6 Diversifying function

6.1 Environmental diversity enables functioning

Safety and choice

Environmental diversity provides alternatives that allow one to survive *risks* and freedom of *choice*.
This section demonstrates how any function *requires* some environmental diversity.
The reverse, human functions and facilities, *cause* changes of environmental diversity.
The next sections of this chapter concern functional diversification in its own right.
The history of human specialisation is a history of diversifying functions (sections 6.2 - 6.3).
But, the resulting facilities do not cover all the conditions for human life (sections 6.4 - 6.5).
Diversifying facilities may diversify the environment again, the process where it all starts.

Diversity functioning at R = 10^6m

People, animals and plants would not survive in a totally homogeneous environment.
Imagine an equal distribution of two billion households of 4 persons at the surface of the Earth, equalised into a flat plane, without differences of altitude and temperature.
Any household, then, would possess ¼ km^2 of surface. But, it would be covered by nearly 3km of water, and 50m of that water would be ice. It is clear that nobody would survive at the bottom of this world-wide sea. What would you have to do as a designer to make the world liveable? You should introduce the first difference by dividing land and sea, as described in Genesis 9. Suppose you decide there must be 70% less surface to concentrate the water. This surface you call 'sea', and the remainder 'land'. Any household, then would possess 0.07km^2 , or 7ha, of land. But, it still would be covered with 50m of ice.
To store the ice at the poles, a second difference has to be added: a difference of temperature (Genesis 3). You are happy that there is a sun that the earth orbits around. Your planet circulates exactly at the right distance to provide water in different physical conditions, as ice, liquid and vapour. You are happy that the form of your planet provides different inclinations of sunlight, in order to make the required differences. If you keep the globe turning perpendicular to that direction in order to distribute the sunlight equally over the households every day, the resulting differences and changes of temperature will cause wind. Evaporation and precipitation would be distributed more equally through variations of temperature. To keep some water available on land subsequently requires some continental differences in altitude. Creating mountains and lakes provides local reservoirs of ice for long term storage, and fresh water that is used in the short term is distributed by rivers. Temperature and wind will be diversified more, by distributing the rain more randomly and equally for any household. I do not have to continue this thought experiment further to understand the function of environmental diversity at the largest relevant scale.

Diversity functioning at R = 10^{-6}m

At the smallest scale of life, the living cell shows an inconceivable amount of environmental diversity between its numerous membranes. The outer cell membrane enables rare physical-chemical processes to occur inside. They produce complex molecules and particles, which are assembled and partitioned in a sequence that would be very improbable outside the membrane. The particles move through numerous rooms, corridors and tubes. These environments have different concentrations of components, which are separated by membranes. These membranes protect each part of the assembly against concentrations of disturbing components. The membranes take part in the processes themselves. Movement is caused by a delicate storage and exchange of energy, and differences in electric potential and concentration.

Diversity functioning at intermediate scales

The diversity in the images of Boeke and Morrison[a] (10^{-18} -10^{26}m) seem to appear between 10^{-6} and 10^{6}m. If you take millimetres and kilometres as the boundaries of our normal visual reach ('grain' r = 10^{-3}m and 'frame' R = 10^{3}m), then this resolution counts 6 decimals. Bacteria and individual cells (r = 10^{-6}) go beyond our daily visual range. Your direct awareness of environmental diversity starts with grains of sand and small insects. In the open field, it ends at 5km distance (horizon). At 10km distance somebody 5km behind the horizon can appear. But your scope, your 'window of attention', is smaller. If you take a closer look at the ground or a wider look at the horizon, you may start to divide the scene into a central component and its adjacent components (see *Fig. 111*on page 173 and *Fig. 65* on page 102). This thesis takes this smallest factor, 3, (one central, two adjacent) to distinguish diversities at different levels of scale. The normal visual range then counts 14 levels of visually distinguishable diversity: R = {0.001, 0.003, … , 1000, 3000m}. In the centre of this range, our R = 1m body is a miracle of diversity, which is caused by the organised specialisation of organs and cells in an organism. The function of environmental diversity from the cell to the organism as a whole, does not have to be explained here. The artificial environments, and those at the larger scales R = {1m … 10 000km} *outside* organisms, exhibit much less diversity as a diversifying challenge for design. It is the domain of ecology, technology, economy, culture and management. Let me first elaborate on the ecological function of environmental diversity.

Artificial environments

Levelling the surface and water-supply for agricultural purposes, in favour of one useful crop species, causes the loss of other species, and an increased risk for the remaining one. Farmers will complain in periods of both too much or too little rain. Different altitudes would have given differences of wetness and a smaller, but a more reliable and resilient yield. The same counts for other variables, such as too much or too little sunlight, temperature or fertilizer. Nutritious soils benefit from fast growing species, which oust others. They push slower growing rare specialist species away. Poorer soils may produce less, but they mainly produce more different *kinds* of species in the long term. Popular crops may become prey to massive diseases. Biodiversity may contain a reservoir of genetic material to replace them or to restore their resistance (potatoes[b]). In the past decennia, ecologists have discovered a remarkable diversity of plant species in towns (see *Fig. 189* and *Fig. 190*). *Fig. 191* shows the kind of urban environmental diversity that is apparently appreciated by wild plant species. *Fig. 192* demonstrates that these species are not merely the most common species. The unexpectedly high biodiversity in towns can be explained by the many environmental variables that diversify potential habitats on a relatively small urban surface. It is, however not always clear why wild plants 'choose' a location. Ecology still cannot determine all locally responsible environmental variables and values relevant for every species or even specimen. That is why any environmental diversification may be useful.

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[a]Boeke(1957)*Cosmic View*(New York)John Day
Morrison;Eames(1982)*Powers of ten*(New York, Oxford)Scientific American Books, Inc.
[b] Haan(2009)*Potato diversity at height*(Wageningen)University PhD thesis

Technology

If the raw material required for any technology would be totally dispersed and mixed with any other material on Earth, then its extraction would be a great problem. Plants capture and synthesize hydrocarbons from CO_2 that is dispersed in the air. They do this job with sunlight and water, if the sub-soil provides the right conditions, such as minerals and support. Any plant or tree requires different conditions. These conditions determine the possibility of obtaining different biological products, such as food and wood, that can be processed by different kinds of technology. These differences enable exchange, trade and local economic or technological specialisations. The hydrocarbons left from previous biological production, such as coal, oil and gas, are concentrated at specific locations, and can be mined economically. The *concentration* of minerals in general is a great thermodynamic advantage that is offered by the geological diversity of the Earth. But, the current technology of production and consumption mainly results in the *de-concentration* of raw materials as mixed waste. Technology mainly equalises the environment, and adapts it to currently common needs, with some exceptions, such as built-up areas that provide more diverse environments R = {10 … 3000m}. Transportation technology has made techniques foot-lose, except if the raw materials are difficult to transport, such as building materials. The best technical means survive, and they are dispersed world wide through communication. The remaining diversification of techniques is caused by specialisation, which is possible at any location. But, if raw materials, such as phosphate or rare earth elements, become scarce, then export quotas and cartels may again cause the emergence of alternative local technologies that are based on more locally available materials.

Economy

Environmental diversity has caused different kinds of production using local resources. Countries, regions, towns and even neighbourhoods have been specialised in particular kinds of agricultural and industrial production and services. But, technology (transport, greenhouses) made them more dependent on differences in wages than on environments. In a world market, a locally one-sided economy is vulnerable to changes. Homogeneous ecosystems in general are at risk in changing conditions. Thus, the diversification of regional economies have become accepted as a common strategy to reduce risks. But, economic diversification is not easy if a local economy depends one-sidedly on the export of raw materials, and if a low level of education hampers the importation of alternative technologies. Ongoing industrialisation of agriculture and specialisation in cities have caused a flow of unemployed people into the cities and into more developed regions and countries. Environmental diversity may regain an impact on economic diversity through export quotas of rare materials and increasing wages. If developing regions obtain higher wages, then this comparative advantage disappears (e.g. China). The priority will change into luxury goods, cars, housing, environment and perhaps nature. If the price of energy drops through the dispersed application of solar energy, then ongoing computerization and the development of robotics, may decrease the impact of wages once more. The more the capacities of people are replaced by computers, the less manual and routine work can be employed, and the more specialised jobs are needed. Smaller, more specialised enterprises (allowing productive experiments) may have opportunities everywhere. Cultural differences of their environment and changing encounters may determine their success more than wages and physical resources. Pedestrian areas are rediscovered as opportunities for such encounters (e.g. Broadway, New York). City marketing may stress its identity through its economic specialisation, and its historical, cultural and environmental differences from other cities.

Ecology

Londo (1997)[a] considered diversity as a *risk-cover for life*. Life has survived many catastrophes in its evolution. Its diversity always has provided a species, or within a species a specimen, that has been able to survive in changing conditions. Survival of the *fittest* presupposes a diversity of species and environments from which a few 'fit'. Diminishing the diversity of habitats, then, undermines the resistance against catastrophes. From the 1.7 million species we know, we probably lost some 100 000, mainly because of the loss of fitting habitats. By doing so, we not only introduce ecological disasters, but we also undermine the resistance of life against disasters, such as climate change and epidemic diseases in homogeneous populations. The curve of *ecological tolerance* relates to the chance of survival of a species, a population or an ecosystem, in relation to any environmental variable, e.g. the presence of water. In that special case, survival can be ended through the water evaporating, or drowning (see Fig. 188). Imagine the bottom picture as a slope from high and dry into low and wet. Species A will survive best in its optimum. Therefore we see flourishing specimens on their optimum line of moisture (A). In the higher and lower areas, there are marginally growing specimens (a). The marginal specimens, however, are important for the survival of the species as a whole. In the case of long-lasting showers, the lower, too wet standing marginal specimens die, the flourishing specimens become marginal, but the high and dry standing marginal specimens start to flourish! Long-lasting dry weather has the same result in a reverse sense.

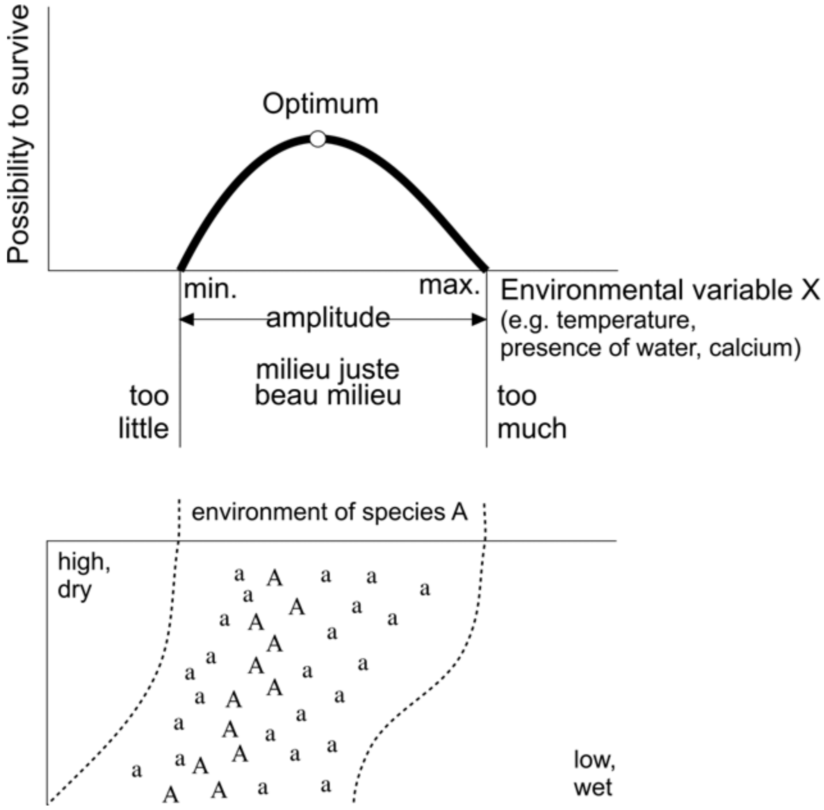
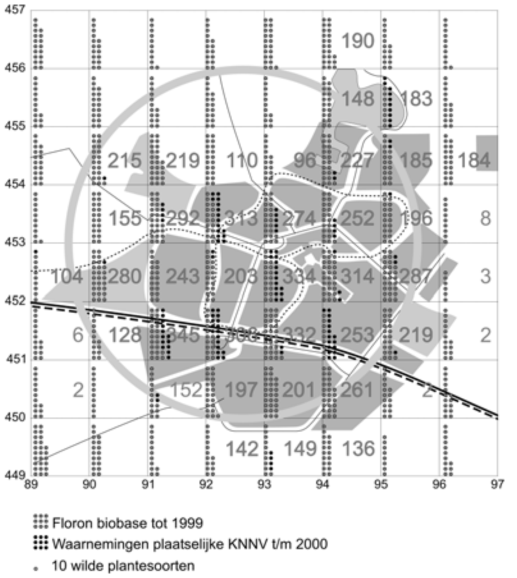


Fig. 188 *Ecological tolerance*

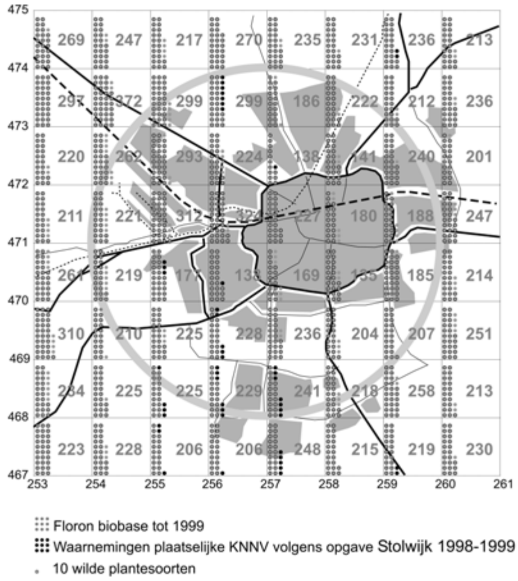
Differences of altitude offer every species an adjacent alternative to survive. Marginally surviving specimens take care of the survival of the species as a whole. A reservoir of unhealthy specimens, then, favours the survival of a species. The curve of ecological tolerance can be applied to many different variables other than the presence of water, at many levels of scale.

