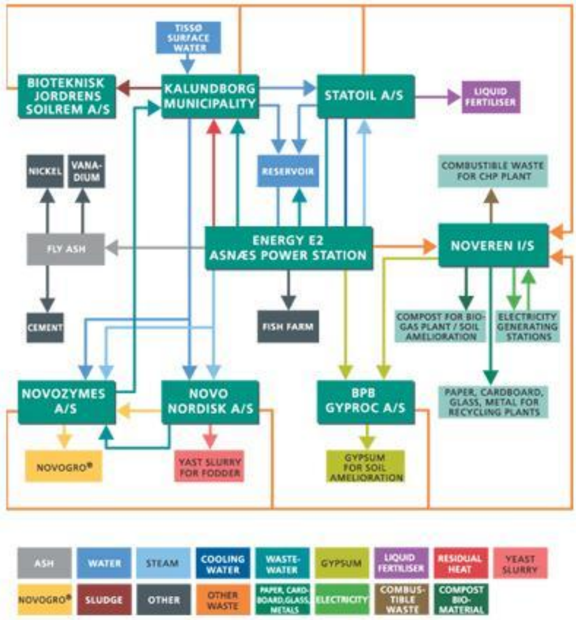
Emscher region, Ruhrgebiet (Germany). LATZ,2006.



Emscher region, Ruhrgebiet (Germany). Ecological sound renovation of rivers and brownfields in an old industrial area.
Picture Erik Rombaut

[12] Symbiosis means co-existence between diverse organisms in which each may benefit from the other. In this context, the term is applied for the industrial co-operation taking place in Kalundborg between about 20 companies (ROMBAUT, 2007b), all of which exploit each others residual or by-products mutually. The Symbiosis co-operation has developed spontaneously over a number of decades (http://www.symbiosis.dk)

JANSONIUS, T & P. JACOBS (2005). Factories in green surroundings, 12 Dutch examples



Kalundborg (Denmark). An industrial ecosystem is designed in which waste materials from one factory is interesting raw material for another one. (www.symbiosis.dk)

Figure 36 : Different green initiatives in industrial areas.

5. Closing Remarks

5.1 The lobe-city versus the garden-city': compactness versus energy and mobility.

5.1.1 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 37) 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.

5.1.2 Compactness versus energy

Figure 37 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.