[a] Londo(1997) *Natuurontwikkeling* (Leiden) Backhuys Publishers



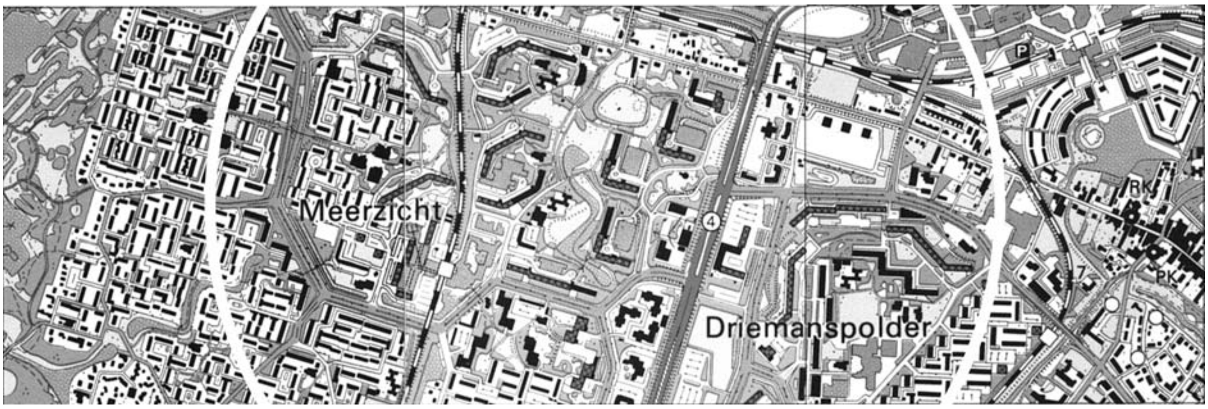
• = 10 wild plant species

Fig. 189 R=3km Zoetermeer 1999 More wild plant species than in its agricultural environment



• = 10 wild plant species

Fig. 190 R=3km Enschede 1999, the number is comparable to its forest environment



346 wild plant species 308 wild plant species 332 wild plant species

Fig. 191 R=1km Zoetermeer 1999 Number of species from the outskirts into the centre

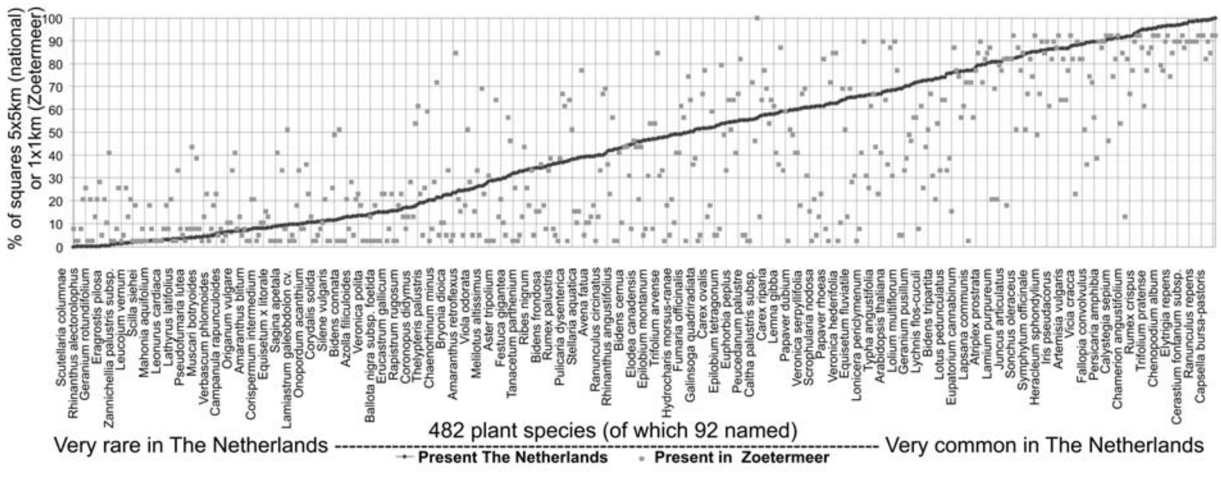


Fig. 192 National rareness of 500 urban plant species in Zoetermeer

Culture

Cultural differences within a city may be based on income (low-high), stage in the life cycle (young-old) and life style (e.g. consumers, careerists and familists, see page 139). Ethnic concentrations at R=300m may seem a problem in the beginning, but they appear to become attractive as an urban extension of the international economic network, or as a recreational destination. The quality of specific residential environments for different categories of people depends upon the scale of its internal familiarity and external contrast. Homogeneity of life style in a radius of R = 30m may give children at the age of 5 enough confidence to experience and explore differences in hygiene, nature, behaviour, possibilities to decide or to take initiative. A different kind of homogeneity at R = 100m may give children at the age of 10 the opportunity to explore other ways of life at R = 300m and cultures at R=1km (see *Fig. 19* on page 59). The composition of facilities of a district, a town or a conurbation (see *Fig. 205* on page 227) may represent a cultural diversity, which is emphasised by design and planning, and they are detailed at their boundaries. The kind of schools, shops and public space may be different. Repetition (r) and difference (d) may alternate at different levels of scale: the variety accord (see page 21) $d_{10m}r_{30m}d_{100m}r_{300m}d_{1km}$ will represent another urban environment than $r_{10m}d_{30m}r_{100m}d_{300m}r_{1km}$.

People need stimuli. Sensory deprivation[a] in space may cause a need for variation in time, and the reverse. The experience between too much and too little diversity should be balanced (see *Fig. 64* on page 102). Too much diversity can be reduced by selective attention, but too little diversity may cause boredom, and a search for adverse adventures. Busy people may choose simple interiors; people with boring work may choose an overload of ornaments at home. People in roaring times, such as the early Middle Ages, chose a simple Roman architecture; people living in the more quiet times that followed chose ornamented Gotic styles. The emerging money-economy, world-trade and the discovery of America introduced a more modest and recognisable Renaissance, which was followed by the exuberant Baroque period. This style compensated for the boredom of wealth. Classicism followed great revolutions, Jugendstil amused the new rich, and world wars introduced Modernism, which was followed by Postmodernism accepting more diversity. The main waves of culture alternate between tradition and and experiments.

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[a] Proshansky;Ittelson;Rivlin(1976) *Environmental Psychology 2nd Edition. People and his Physical Setting* (New York) Holt, Rinehart and Winston

Management and government

Mass production requires an efficient equality of minds and material. Innovation requires an ability to cope with a diversity of minds and possibilities. The management laws of mass production applied to teams with an innovative task may be productive, but they will mainly produce what can be expected. A management of production elaborates what is already known. It cannot go beyond the imagination of management, which is enclosed in its targets and regulations (Meno's paradox[a]). Innovation often hides in the details, the side-roads that open up landscapes that are not foreseen in any targets and regulations. It is often the product of individuals driven by curiosity beyond citations. You may conclude, that a laissez-faire style of management would be most appropriate for innovative teams, but that is not the case. On the contrary. A production management shaping the conditions for production even may have more periods of laissez-faire than innovation management. Innovation requires continuously and actively shaping new conditions and possibilities, and collecting new minds and resources. It requires a multitude of initiatives, but only a switch into production-mindedness if something is found that has market value. It requires the acceptance of many failures. Government, however, is a kind of management, taking care of conditions at a larger territorial scale and for a longer time span. Laissez-faire governments may produce environmental diversity at the smallest scales, but producing or protecting diversity at a larger scale requires initiatives, planning and design. Regulation by orders and prohibitions may produce homogeneity, but shaping conditions may produce diversity. Government is a scale-sensitive balance of laissez-faire and initiative. Different environments have resulted in different kinds of government, and the reverse. A diversity of environments avoids substantial risks. Applying different strategies of territorial development provides alternatives in changing conditions and exchange of experience. China accepted two Special Administrative Regions (Hong Kong and Macau), and several special economic zones. The territorial diversification of laws and treaties is usual in the task division of a nation, its states, provinces and municipalities. It is based on local tradition, culture, economy, technology and ecology. It exploits the possibilities of different social contexts and physical environments.

[a] Plato (380BC) *Laches Protagoras Meno Euthydemus* (Cambridge Massachusetts 2006) Harvard University Press Loeb Classical Library series page 299

6.2 Functions

Outward and inward functions

Dwellings, schools, energy plants and so on, are *structures* with a *function*, in a larger whole. They are called ‘functions’, but I name them ‘facilities’. ‘Function’ indicates their ‘working’. Facilities *have* a function, and this function is two-sided. It contains their *outward* effect or performance on a larger whole, and the *inward* effect of the larger structure, keeping them operational. This distinction between outward (bottom-up) and inward (top-down) function will prevent a confusion of tongues. Outward and inward functions require different approaches, such as counting outward profits for the whole or inward profits for the parts. The difference is comparable to the subject of study in micro- and macro-economics, but in technology and design you may meet that difference at any level of scale again. At any level again the parts have a function for a larger whole, and this whole has a function for its parts. Both functions include positive (eufunctional) *and* negative (dysfunctional) effects. An energy plant produces electricity for the human population, but it may have negative side effects on its environment. A municipality offers you infrastructure and protection for your business, but it also imposes restrictions and you have to pay taxes. Any outward supply meets inward demands and conditions. The larger spatial, ecological, technical, economic, cultural and organisational structure of a human population and its habitat conditions its facilities. This inward function enables and restricts *specialisation*. A human population divides its tasks between its facilities at different locations of its habitat. A municipality may decide to build an industrial estate. A population may change its tasks, in order to balance the supply of facilities. A school may obtain a different educational programme if the society changes its requirements. In the next section, I will elaborate the inward function first. But in practice, they develop simultaneously, reacting on each other in an alternating sequence.

A history of specialisation

Substantial specialisation began approximately 10 000 years ago due to the invention of agriculture (Neolithic Revolution). It bound former hunters and collectors to a location. The concept of defended property, labour and delay of benefit stabilised. The bond between people and their land led to the need for people to exchange goods. Agriculture soon resulted in a surplus production that could be exchanged between people. Beyond agriculture, the surplus enabled specialised crafts and trades with new techniques and products. The development of specialised techniques enabled the use of stone, bronze and iron. Central market settlements emerged. Tradesmen, captains of barges and soldiers could survive through trade and providing services, without growing their own crops and cattle. Their facilities replaced former domestic functions, such as production, education, health care, religion, jurisdiction or defence. Money (the delay of benefit) extended the market. Centralised power exacted by paid soldiers resulted in great empires concentrating the agricultural surplus in defended towns.

Capital, a replacement of human power

Natural energy sources replaced human and animal power in Holland (wind), in the United Kingdom (coal) and in the United States (petrol), successively in the 17^{th}, 18^{th} and 19^{th} century. Natural energy sources led to the centralisation and increased efficiency of production. The steam engine, improved by Watt, introduced the Industrial Revolution. This innovation was followed by the invention of the petrol engine by Benz. Industrial production ousted dispersed industry in villages and still autarkic farms with extended families in local communities. Rural people were forced to sell their labour to the growing industrial companies in rapidly growing towns. The development of know-how and science resulted in an explosion of new technologies and specialisations. Newly invented products changed consumption from largely driven by demand into substantially driven by supply. Companies may de-concentrate their activities, in order to come closer to the different consumer markets, but others may concentrate close to their resources, labour or suppliers.

The size and form of towns changing by function

The urban surface of cities did not only increase in regards to their increasing populations (see *Fig. 193* 1 and 2), but also through increasing prosperity (3), which required the development of more facilities. People began to use more and more space, while at the same time, urban density has become lower. *Fig. 193* shows both kinds of growth, roughly worked out, in Europe. The same process occurs in cities throughout the world.

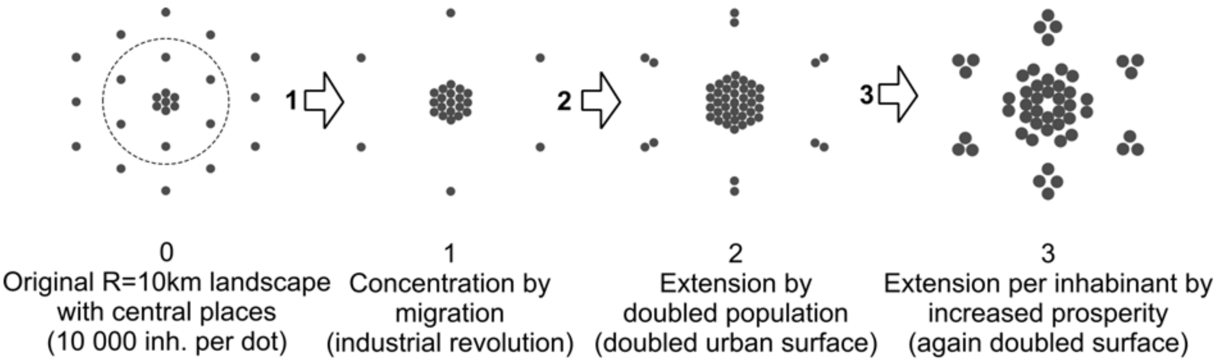
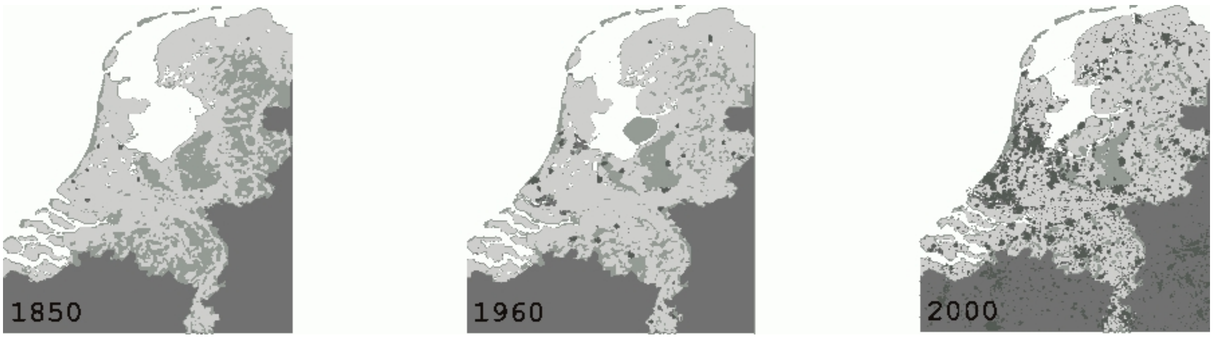


Fig. 193 Three processes increasing the urban surface *R=10km*

Fig. 194 shows two changes in the Netherlands: an increasing population migrating into the cities during the industrial revolution after 1850, and a growth of the economy after 1960. Both developments have substantially increased the urban surface within a century or two, but elsewhere this phenomenon occurs within a decade, threatening the economic balance between town and country.



3 million inhabitants 12 million inhabitants 16 million inhabitants

Fig. 194 The urban history of the Netherlands[a]

R=100km

[a] Based on images made by dr. Scheele(1988), University of Utrecht

For example, China struggles with a declining agriculture, and the threat of insufficient food production for the populations in its exploding cities (see *Fig. 195* - *Fig. 200*).

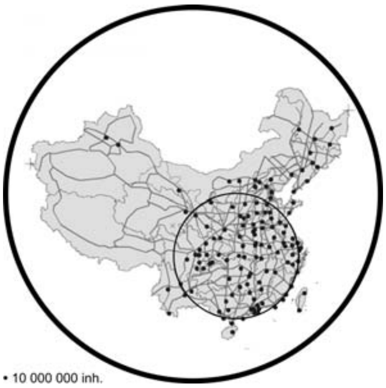


Fig. 195 China inhabitants[a]
R=3000km

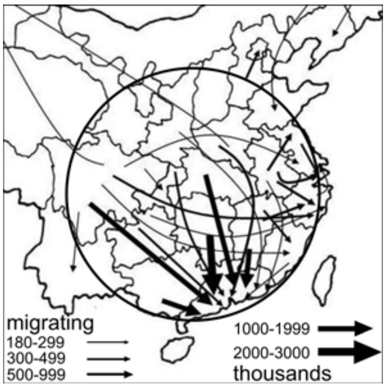


Fig. 196 Migrations 1995-2000[b]

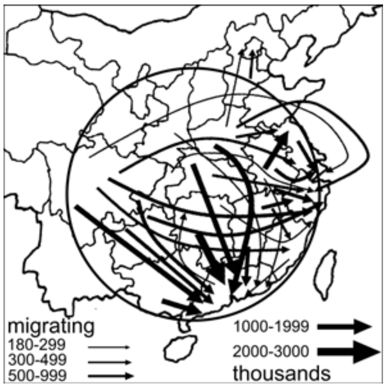


Fig. 197 ~ 2000-2005[b]
R=1000km

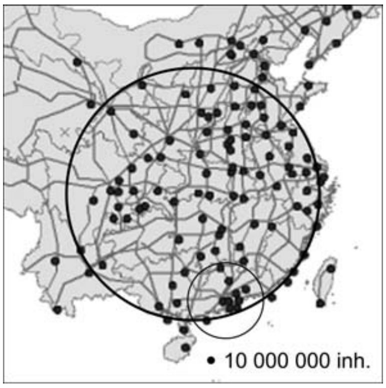


Fig. 198 R=1000km

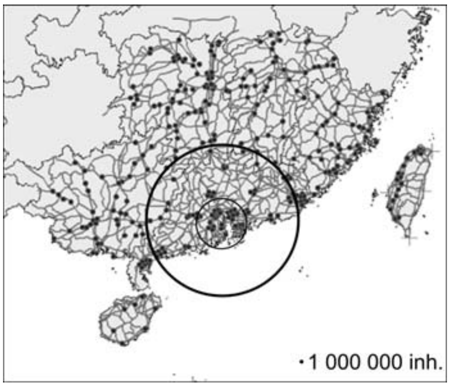


Fig. 199 R=300km

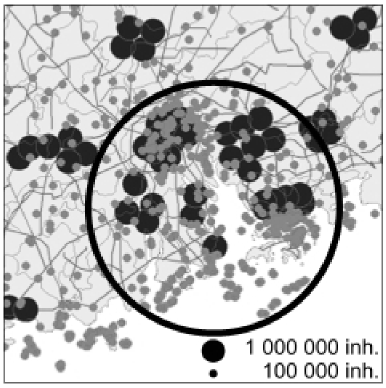


Fig. 200 R=100km

[a] Liang(2010)*Spatial Transformation Pearl River Delta*(Delft)TUD PhD report
[b] Chan(2008) *Internal labour migration In China. trends, geographical distribution and policies* (New York) Population Division, Department of Economic and Social Affairs, United Nations Secretariat

6.3 Inward functions

Ecological specialisation enables social organisation

Any population has a habitat, a dispersion in *space* with *ecological* connections, and a *technique* to exploit them. Human populations occupy different habitats. They may specialise in different techniques (harvesting, cattle breeding, fishing). Specialisation based on different techniques enables people to exchange their products at a market (an *economy*) to fulfil the needs they can no longer fulfil themselves. A market enables the emergence of shared suppositions (about other people, their products, their behaviour, their demand and expectations). The set of shared suppositions in a population is its *culture*. Culture disperses techniques of specialisations through education, and an awareness of a larger spatial, social and even religious whole, in which you are supposed to function. Specialisation makes you vulnerable if you cannot trust everybody in an enlarged society. It requires a common infrastructure with regulations that you cannot exact on your own. A set of shared suppositions enables an *administration* that registers and defends your rights, and takes care of requirements that you cannot buy yourself. 'Space-time', 'ecology', 'technology', 'economy', 'culture' and 'administration' as they are italicised above, are thus conditioned by people's specialisations.

Specialised facilities

Around the market square of old towns you may recognise 'economy', 'culture' and 'administration' as a '*trias urbanica*'[a] (see *Fig. 201*).
Towns may have their origin or specialisation in one of these three facilities.[b]

Specialisation	Urban facilities
Administration	castle, palace
Culture	church, cloister, schools
Economy	market, shops, small businesses, dwellings

Fig. 201 Trias urbanica in the Middle Ages

In modern towns, a further subdivision[c] is recognisable in their buildings (see *Fig. 202*).

	Specialisation	Urban facilities
Politics	legislative power	town hall
	legal/administrative	law court/government services
	executive power	police station, prisons, military facilities
Culture	religion/ ideology	churches, monuments, signs
	art/science	museums, institutes, libraries
	up-bringing/education	schools
Economy	Production	companies, offices
	Exchange	infrastructure, shops, banks
	Consumption	hospitals, leisure facilities, parks, dwellings

Fig. 202 Social and urban specialisation recognisable in modern towns

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[a] George(1964) *Précis de géographie urbaine* (Paris) Presses universitaires de France
George(1966) *Geografie van de grootstad, het probleem van de moderne urbanisatie* (Utrecht / Antwerpen) Het Spectrum
[b] Brugmans;Peters(1910) *Oud-Nederlandse steden 1 en 2* (Leiden) Sijthoff
http://team.bk.tudelft.nl/Publications/2012/Literatuur/Brugmans(1911)1.pdf
http://team.bk.tudelft.nl/Publications/2012/Literatuur/Brugmans(1911)2.pdf
[c] Jakubowski(1936) Der ideologische Ueberbau in der materialistischen Geschichtsauffassung (Danzig 1974)
Parsons(1966) Societies : evolutionary and comparative perspectives (Englewood Cliffs, N.J.) Prentice-Hall
Parsons;Toby(1977) The evolution of societies (Englewood Cliffs; London) Prentice-Hall
Montesquieu(1748) De l'esprit des lois (Geneve http://www.gutenberg.org/ebooks/27573) Barrillot

Inhabitants required per facility

From the approximately 300m^2 gross urban area per inhabitant in the Netherlands in 2000 A.D., one half were covered by facilities. Residential areas, including daily facilities, covered the other half.[a] For example, the urban surface of Amsterdam increased in regards to its population until 1960 (see *Fig. 203*), but afterwards it increased *per inhabitant* through an increase in prosperity (see *Fig. 204*).

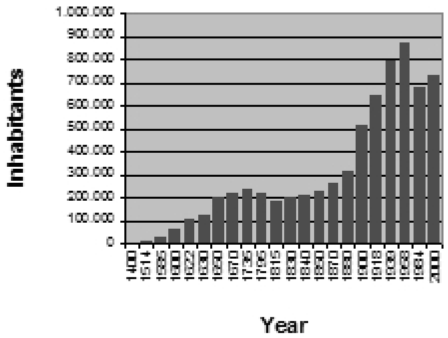

Fig. 203 Amsterdam population[b]

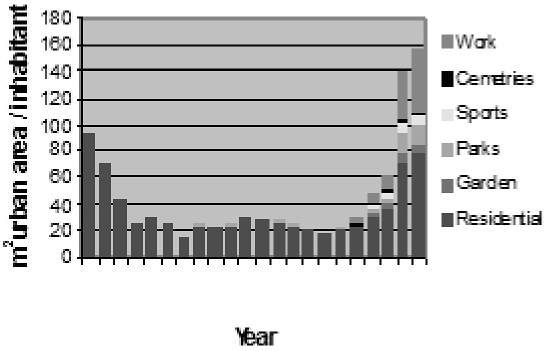

Fig. 204 Urban surface per inhabitant[a]

The development of technology and infrastructure enabled the concentration and de-concentration of specialised facilities. The number of inhabitants served by one facility mainly increased, but also sometimes decreased. For example, the 16 million inhabitants of the Netherlands in 2000 A.D. supported one national, 12 provincial, and approximately 500 municipal governments (in 2010 fast decreasing into 400). On average, there are approximately 16 million inhabitants served by the national government, 1.3 million inhabitants served by each provincial government, and 30 000 inhabitants served by each municipality. To obtain a rough impression of what kind of facilities you may expect in a neighbourhood (300-3000inh.), a district (3000-30 000inh.) and so on, you may calculate the average bearing surface for any facility. Simply divide the national number of inhabitants by the number of each facility (see *Fig. 205*). The distances named in *Fig. 205* are the nominal radiuses R within which you may expect these facilities.[c] You may check if you can find the named facilities in your neighbourhood, district and so on within the indicated radius.