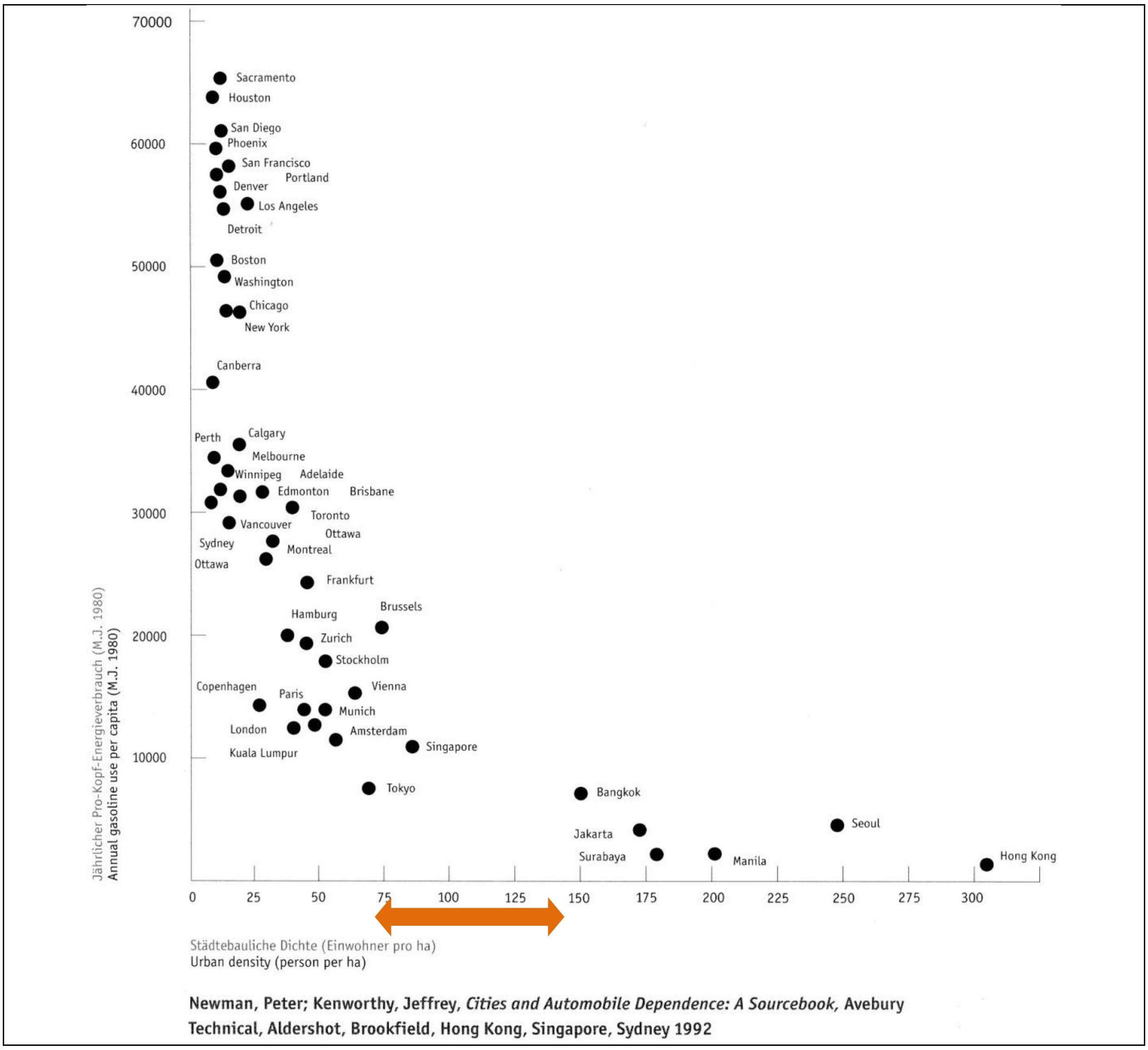


Figure 37 : There is an amazing exponential correlation between urban density in cities and the energy consumption. 75-125 inhabitants per hectare. seems a density which enables payable, viable public transport.

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. Also in Belgium this suburban expansion has been introduced in the second half of the 20th century. This is the main reason for the very high energy consumption in Belgium, illustrated in Figure 38. For the same unit Gross Domestic product (GDP), Belgium needs 25 % more energy (85) than Germany (60). Also the EU-27 (64) is doing far better (21%) than Belgium.

ktoe$05p	2006	2007	2008	2009	2010	2011	2012	comparison % 2012
world	0,20	0,20	0,19	0,19	0,19	0,19	0,18	100
Europe	0,13	0,12	0,12	0,12	0,12	0,12	0,12	64
EU-27	0,13	0,13	0,12	0,12	0,12	0,12	0,12	64
Belgium	0,17	0,16	0,16	0,16	0,17	0,16	0,16	85
France	0,14	0,14	0,14	0,13	0,14	0,13	0,13	70
Germany	0,13	0,12	0,12	0,12	0,12	0,11	0,11	60
The Netherlands	0,13	0,13	0,13	0,13	0,14	0,13	0,13	70
United Kingdom	0,11	0,10	0,10	0,10	0,10	0,09	0,10	52

Figure 38 : Energy Intensity (2006-2012) per unit GDP at constant purchasing power parities. (source : "World Energy Intensity Data". *Enerdata Statiscal Energy Review 2012*. Enerdata. http://yearbook.enerdata.net/#/energy-intensity-GDP-by-region.html)

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 39). 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.