Concentration at some levels of scale

Older figures with different, and thus incomparable, categorisations show discontinuities with accumulations at distinguishable levels of scale. The general categories in the left part of *Fig. 206* are specified into more specialised subcategories in the right part. For example, the general category ‘swimming pools’ (available for approximately every 20 000 inhabitants) in the left graph is subdivided in the right graph as ‘indoor swimming pools’ (50 000inh.), ‘outdoor swimming pools’ (60 000inh.) and ‘mixed swimming pools’ (70 000inh.)[d]. More general categories may be more useful to understand the spatial consequences than further specifications. The mutual differences between swimming pools are less relevant than the difference between swimming pools and shops. This example shows how categorisation may influence the image substantially.

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[a] http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=37105&D1=1-8,13-16&D2=0,2,7,9,l&D3=0,46,96&HDR=T&STB=G1,G2&VW=T

[b] Figures based on data in: Haupt;Berghauser Pont(2005) *Spacemate©the spacial logic of urban density* (Delft) Imprint: DUP Science

[c] The nominal radius is calculated assuming an urban land use of 300m^2/inhabitant, but this number varies. If 1000 inhabitants in the East of the Netherlands use 400m^2 and in the West 200m^2, then the real radius would be 350m and 250m respectively, but these distances still fit well within the tolerance of the nominal R=300m (see *Fig. 17* on page 52).

[d] 1/5 + 1/6 +1/7 ≈ 1/2

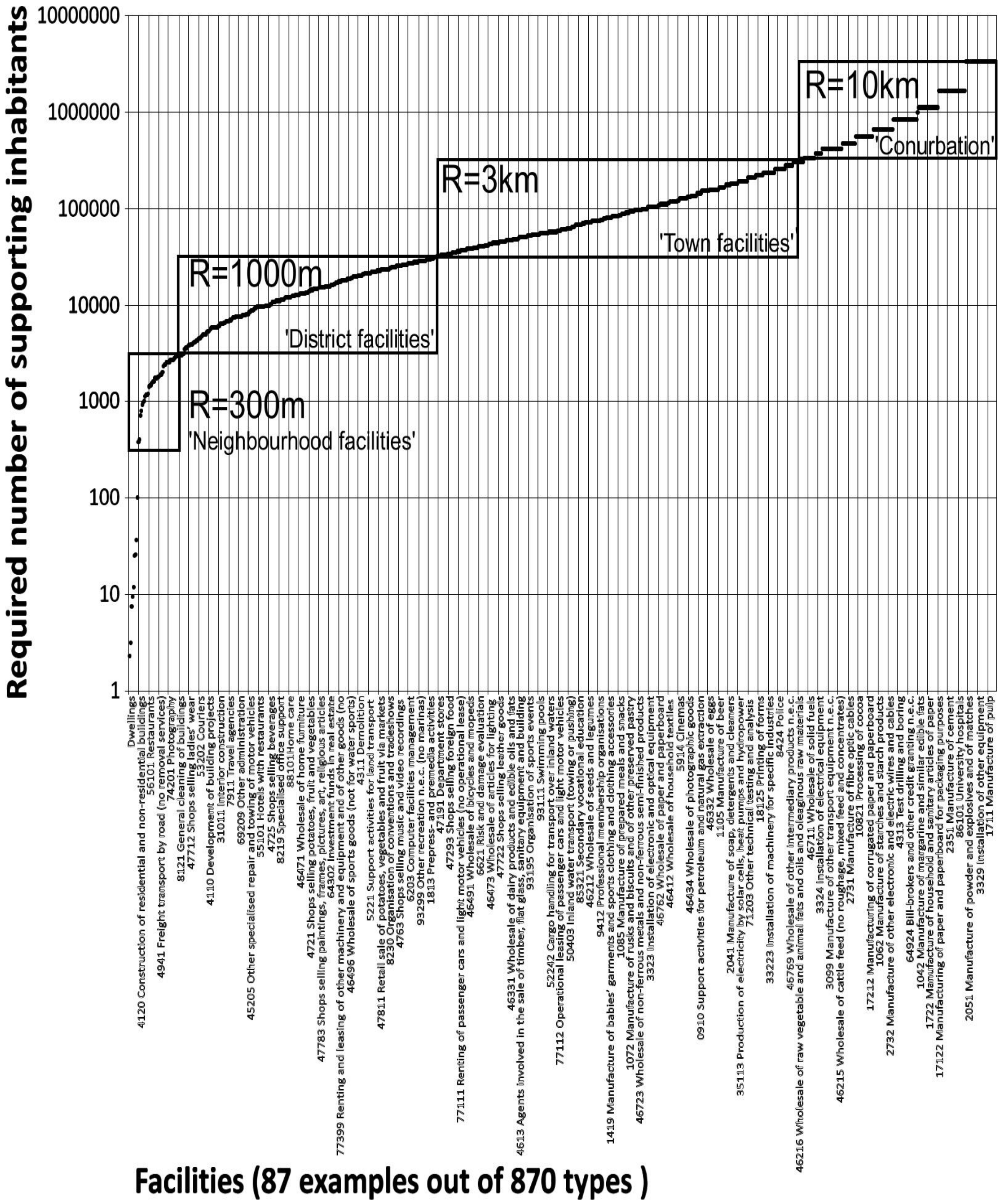

Fig. 205 The average number of inhabitants required for each of the 870 facilities distinguished[a]

[a] Most of these numbers were derived from the database of the Dutch Central Bureau of Statistics (CBS) in 2012. The ranking, however is very dynamic. It changes per year. The graph is intended only to give an impression. In the graph every thenth facility is named at the horizontal axis, the others are specified in http://team.bk.tudelft.nl/Publications/XLS/06aLiving.xls .

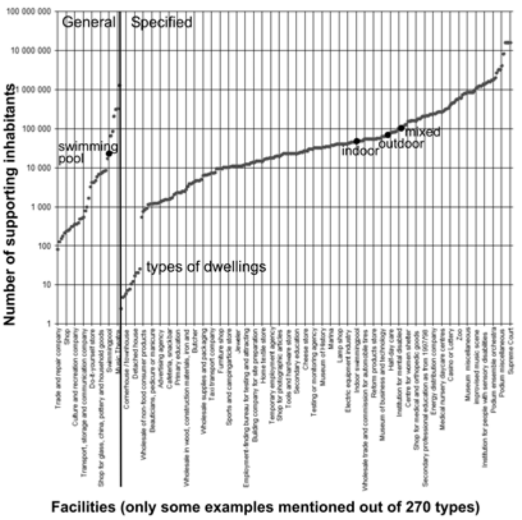

Fig. 206 National discontinuities 2000

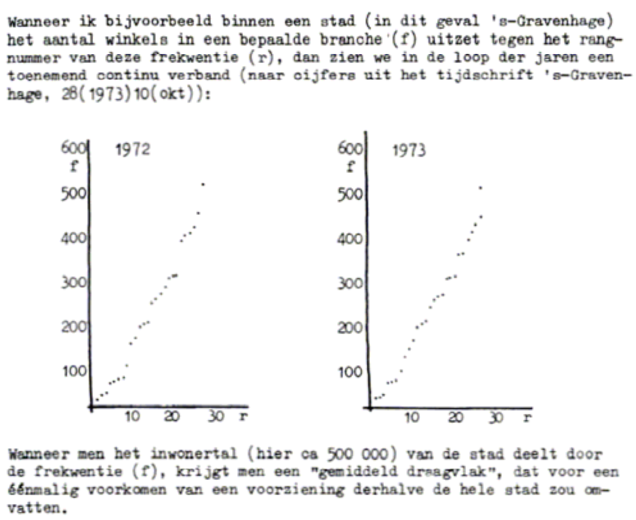

Fig. 207 Urban discontinuities 1973[a]

In my earlier thesis of 1978, I found a remarkable difference between 1972 and 1973 in the statistics of shops in The Hague. The frequency (f) of any kind of shop (r) from the 30 ranked categories in *Fig. 207* still showed accumulations around 100, 200, 300 and 400 of the same kind of shops in 1972. The Hague had approximately 500 000 inhabitants.
The accumulations in 1972 thus supported different combinations of approximately 5 kinds of shops for 5000, 2500, 1700 and 1250 inhabitants respectively. Between a neighbourhood~ and a district centre, each could have a different composition.
A year later, however, it had become more difficult to choose the right level to concentrate the shops. The largest gap in the graph appears at f=300 (500 000/300 ≈ 1700 inhabitants), apparently enough for 10 different kinds of shops in 1973.
In 2010 (see *Fig. 205*), a modern supermarket requires 3000 inhabitants.

A diversity of sizes

Both inhabitants and facilities require more and more floor space, private yards, gardens and public (parking) space. This results in sprawl, a larger distance between inhabitants and facilities, which is compensated by internet shopping. The floor space of dwellings is rather well monitored, but the surface requirements of facilities are very different per facility, and they change every year. Private advisors keep their precious knowledge behind, and it is difficult to obtain an overview. General categories such as parks, swimming pools and shops obviously require different classes of floor space, but their economic categorisation is not based on such a diverse and changing property such as size.

A diversity of forms

Suppose you have to design a shopping centre with 10 000m^2 business floor space (the size of a large district centre or a small town centre). There are two alternatives then: extended along a district road or compact in a covered shopping centre. Many parameters will determine your design[b], but in both cases the spatially most influential parameter appear to be the depth of the shops. Compared to the result with 10m deep shops (see *Fig. 208*), a solution with 20m deep shops (blue in *Fig. 209*) substantially reduces public space and walking distances (into the red parking spaces or the yellow stops of public transport). Shopping centres may become outdated by the internet, but building depth of residential areas or any other built-up area has the same impact.

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[a] Jong(1978) *Milieudifferentiatie; een fundamenteel onderzoek* (Delft) THD Bk Thesis
[b] See the downloadable interactive computer programme http://team.bk.tudelft.nl/Publications/XLS/06aLiving.xls .

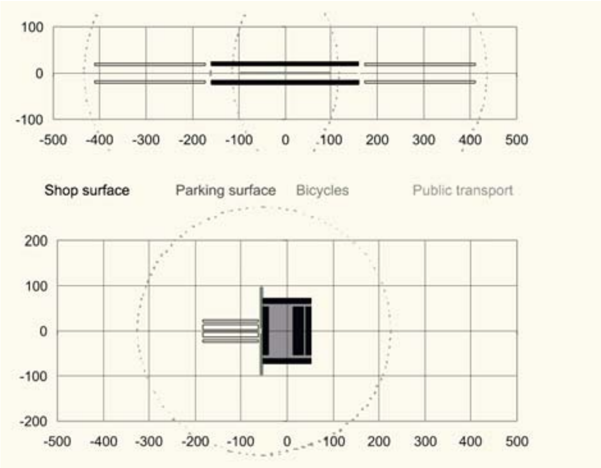

Fig. 208 10 000m² floor space 10m deep

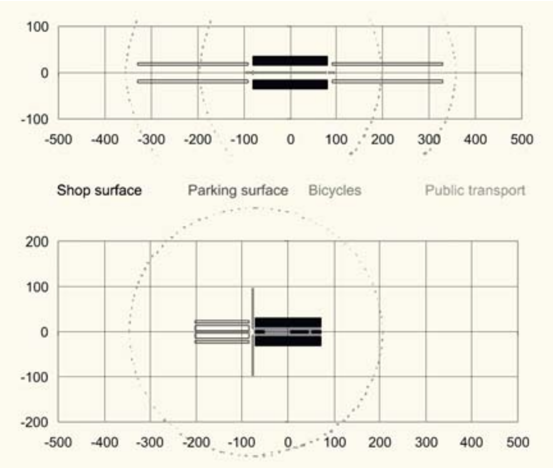

Fig. 209 10 000m² floor space 20m deep

Environmental effects

The problem of having sufficient parking spaces, however, remains a challenge anywhere, particularly if you choose to develop narrow and deep buildings in order to save public space. In *Fig. 208* and *Fig. 209* I have chosen for 1 parking lot per 15m^2 floor space for cars 5 x 2,4m (1600m parking length drawn red) and 1 cycle place 2 x 0,6m per 20m^2 business floor space (300m parking length drawn green). This is nearly a 2km road length for parking if it is not folded up into a building.
Around industrial or traffic facilities, you may avoid destinations that are vulnerable to noise, air pollution, smell nuisance and so on (outward zoning), or you may avoid facilities that are around vulnerable (residential) destinations (inward zoning). Both cost space, or reduce its use potential. Environmental effects affect the primary physical conditions of specialisation itself: space, time, ecological resources and the tools and techniques required to exploit them.

Space-time conditions of specialisation

The inward functions mentioned above are visible on a map as social facilities and buildings for government, culture and economy (see *Fig. 201* and *Fig. 202*). On page 225, however, space, ecology and technology have been mentioned also as conditions that facilitate specialisations. They may be less recognisable on the map, but if they are lacking they appear to be even more basic. If there is not enough space, if the resources are not available, or the technology is inappropriate, then any specialisation will fail. In general, separating functions (specialisation) seems to save time at the cost of space, while combining functions the other way around takes time but saves space. If you separate cooking and eating, separating your table into a kitchen unit and a dining table, then it will save time, but it will take more space. If you give walkers, cyclists and cars their own lane on the road, then it will take space, but it saves time (and even 'life time' if you take casualties into account). If arts and crafts move from residential areas into an industrial estate, then the increased efficiency of work saves time, but it requires space. There must be a relation between specialisation and our space-time budget, but the rule of saving time by specialisation at the cost of space suggested above is too simple on its own. A canteen in a company may *save* time, but that combination of functions within a building may *cost* space, *violating* the suggested rule. *According* to the rule, however, sharing a restaurant with other companies in the neighbourhood may cost time saving space. The way time and space are measured as lost or saved and the levels of scale involved must be determined deliberately, in order to obtain a valid ´space-time law´ of specialisation. I still have not succeeded in finding such a method, or a reference that describes it.

Ecological conditions of specialisation

Any population is ecologically connected to its habitat in different ways. The diversity of these connections and the diversity of the resulting resources may lead to different tasks. The other way around, specialisations may emerge if the same resource is used differently by different people. Both the diversity of people and the diversity of their habitat are ecological conditions for specialisation. If all people were the same, living in the same non-diversified habitat, having the same connection with their habitat, then there would be no specialisation. It would be either a world of extreme competition with survival of some accidentally fittest or a world of isolated individuals with no expectations from each other because nobody has to offer anything that anyone else may need. Fortunately, this is a frightening theoretical case, but it clearly demonstrates diversity as the core of ecology and ecology as a primary condition for specialisation beyond space and time. The next question then is, which *kind* of ecological diversity determines the inward diversity of functions within a population or its habitat? I will postpone the development of an answer to the philosophical question of whether you can speak about 'kinds of diversity' at all, until my next publication. It is a mind-bending question, because any categorisation you may propose, already supposes the differences between the categories chosen. The question, however, demonstrates that to explore diversity, any distinction between 'kinds of diversity' is fundamentally arbitrary, limited by the categorising nature of words and language themselves. Ecological conditions which enable the specialisation of populations and their habitat, are spatial or temporal. Temporal conditions are differences between seasons, day and night, the hours of the day and so on. These differences are called 'changes'. The *amount* of change may differ itself in space, but not the other way around. Time then supposes space, not the other way around. Space is the primary container of difference *including* change. It is filled with matter, energy and information and all of them may differ. Outdoor and indoor conditions differ in light, temperature and humidity, enabling different functions and specialisations. Land and sea, forests and meadows, urban and rural ecosystems enable different functions and specialisations. Many ecological variables enable the technical *possibilities* of function: sun, energy, wind, noise, water, earth and life, as well as people, can be considered environmental variables.

Technical conditions of specialisation

During 3 million years, the natural environment of the Earth has offered approximately 3 million people direct resources for all their human functions. Since approximately 10000 years, however, the world population has been increased nearly with a factor 3000 into the current population. There is no way back to ´Nature´. A population of the current 7 billion or the near future 9 billion people can no longer survive without a multitude of artificial tools and facilities. The current population requires tools enabling techniques of mass extraction, selection, transformation and assembly to survive. It requires transport facilities in order to collect the distributed products of these locally specialised techniques and to distribute them amongst the intermediate producers and final consumers (see *Fig. 178* on page 209). These are the technical conditions of any specialisation. Their application requires specialised skills and knowledge of these tools and techniques. The history of mankind cannot be understood without the under-laying history of its discoveries and inventions. There may be some animals that make tools, but the unique ability to overlook a larger sequence of actions, of which only the first can be done immediately and only the last will satisfy the actor (see page 15), enabled the human population to survive and grow to its current size. Its survival now depends upon exploiting the natural resources through the application of artificial tools and techniques in many parallel sequences by many specialists. Without the these technologies of production and transportation, the actual division of economic, cultural and managerial tasks would be unimaginable.

6.4 Outward functions

Going out and coming home

The dwelling, with its many kinds of use, is still the most multi-functional urban facility.
The archetype of a dwelling is the autarkic farm. In these farms, the different generations of an extended family were united in a common household for many millennia after the Neolithic Revolution. "The more isolated a system is, the more totipotential it must be."[a]
This household, however, gradually handed over more and more functions to the surrounding, increasingly specialising society.[b] Manufacturing tools, clothing and buildings could be farmed out in exchange with home-grown products, which saved time and increased production rates. Medical, religious and educational tasks were removed from the scope of home businesses, in order to be continued more efficiently in hospitals, churches and schools. Governments took over the tasks of defence and jurisdiction. Finally, even the major part of productive labour was replaced into locations outside the dwelling. The family household thus lost many integrated functions, and consequently its structure. It reduced the necessity of a certain size (say 30 people). The members of the family became hunters and collectors again, searching for personal fulfilment of more individual needs outside their home. This development of the household has had far-reaching consequences for the management, culture, economy, technology, ecology and use of space-time in an urban society. The transition into the modern family is experienced most radically by immigrants from rural societies into the city. Parents with an agricultural background must cope with children becoming hunters and collectors in an unfamiliar urban jungle.

Increasingly interfunctional activities

An economy with specialised functions requires a more formal organisation of activities than the prototypical autarkic farm. This community was operated through informal social control. It allowed the easy take over of diverse but relatively simple tasks, which were learned through daily practice from childhood onwards. Your tasks thus may gradually change according to your age, appearance, and changing capacities and talents. The activities in an extended cooperating family fulfilled personal needs and inclinations more directly, and were more often ‘functional on their own’, or ‘solo-functional’, as I will call them. Eating, sleeping, and leisure are examples of solofunctional activities that directly fulfil needs.
Paid employment requires more strict appointments than the task divisions in an extended family. An economy with advanced specialisations requires less autonomy and more written contracts for well-described, homogeneous performance, which are proven by educational certificates. Employment activities do not directly fulfil personal needs. These activities only make sense within a longer series of activities. Therefore, I will call them ´inter-functional´. Travelling or moving (if it does not have any leisure or sightseeing function) is a clear example of an interfunctional activity. The fulfilment of personal needs, the final reward, is substantially postponed through time consuming interfunctional activities that must be performed before attaining a reward. Money thus is the certificate of a postponed reward. The reward can then be chosen more freely later. This freedom of spending may compensate the lost kinds of former freedom.

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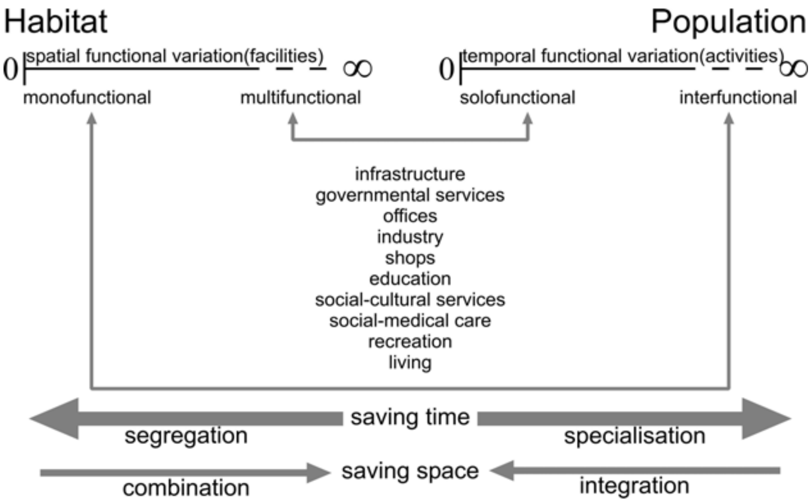
[a] Miller(1965) *Living systems* (Behavioral Science)10 p 193-237, 337-378, 380-411
[b] Mayntz(1955)*Die moderne Familie*(Stuttgart)Ferdinand Enke Verlag

Activities and facilities

Multi-functional facilities provide more possibilities for *solofunctional* activities than mono-functional facilities. *Mono-functional* facilities mainly facilitate *interfunctional* activities.
This may be interpreted as a negative relation between space and time (see *Fig. 210*).
The main stream of modern functional diversification (thick arrows in *Fig. 210*) is recognisable as a specialisation of the activities, and a segregation of the facilities where they take place. There are, however, also minor developments in the other direction. Sometimes, different activities are integrated and combined in more multi-functional facilities (thin arrows in *Fig. 210*). The development of information technology enabled more work, shopping, education, culture, care and leisure at home. If this development continues, then the residential environment may become more important.



	1970[a]	1970[b]	1970[c]	1983[d]	2000[c]
infrastructure	70	14	52	91	71
government	1	1		1	
offices	2	1		3	
industry	12	10	18	67	83
shops	6	2		2	
education	6	1		6	
cultural	5	4		8	10
care	3	2		4	
recreation	45	30		64	56
residential	60	145	145	137	139
	210	210	215	383	359

Fig. 210 Urban functional variation … *Fig. 211 .. m^2/inhabitant*

It is difficult to retrieve information concerning the surfaces involved. Changing categories of land use statistics in the Netherlands made them incomparable through the years
In addition, the distinguished categories are not very suitable to observe functional diversification. *Fig. 211* shows an increase of urban surface per inhabitant, but a substantial part of the counted industry and recreation may be located outside the urban area. The urban area/inhabitant thus may approach the earlier mentioned 300m^2.

Intensity of use

The hr/m^2 *intensity* of use of facilities may determine their profit, but it is difficult to determine. Dividing the hours spent for specific activities by the surfaces involved, delivers the intensity of ground use, but these data sets (if available) may be categorised differently. *Fig. 212* is my last (1986) attempt[d] to tune different categories of time and ground use. The resulting data are not very reliable, but if you give them some credit, the surface of shops appeared as most intensely used. It is remarkable that the surface in and around the dwellings are much less intensively used. Even if the figures of total time and surface are not very precise, the average intensity is low. If the average intensity is indeed 41hr/m^2 per year, then an average square meter in the Netherlands remains unused during the rest of the 8760 hours of the year. This may be an adequate explanation for the surprising observations of wild life in towns.

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[a] Angenot(1970) 1) Algemene planologie. 2) Sociogenese. 3) Stedelijke elementen. 4) Methoden en technieken 5) Verkeersonderzoek (Delft) THD

[b] Jong(1978)*Milieudifferentiatie*(Delft)THD PhD-thesis, redistributing some categories of Angenot (1970) as residential

[c] Figures of CBS http://statline.cbs.nl/StatWeb/selection/default.aspx?DM=SLNL&PA=37105&VW=T with a different categorisation and some categories not specified.

[d] NNAO(1986) *Ontspannen scenario* (Den Haag) MESO The sources of the report are destroyed by fire in 2008.

1983	hr/ inhabitant	m^2/ inhabitant	hr/ m^2
infrastructure	387	91	4
government	61	1	61
offices	51	3	17
industry	298	67	4
shops	238	2	119
education	374	6	62
cultural	539	8	67
care	77	4	19
recreation	198	64	3
residential	6526	137	48
total, average	**8749**	**383**	**41**
(agriculture	11	1667	0.01)

Fig. 212 Intensity of use[d]

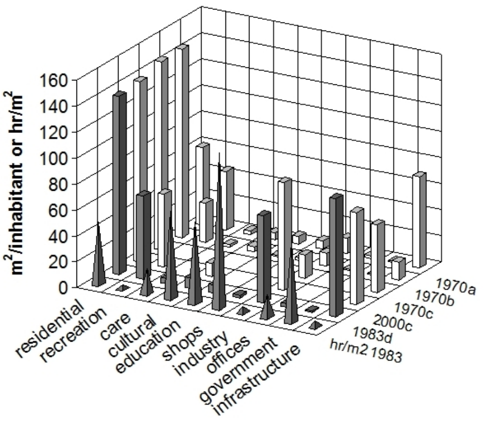

Fig. 213 Surface and intensity[abcd]

The Dutch paved public space counted ample 1100km^2 in 2010. If, on average, 16 million people are on the road half an hour per day, then every square meter is used less than 3 hr/year. If you suppose streets to be empty at night, then it still comes down to only one person in a 20m wide street of 100m length (2000m^2) at average per day. You do not expect such an emptiness, because you mainly visit busy streets at busy periods. This implies, that the other streets at other periods are even more empty than the average. The conclusion must be, that the locations where an adequate amount of visitors to support shops and other visitor-dependent facilities are limited and scarce.