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 11)

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 39 : CHP plants in some European cities.

5.1.3 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 11, 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 (boven) .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)', 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.

5.2 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 40): 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.

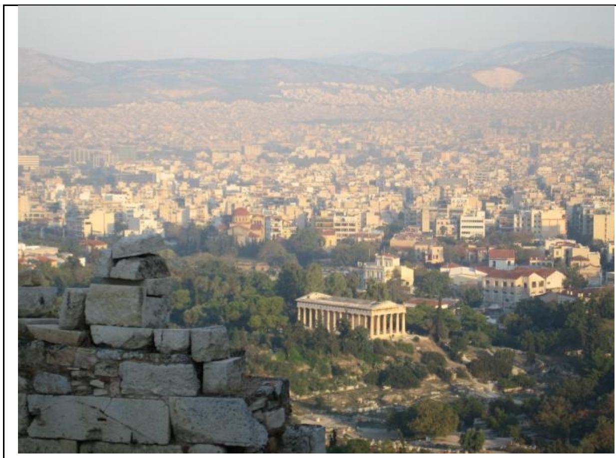
 Athens (Greece). A big compact city, expanding in a concentric manner, surrounded by mountains is vulnerable for summer smog (city heat island effect), threatening the health of people and the cultural heritage. *Picture Erik Rombaut*.	 Amsterdam (The Netherlands). The blue-green network in the lobe-city of Amsterdam creates nice living conditions for people and has a good influence on city climate conditions (www.dro.amsterdam.nl)

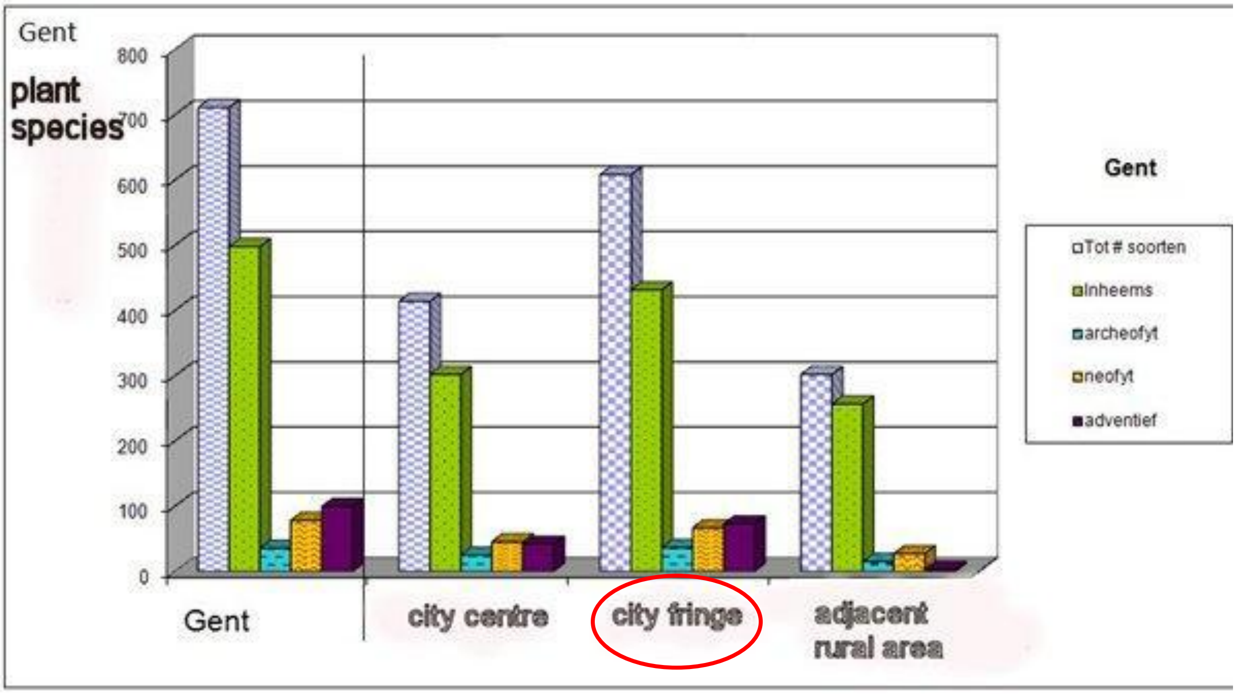
Figure 40: Problems of compact cities such as Athens cannot occur in lobe cities such as Amsterdam.