The economic value of facilities

A low intensity of use does not always imply a low value. On the contrary, facilities such as recreation in *Fig. 212* (including parks and playing fields), may obtain their value by a low intensity. Shops, however, cannot pay back their investments without a high intensity of use. Internet shopping may reduce the intensity of use in specialised town shopping areas. Information and communication technology may reduce the use of offices and workplaces. Much work can be done at home through ICT.

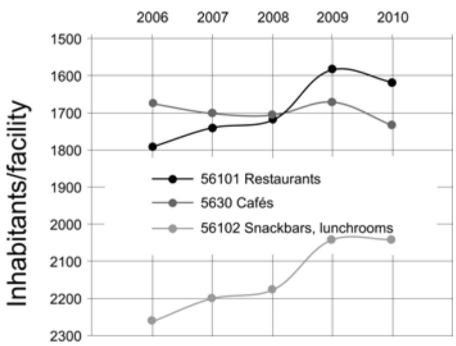

Fig. 214 R=300m increasing …

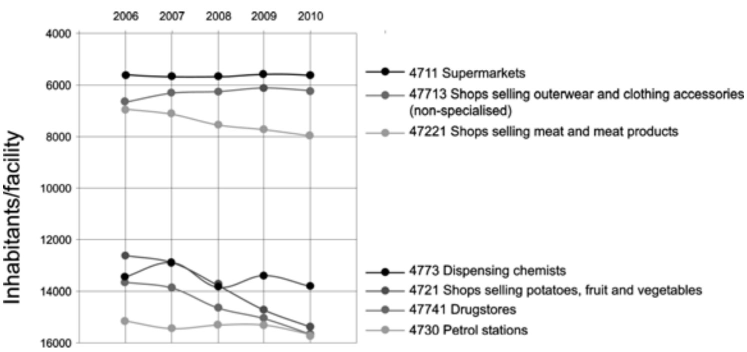

Fig. 215 … and R=1km decreasing support[e]

The residential environment and the neighbourhood then may become more important. Some facilities are returning to the home, saving time and increasing choice, but this phenomenon may also stimulate people to go out to dinner in the neighbourhood. The number of inhabitants required for the economic survival of a restaurant in the

[a] Angenot(1970)Collegediktaat stedelijke elementen(Delft)TH Bk
[b] Jong(1978)Milieudifferentiatie(Delft)TH PhD-thesis, redistributing some categories of Angenot (1970) as residential
[c] Figures of CBS http://statline.cbs.nl/StatWeb/selection/default.aspx?DM=SLNL&PA=37105&VW=T with a different categorisation and some categories not specified
[d] MESO(1986)Ontspannen scenario(Den Haag) NNAO The sources of the report are destroyed by fire in 2008
[e] http://www.cbs.nl

Netherlands recently decreased from 1800 into 1600 (neighbourhood level R=300m, see *Fig. 214*) in 4 years. Shops selling meat or vegetables and drug stores at the district level (R=1km) declined in the same period. They required thousands more of inhabitants to survive, probably due to competition with the supermarkets (see *Fig. 215*).
Bookshops and other specialised retail disappeared at the level of a town centre. They probably lost the competition with the internet. Specialised drugstores, greengrocer's shops and butchers may help district centres survive by attracting more potential visitors in town centres.

The ecological value of facilities

Money and payment cannot always determine the value of facilities and affordances in the long term. The carrying capacity of the Earth, our technology and economy may be imagined as tanks filled with liquids of decreasing specific gravity (see *Fig. 216*, comparable to *Fig. 45* on page 83). They will loose liquid (carrying capacity) if the upper tank becomes too heavy. The values of facilties are compared in a conditional sequence determing strategies of sustainability. A more fundamental and practical ecological comparison of natural and artificial structures may express their value in kilometres and years (see *Fig. 217*). The kilometres represent the distance into the next example (rarity), while the years express the time required to replace the structure (replaceability). The ecological value may be expressed by their product: rarity times replaceability. This method appeared to be convincing in order to evaluate urban plans ecologically in Almere[a]

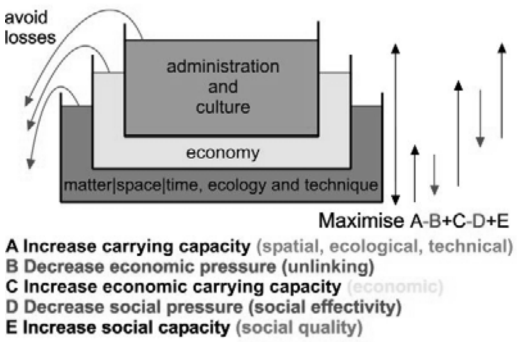

Fig. 216 Carrying capacity

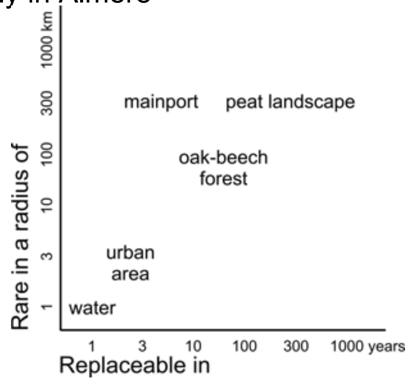

Fig. 217 Rarity and replaceability

The designer’s limited role in giving function

It is not the task of a designer to *determine* functions, but to make them *possible*. Paintings with a *determined* political, commercial or emotional function may become predictable kitsch. A piece of art should surprise, without losing sufficient possibilities of recognition. There should be more than one possible interpretation for it to remain surprising and recognisable for a long period of time. Spatial design creates conditions that give the users freedom of choice for a longer period than the first ownership. The means of spatial design select the *content*, *form* and *structure* of an environment. The *content* determines its possible differences and changes, including their zero-point of equality and continuity. *Form* determines the dispersion in space of their values, making separations and connections (structure) possible. *Structure* enables selection. Selection enables life and its economy, including human life. The history of living together has specialised society into spatial, ecological, technical, economic, cultural and managerial tasks. It is the inward functional diversification that is discussed in 6.3, from page 225 onwards. These tasks developed institutions at different levels of scale. Any spatial initiative should coordinate the intentions of many interested parties from this context.

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[a] Jong (2001) *Ecologische toetsing van drie visies op Almere Pampus* (Zoetermeer) MESO

Functions ⇓ facilities ⇓ supply ⇓ demand ⇓ needs ⇓ conditions

All accessible facilities together should be sufficient to live a satisfying life. The motivating physical, social and psychological needs, however, change. They cause changes in facilities that are supplied by the market, based on sufficient demand (e.g. those of *Fig. 214* and *Fig. 215*). A sufficient economic demand, however, still may not cover all individual human needs. Human needs become observable if *conditions* to live a satisfying life are not fulfilled. Some of them may be unnoticed by the *possibilities* of a spatial environment. Space and time are primary conditions to exist, but they are not sufficient to survive. Hunters and collectors survived in different ecosystems. Farmers survived in autarkic farms. Modern people survive in towns. These ecosystems, farms and towns, with their varying facilities, obviously contained all conditions to survive. But, were they sufficient to live a *satisfying* life? Conflicts and criminal behaviour are signs of dissatisfaction. The urban life may have gained satisfying conditions and lost other ones in spite of the supply by many facilities. If there would exist a checklist specifying all (partially silent) conditions for a satisfying human life, then the shortages of any residential environment could be distinguished by checking the list. The limited contribution of any facility could be counted. Their accessibility within any space-time budget could be determined. There are, however, different space-time budgets. Unemployed people may have enough time, but they may not have sufficient access to space in order to effectively utilise their time. Employed people may have enough access to space, but may not have sufficient time to utilise it. Even if you manage to balance these primary conditions of existence (space and time), then the stability of their balance may bother you. Even if you manage to safeguard that balance, then you may become bored or teased by a new dissatisfaction. Moderate dissatisfaction motivates, but too much negative conditions increases personal frustration. The checklist of conditions should not summarise everybody's actual outward functions, but rather, the *possibilities* of their fulfilment, and the *conditions* that make such functions *possible*. The sections below are an attempt to make such a checklist. It is necessarily an abstract exercise to be interpreted and elaborated differently in different cases. On the other hand, it should be concrete enough to be applicable. This section summarises the physical conditions that may be fulfilled by spatial design. The next sections will modify them in regards to the perspective of human needs. A further theoretical elaboration should be the subject of another publication.[a]

The condition of space

Without space, nothing can exist. Space is a crucial condition for any human function, but how much space is required in total to exist, to survive, to live a satisfactory life?
The surface of the Earth is an ample half a billion km^2. If you share it with 7 billion people, your part is at average $0.07km^2$, divided in approximately 5ha of sea, and 2ha of land. Your 0.2ha of agriculture is half luxury crops or cattle, and half crops that are crucial for survival, such as corn (see *Fig. 218*). The rest is nature, which is continuously declining by exploitation. When I was born, I 'had' twice as much space, and when I die these figures may be halved again. The green revolution amply doubled the production per ha, mainly through artificial manure, with phosphate as a crucial component. It is developed from a limited number of mines in Morocco and China. They will be exhausted in this century or the next. How many people may survive finally? What is their final spatial requirement? What is 'space' as an ecological condition? Is it the space required to exist, to survive or to live a satisfying life? Article 1 of UN Declaration of human rights of 1948 reads: 'All human beings are born free and equal in dignity and rights.' This immediately raises the question of freedom. 'Space' provides a freedom of choice, 'time' provides a freedom of action, but space and time are not equally distributed by birth, acquisition time and death.

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[a] Jong(1992) *Kleine methodologie voor ontwerpend onderzoek* (Meppel) Boom http://team.bk.tudelft.nl/Publications/1992/Jong(1992)Kleine%20methodologie%20voor%20ontwerpend%20onderzoek(Meppel)Boom.pdf

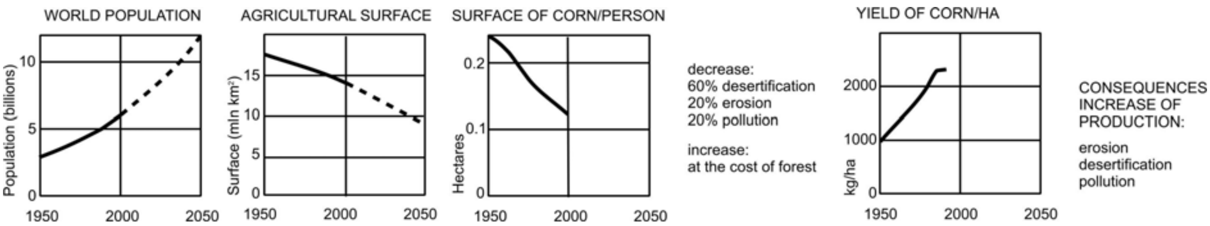

Fig. 218 Increasing population, decreasing agricultural surface, increasing productivity[a]

You may increase private property (e.g. land ownership) through personal effort, but is broadly accepted as inheritable, and any effort requires space and time. They are more or less inversely proportional. Less space (less freedom of choice) requires more effort, more time. In principle, public space safeguards the physical accessibility of facilities, which enables anybody to live a satisfying life. 'In principle', because there are other conditions that need to be fulfilled. It still does not solve the problem of an unequal distribution of time.

The condition of time

An interfunctional activity invests time to obtain a greater profit afterwards. Toolmaking, growing crops, learning to become a well-paid specialist, being employed, saving money, investing it, designing and planning, all postpone the reward, in order to increase it. Even money itself is a delay of reward. Money represents saved 'time' and 'space', freedom of action, and freedom of choice. You invest time now to obtain more later. Education, for example, is an interfunctional activity that promises a higher income the more you study. It places you in a dilemma, because spending time for education does not stop living costs, and you have to pay the teacher. You have to invest before you can harvest, but the yield is uncertain. You cannot decide whether a specialisation suits your talent before you have practiced it. The media feed your doubt by preferring to report exceptions, telling stories about millionaires without education. You have to balance unknown profits against the costs that increase with the time spent on studying. Most of the young people in the world need every minute for direct survival. They cannot invest anything. If they do not survive, then their time is over, nobody will hear anything about them anymore. Nobody will care. They are not the exceptions that are interesting enough for a newspaper. Time is unequally distributed, but even if you have time to invest, and space to choose your direction, then there are still many more conditions that need to be fulfilled.