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 41; 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 42).

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.



City of Ghent (B)

Figure 41 : 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)

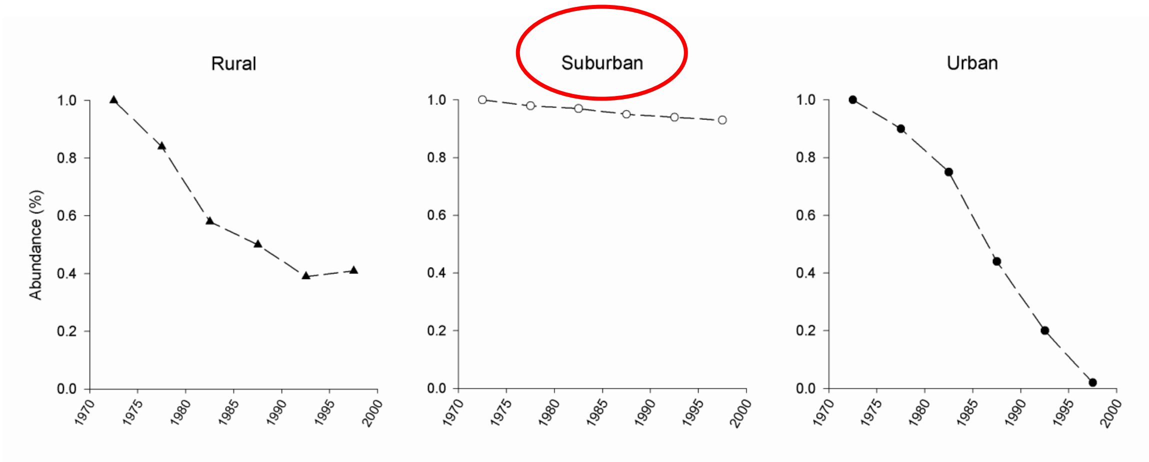


Figure 42 : Population trend of house sparrows (1970-2001) in some *urban* (London, Glasgow, Edinburgh, Dublin and Hamburg), *suburban* (Stockton, Crewkerne, Guisborough en Sandhurst college in Sussex) and *rural* (common bird census counts in England) areas in Europe

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 Figure 43).