The condition of content

The freedom to choose a direction (space), and to move (time), is a prerequisite for use. This freedom, however, is still useless in a space without content. You may be free to walk in any direction, but without water, food and many kinds of protection, you cannot survive. As soon as the interest of people goes beyond mere survival, the required content increases. Some of these facilities are mentioned in *Fig. 205*, but populations are different, and the requirements of future generations will be different from ours. Many resources are running out, which changes the kind of facilities we need. Approximately 1000 species become extinct every year. We do not know their function in the ecosystem we belong to. Only recently, our engineers attempted to imitate the biological performances and chemical processes they did not previously think to be possible (bio-mimicry), but nature still remains superior. For example, after the discovery of the Anamox bacteria[b], the nitrogen cycle appeared to be totally different from what we learned in high school. It is now used in industry to purify water, because it still performs cheaper than our imitations. We would not have been able to invent its process if it would have become extinct before we discovered it. Many of our medicines originate from the biological treasury.[c] We do not know what we lose.

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[a] Jong(1995) Doom scenario rough estimates
[b] http://en.wikipedia.org/wiki/Anammox
[c] Civian, Bernstein(2008) *Sustaining Life. How Human Health Depends upon Biodiversity*(Oxford) Oxford University Press

The natural answer to uncertainty and risk is diversity. The diversity of our human environment is limited compared to nature, and it causes an unprecedented mass-extinction. Some variables of *possible* diversity are summarised in Chapter 3, but it is still a poor list. From a viewpoint of risk reduction, any possibility to diversify the content of space should be utilised. At some locations in our cities, the number of wild plant species already exceeds 350/km^2 (more than in many nature reserves). Nature appears to discover and utilise a diversity we created unconsciously. Providing different locations with a different content provides 'identity' to any location. Even the police ask your name and address to determine who you are. It is the continuity of descent, and the difference of origin. Where you live is obviously part of who you are. If your home is exchangeable and anonymous, then you have to search for a unique identity through action, be it positive or negative.

The condition of form

Resources and facilities must be available within different spans of time: water, energy and protection every second, food, education, employment every day, other facilities every week, month or year. What you need every second should be everywhere, what you need every day should be available within a day, and so on. The available facilities are laid out at different distances. These distances determine the *form* of your environment. From the point where you are, the distances of the building materials of your house determine its form. Form is often primarily conceived as a visual property, but it is also a substantial condition for construction and use ('visual use' included). Form is the distribution of any content in space between total accumulation and total dispersion (see Chapter 4). Some content, such as air, must be totally dispersed to be useful, while other content, such as poisonous matter, should be concentrated and separated. It is easier to dissolve sugar in your coffee, than to get the dispersed sugar back in its originally concentrated form. This does not apply for sugar only. De-concentration is more probable and easier to achieve than concentration. Clearing up your room, is *concentrating* its different contents into different locations. Dispersing CO_2 in the air is easy, but to concentrate it is difficult. Against the main flow dictated by the laws of thermodynamics, plants collect CO_2 and concentrate it as hydrocarbons C_xH_y ,using the power of sunlight. It took millions of years to store hydrocarbon as coal, petrol or gas in the sub-soil, until humans dug it up and dispersed it into the air. Any economic activity, however, is a process containing phases of collecting and distributing some content (see *Fig. 179*). Any facility or household collects and distributes. Any artefact is a product of concentrated content with a distribution in space, a form. To use them, however, there is still a condition that needs to be fulfilled, the condition of structure. Structure stabilises a form, which keeps it useful.

The condition of structure

Any outward function requires access to facilities and protection against threats. It requires a structure operating selectively by connections and separations. Modern society and its habitat provide structure. It seems normal. You become aware of it in the case of war. Separations that protect you then may be destroyed, and connections may fail. You cannot expect them to be operational anymore. People with an experience of the state of war may appreciate structure more than those who do not. Chapter 5 has demonstrated polarities at any level of scale between 'open' and 'closed' environments. Going out is an example of leaving a closed environment, which selectively connects you with the required facilities, but it exposes you to risks from rain to robbery. At any level of scale, however, structure plays a role of stabilising useful distributions in space through connections and separations. No specialised facility or household may function without a stabilised network of connections with specialised and separated facilities. Specialisation requires organisation: separating different tasks at different locations, connecting them selectively, and avoiding disturbance.

6.5 Failing conditions as a challenge for design

More than physical requirements

Space, time, content, form and structure are physical conditions for human functioning. They successively enable freedom of choice and action, the availability of resources in time, their effective distribution in space, and they are stable enough to use them. Content, form and structure may be the direct object of design, but the physical conditions are taken for granted by the users as self-evident, as soon as they are realised. They do not directly answer the biological and conceptual needs that motivate their daily actions. They only make them possible. To include these human needs and to relate them more directly to the A-biotic ones you may provide as a designer, you can add Biological and Conceptual conditions to the checklist (ABC-model, see *Fig. 45* on page 83). This will put them in the perspective of human intentions (the subject of the next Chapter).

Human needs as lacking conditions

Maslow's theory of motivation[a] (see *Fig. 44* on page 83) does not even mention the a-biotic conditions separately. It takes them for granted in 'physiological needs'. Once they are fulfilled, needs for safety, affection, esteem and self-actualisation may follow in a sequence of 'prepotency'. This sequence is similar to the sequence in *Fig. 45* of a-biotic conditions (A) shaping the possibility of life (B), and enabling conceptual performance(C), but it hides A and B. It is also similar to the sequence of space-time, ecological, technical, economic, cultural and managerial conditions (see *Fig. 46* on page 83, utilised in section 6.3 from page 225 onward), but Maslow's sequence is more specific at an individual level.
Any of these distinctions show a 'conditional sequence', a sequence by which the next condition cannot be achieved before the preceding condition is fulfilled (at least to a certain extent). If one of the previous conditions is missing, the next cannot emerge. Conditions do not *cause* anything, they only make things *possible*. The other way around, the next condition *supposes* (⇓) the previous one. C ⇓ B ⇓ A ; self-actualisation ⇓ esteem ⇓ affection and so on; management ⇓ culture ⇓ economy and so on.
In the same way, the chapters of this thesis suppose each other: function ⇓ structure ⇓ form ⇓ content (see *Fig. 4* on page 18).

Biotic and conceptual conditions

According to Maslow, the last human need – 'self-actualisation' – supposes esteem. Maslow apparently cannot imagine 'self-actualisation' without 'esteem': the recognition of your achievements by others, and their respect or even admiration (prestige). It then supposes that you are dependent on their judgement to reach a state of 'self-actualisation'. Such a dependency I would rather call 'self-denial'. Prestige is a well-known biological function for survival by hierarchy in groups of wolves or apes, in order to command coherent behaviour in case of danger, through obedience. I accept the authority of authorities because they take care of the structure I need to function. To obtain esteem in a group is a very common human inclination, but it is not typically human. It belongs to the biological layer between a-biotic and conceptual conditions for a satisfying life. If 'esteem' becomes part of the competition between individuals, then the winner would obtain the most satisfying life, and a majority of losers would not. Stimulating ambition in this majority is using the most common biological inclination of competition to stimulate their effort in maintaining the existing structure. What, then, are the *conceptual* conditions, not being a part of the conditions known from biology, but so typically human?

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[a] Maslow(1943) *A theory of human motivation* (Psychological Review 50)50 p 370 - 396

Conceptual conditions

I cannot imagine a satisfying human life without a satisfying self-image. A satisfying self-image is the reflexive concept of a unique individual, free to choose and to act in sufficient space and time. A subsequent human life is satisfying, if this freedom can be actualised by some influence in the environment that mirrors the individual, and confirms his/her self-concept. The uniqueness is part of a broader concept of 'identity' (*difference* from the rest and continuity in itself). Where Erikson[a] emphasised its biological roots, I would like to distinguish its conceptual upper layer first. The human identity develops by alternating inward and outward functions known as identification and projection. Birth separates mother and child by the parturition (*partus*). If you would have had any concept of that event at all, it must have been a change from being part of an all-embracing body without much sensory diversification or orientation, into an environment full of differences between cold and warm, light and dark, satisfying and unsatisfying. The continuous satisfaction, then, should have caused a state of unconscousness comparable to sleep. Only a dissatisfaction after birth may have motivated you into a consciousness and imagination separated from the unsatisfactory reality and into expression and action. It must have taken some time before you might have recognised something in the 'tableau mouvant', as Piaget[b] called the chaos of impressions you have been exposed to after birth. It is very probable that the first object you have recognised, has been your mother as a unique source of satisfaction between all appearing and disappearing objects. This uncertain world should have raised a feeling of unsafety. Her warm embrace and feeding reunited you, reminding you of your prenatal stage. Satisfaction is the biological root of affection. Its conceptual component is primarily the concept, or non-concept, of *unity*. The *awareness* of unity cannot emerge without an experience of separation. A disturbed unity, however, can be restored conceptually by identification and projection. Identifying yourself with your mother, your father or the other objects, replaces the kind of unity you miss (in-dividuality means un-dividedness). Imitating them incorporates their presence in absence. Projecting your desires and imagination upon them may disappoint, if they still do not supply what you want. The failing unity increases the awareness of separation and difference from the rest, and forms the very beginning of identity. The function of identification and projection is recognisable in the history of art as impressionism and expressionism. If projection disappoints, then you may express your desires and imagination in words and drawings. Mastering language through imitation is another way to restore a unity conceptually. The conceptual basis of this process, however, is the availability of surprising impressions with some repetition enabling recognition. Beauty is the balance between surprise and recognition, in order to avoid passing the limits into chaos and boredom (see *Fig. 6* on page 21). Boredom is killing. Babies in homogeneous environments without any difference or change die[c]. Experiments on sensory deprivation of adults lead to hallucinations[d]. At the other hand, chaos without any possibility of recognition cannot produce a conceptual ability to separate and incorporate an image from your environment. These kinds of dissatisfaction urge you to outward involvement and influence in order to obtain your own order of recognition and surprise. This personal order can be expressed in an extended territory for projection and identification. *Fig. 219* summarises the inference above in 5 key words, representing conceptual requirements in a conditional sequence.

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[a] Erikson(1968) *Identity youth and crisis* (New York) Norton

[b] Piaget;Inhelder(1947) *La representation de l'espace chez l'enfant* (Paris) Presses universitaire de France

[c] Spitz(1945) Hospitalism: An inquiry into the genesis of psychiatric conditions in early childhood **IN** Psychoanalytic Study of the Child. Vol 1 (New York) International Universities Press p53-74

[d] Vernon(1963) Inside the black room, studies of sensory deprivation (London) Penguin

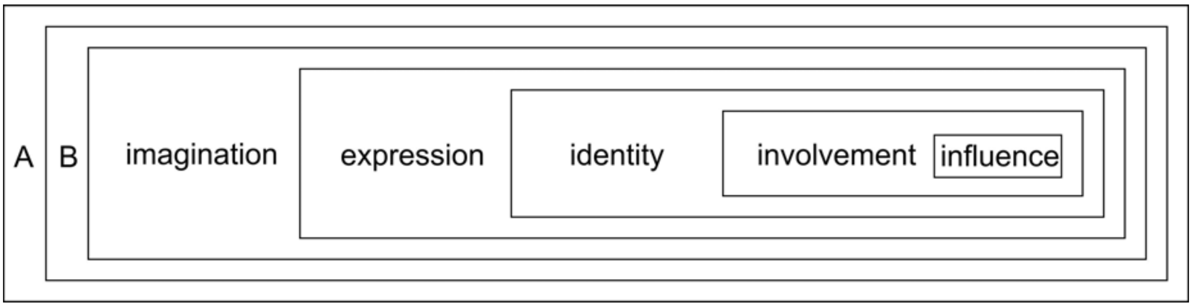

Fig. 219 Conceptual conditions

You can choose other key words, but I avoided the emotional load of terms such as surprise, recognition, affection, esteem and self-realisation stemming from the biological layer (B) to be elaborated in the next paragraph, on its turn supposing the a-biotic layer (A). You can add many more conditions in between, but I restricted myself to the 5 derived from Maslow's categorisation, cleared from its biotic components.

The concept of 'concept'

One of the remaining questions is the concept of ´concept´ itself. If a conceptual ability is supposed to distinguish humans from the other animals and conceptual conditions (C) from biological ones (B), what, then, is its definition? In this thesis it is defined as ´the image of a sequence of actions, taken together with their conditions´[a] A tool making ape may also foresee a sequence of actions, but it is a small range compared to the many interfunctional actions a human can foresee postponing the final reward. The size of the range may matter, but this ability covers any other criterion. The often presented criterion of tool making or language supposes imagining a sequence of operations or words. Ethics supposes an ability to foresee the consequences of what you do. Task division supposes you can imagine a sequence of different actions, and so on. 'Con-cept' thus is precisely what it means in Latin: 'taken together'.