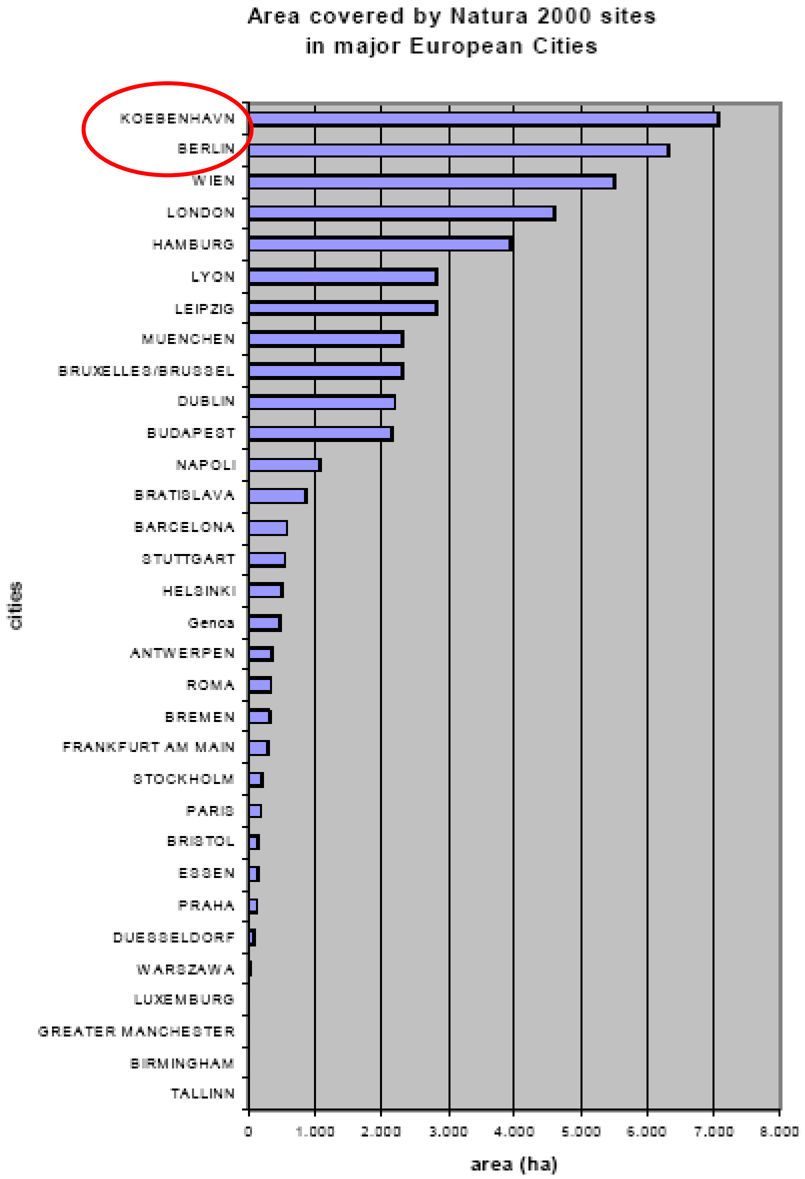


Figure 43 : The lobe-cities of Copenhagen and Berlin have the largest amount of urban Natura-2000 areas (from SUNDSETH & RAEYMAEKERS, 2006)

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).

5.3 Public-private gradient

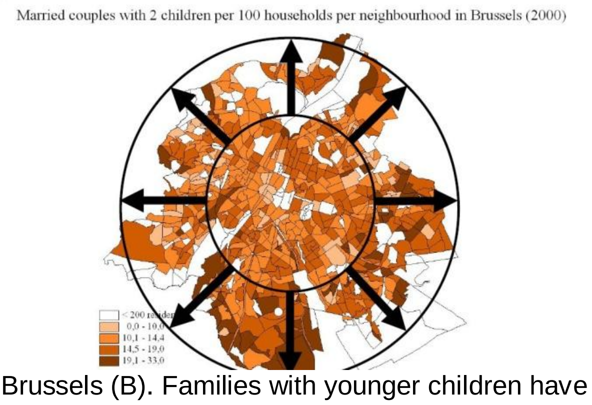
In this paper we emphasised that the design of a “semi-public common interior space” in residential neighbourhoods (through a judicious dosage of the public and the private) looks to be the **town planning key** and a good strategy for solving both ecological and social problems. We gave examples out of different European towns to illustrate the possibilities of such a public- private gradient in the green urban areas (gardens), between the buildings and even within the buildings.

Whether or not such an approach will strengthen the social diversity in towns depends, among other things, on the extent to which one resists the tendency to close these semi-public environments (that is, to privatise them) and to transform them into an urban eco-ghetto.

5.4 Restoring social diversity within a lobe-city context.

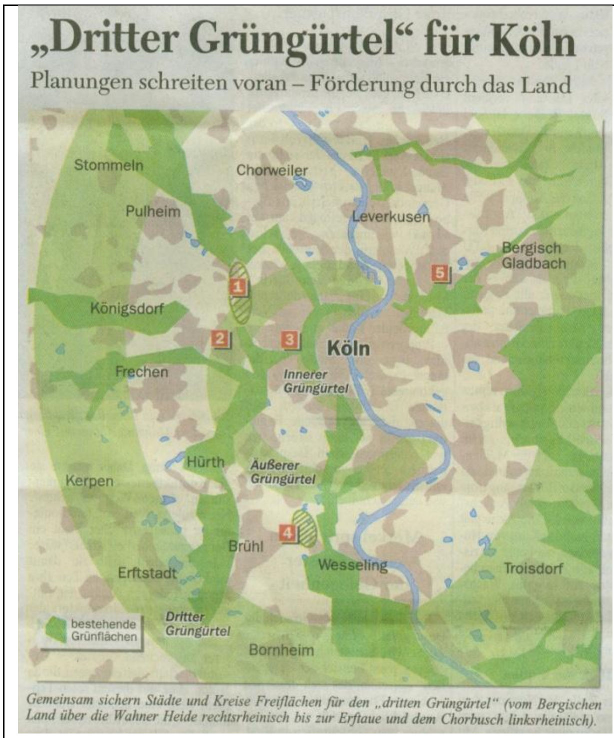
In this paper, we highlighted the statement that designing a lobe-city with a blue-green network within urban areas, can contribute to a healthy city-environment and can give residential zones an agreeable identity. The urban ecosystem is a living system, so very different conditions ought to be designed to attract social diversity (Figure 44) and to improve biodiversity.

In Europe a lot of cities lost a lot of inhabitants, moving to rural areas around cities. This exodus was due to a lack of green areas within the centre and also because of increasing mobility-related problems. Social workers should be aware of these planning tools (the lobe-city with blue-green networks) to attract people again towards the European city centres and to keep them there. A nice example is the ecoquarter *Västra Hamnen* in Malmö (Sweden). In that ecoquarter the municipality achieved the objective to get richer people and young families (with children) back to the city. The ecoquarter in Malmö became the ‘place to be’, and younger people, families with children came back from the surrounding rural areas. The taxes these richer families pay, are now re-invested in new more social eco-housing projects (project Flagghusen http://malmo.se/download/18.24a63bbe13e8ea7a3c6989c/1383643954411/The+Creative+Dialogue+Concerning+Flagghusen.pdf)



Brussels (B). Families with younger children have left the city centre towards the green outskirts (DE CORTE, 2005).

Malmö (Sweden). In the ecoquarter *Västra Hamnen* young families and richer people are re-attracted into the city. *Picture Erik Rombaut*



Köln (Germany). The blue-green network in the lobe-city of Köln (local newspaper Kölnner Stadt-Anzeiger 2 april 07).

Culemborg (The Netherlands). It's great, playing in the common garden in the semi-public parts of the Nesciohof in the ecoquarter EVALanxmeer.

Figure 44 : An ecopolis is attractive for different kind of people, also children feel good in blue-green networks.

Also for elderly people, the lobe city context is a better urban context to live in. That is because of the transit-oriented development and the attention for 'the urban advantages' which are lost in suburban mono-functional developments. Indeed, proximity of public transport, of all kinds of functions and of blue green areas is also an advantage for elderly people, often having mobility-difficulties.

Cities that do not follow anymore the old fashioned CIAM ideas of *Le Corbusier* 11) nor the car-based ideas of *Frank Lloyd Wright* (the broad acre city/suburban development, see boven) but cities that choose for a lobe-city based strategy, are able to restore both social diversity and biodiversity. This new urbanism is friendly for all kinds of organisms, plants, animals, and of course also people: it is both a child-friendly and elderly-friendly way of urbanism

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

6.1 *Building stones for an ecologically sound urbanisation*

6.1.1. 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.

6.1.2. 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).

6.1.3. 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.

6.1.4. 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.

6.1.5. 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**.

6.2 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 [13]. 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 a powerful tool to work with. Indeed, working and planning against nature is doomed to fail….

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

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