Biotic conditions

Fig. 220 summarises in advance what I will explain below. A-biotic conditions (A) are supposed in the conditions of life, finally enabling the conceptual conditions (C).
I chose these 5 key words from the many imaginable biotic conditions making life possible, because they represent the many others and they show a relation with *Fig. 219*.

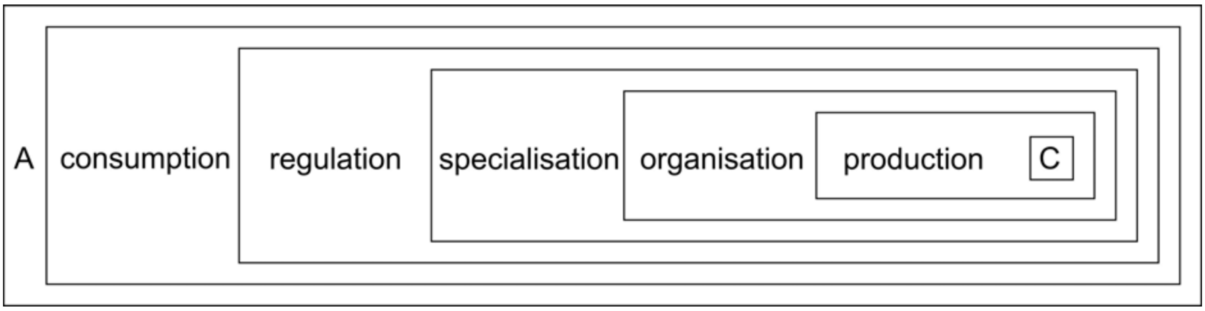

Fig. 220 Biotic conditions

Reproduction is often taken as the primary criterion of life, but then a mule would not 'live'. It is an animal not able to reproduce itself, but it is still a product of sexual reproduction. It is not *possible* without biotic production as a condition. Moreover, it is an animal with organs organised in an organism, the under-laying criterion of life. The term 'organisation' is mainly

[a] Harrison;Weiner;Tanner;Barnicot(1964) *Human Biology* (Oxford) The Clarendon Press, stresses the 'foreseen sequence of actions', but I introduced 'image' of which the origin is usually referring to 'imitation'. However, I would rather refer to 'in-machina', (internal tool).

used in a human context, but it is essentially biotic. On its turn it supposes the *specialisation* of organs. In ecology, specialised species are not ‘organised’ as organs in an organism. You therefore can imagine specialisation without organisation, but you cannot imagine organisation without specialisation. This inference is the ‘conditional test’ I use to determine any conditional sequence. It is the way I tested many pairs of categories. Specialisation is the core of functional diversification, and regulation is its under-laying condition. Different plant species are specialised to survive in different climates and on different soils. In ecology, rare plant species are particularly found on poor grounds. They must regulate their consumption very carefully to survive. In a hot and dry climate, they save water. On acid grounds, some of them compensate for their lack of nitrogen by catching insects. In any species, however, numerous regulating mechanisms compose complex chemical compounds travelling through changing environments, thereby decomposing other compositions bit by bit successively, delivering the required matter and energy at different locations. The required regulations are stored in genes and distributed by messengers, much like they are stored in procedures and distributed by people in a human society. Regulation supposes consumption of matter, minerals, energy and information that is selected from an environment. Selection, however, is not an exclusively biotic phenomenon. It is an a-biotic condition for life, which makes selective consumption possible in different environments. This makes environmental diversity into a crucial a-biotic condition. The biotic conditions of *Fig. 220* are a checklist for economy or sustainability. Where does our exploitation of the Earth fail? Is the consumption, its regulation, task division, organisation or a kind of (re)production disturbed? Designers search for new, improbable physical possibilities to utilise space, thereby increasing the diversity of its a-biotic conditions: content, form and structure.
Chapter 3 elaborated on the *content* of space, by summarising legend units and values that may vary in space and time, and then by categorising them as variables.
Chapter 4 studied the possibilities of their distribution in space and their *form*, which is limited by the extremes of total accumulation and total dispersion.
Chapter 5 studied the possibilities to stabilise their form through separations and connections, or its *structure*.
This Chapter searches the limits of use and the boundary conditions of possible *functions*.

A-biotic conditions

The possibilities of life (including human life) are limited by physical conditions, such as available space, time and matter.

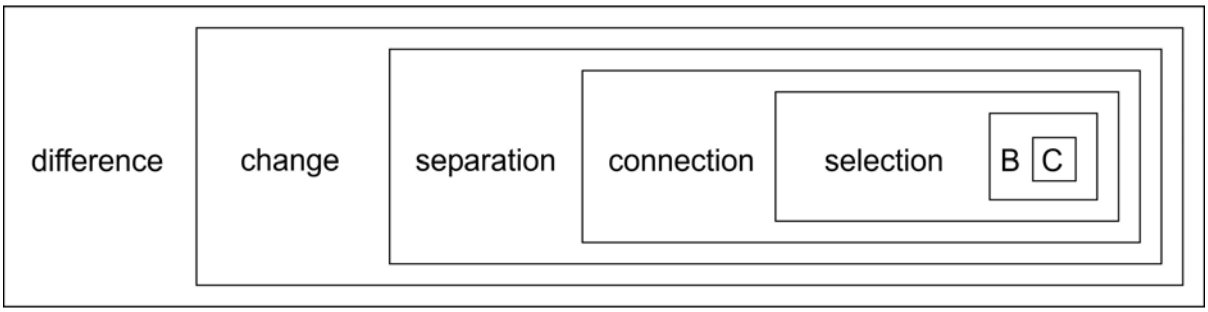

Fig. 221 A-biotic conditions

Section 6.4 studied space, time, content, form and structure as the conditions of use. This categorisation may be useful for design, but these categories are not directly connected to our experiences, needs, choices and actions. For example, the concepts of space and time are constructions of the mind that you cannot immediately explain to a child. You have to refer to their more direct appearance as *difference* and *change*, in order to develop such abstract concepts. The Newtonian concepts of space, time and mass are intended to compare, and to measure *after* such experiences. Even our concept of form is not as obvious as it looks. It supposes different distances between parts distributed in space. Distances, however, are not obvious either, without any motoric experience of movement, or change of position.[a] Distance is primarily experienced as *separation*. For a baby, there must be only two distances: what you can grasp and what you cannot grasp. Movement adds an awareness of more distances, by referring to the effort it takes to reach what you see. But, the primary experience is separation. However, separation includes more than distance. There are separations hampering movement itself, such as solid objects, fences and walls. They increase the initial separation by distance, forcing you to make detours. To translate the abstract design concepts of space, time, content, form and structure into categories of direct human experience and needs, I chose other boundaries to categorise the same conditions in *Fig. 221*. Space and time cannot be experienced and understood without differences and changes of some content. Form, which can be considered as dispersion in space, cannot be experienced and understood without an experience of distance, which is a kind of separation. Connections such as arteries, roads, tunnels, doors and windows overcome distances, or break through material obstacles, such as solid objects, fences and walls: separations. They suppose some kind of separation that must be overcome, or they suppose separations perpendicular to the direction of connection, in order to steer movements in the right direction (see *Fig. 8* on page 29). Selection thus supposes 'connecting separately'. Selection is crucial for any biotic (B) phenomenon, including human functioning (C).

Some repetition in the ABC sequence

Fig. 222 summarises successive conditions as they are delineated above.
Difference is the first condition, because any next condition supposes some difference. You cannot imagine any next a-biotic, biotic or conceptual condition without *some* fulfilment of this primary condition. It does not suppose an extreme amount of difference, but an optimum in between too much and too little difference (see *Fig. 6* on page 16 or *Fig. 64* on page 102).

	1	2	3	4	5
A A-biotic	difference	change	separation	connection	selection
B Biotic	consumption	regulation	specialisation	organisation	production
C Conceptual	imagination	expression	identity	involvement	influence

Fig. 222 A checklist of conditions

The first condition of a next row directly supposes the last condition of the preceding row. A conceptual imagination tacitly supposes a biotic organism producing it. Biotic consumption supposes a-biotic selection. Conditions cannot be expressed in words, without this context of sequence. The conditional sequence may shift the usual meaning of the chosen key words into the direction of what they actually should cover as a condition. 'Consumption' may have a meaning that is slightly different from usual, if it is conditionally located here between selection and regulation. Consumption, in its economic sense of 'use', is necessary to make any regulation of this use possible. How could you regulate anything if nothing comes in? If you select something from your plate and eat it, this consumption is a condition for regulation. If you take regulation as a change through feedback, then there is an initial 'feeding' supposed in the concept of regulation. You may be satisfied by eating for a while, and even talk a little instead of eating. To cover 'feeding', I took 'consumption' as a better key word than 'use', but I still doubt if I chose the right key words.

[a] Held;Hein(1963) *Movement-produced stimulation in the development of visually guided behavior* (Journal of Comparative and Physiological Psychology) 56 5 p 872-876

Conditional tests
The boundaries of conditions can be chosen in many ways, and many more conditions could have been distinguished. But, this categorisation provided rows with a comparable sequence, producing columns as a second possibility in *Fig. 222*, in order to determine the meaning of the chosen key words. In a former publication[a], I supposed organisation as a condition for specialisation, and in the conceptual layer, I consequently supposed ‘affection’ as a condition for ‘autonomy’ according to Maslow, but I am now convinced that it is the other way around. I cannot imagine affection without autonomy, but I can imagine autonomy without affection. A conditional test forces you to sharpen your definitions. What did I include in the term ‘affection’, imagining it without autonomy, and what do I exclude now, *not* being able to imagine it without autonomy? It is the kind of ‘forced affection’, known from cases of hostage. After some days, the hostage begins to show ‘affection’ for the kidnapper. This kind of affection surprises psychologists, but I would not call it affection anymore. It is the consequence of losing autonomy, falling back in a non-conceptual biotic state of mere survival, through surrender and subjection as an unborn baby without identity, as being part of another organism. The organisation is changed by the most simple specialisations of ‘slave’ and ‘master’. Your biotic reaction of mindless obedience has no name, and you call it ‘affection’. It is the same affection without involvement that also appears in populations under absolute and merciless dictatorship

Vertical equivalence
If there is a comparable sequence in the rows, then there also should be some relation between the words in a column of *Fig. 222*, but what kind of relation is it, more than the already existing conditional relation? Is it a relation of equivalence? Could you imagine ‘consumption’ as a biotic equivalent of an a-biotic ‘difference’? Is ‘imagination’ a conceptual equivalent of biotic ‘consumption’? Both questions raised by column 1 may be answered, if you interpret ‘consumption’ as ‘impression’ in its literal sense, as imprint, a thin boundary between the consumer and the consumed, the primary difference. Imagination, then, may be a product of the mind that is equivalent to this impression.

Expressions
Subsequently, expressing an imagination may be interpreted as a transformation, equivalent to change and regulation in column 2 and regulating the consumed. Words change the diversity of your imagination into regulated standard expressions. They equalise your impressions, faded by selective memory. Perhaps any change reduces differences, as Van Leeuwen observed in ecology (see *Fig. 10* on page 36). The equivalent of change in the conceptual layer, however, may also produce something new. Expressing your ideas in a drawing may change them, producing new imaginations through the feedback of what you expressed. This interaction with your expressions is a well-known primary process in design. One of your designs is your identity, by the way.

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[a] Jong(1992)***Kleine** methodologie voor ontwerpend onderzoek*(Meppel)Boom

Checking possible functions

This checklist cannot be used to check the presence of usual facilities. It may suggest unusual facilities, if you interpret these abstract key words with some additional imagination. It can be used to investigate which absent conditions may identify the human needs that are unfulfilled. Some of these recognised needs raise a sufficient demand to evoke a supply. (see page 233). Others do not. They even may be not be recognised. They may insidiously spread as hidden dissatisfactions that are replaced by using insufficient facilities. The less vitamins your food contains, the more you need. The less stimuli your environment provides, the more false alternatives you will try. Our body, and its senses, have been developed in the rain forest during some 3 000 000 years. It supplied an inconceivable diversity of visual impressions, sounds, smells and challenges. It provided sufficient difference, change, separation, connection, selection, consumption, regulation, specialisation, organisation, production, imagination, expression, identity, involvement, influence. How does the urban jungle perform, compared to this prototypical environment? Our genes developed in this environment, and they did not change much in the past 10 000 years. Our environment did. Substantial specialisation created homogeneous environments that required repeating interfunctional actions between 8 and 17 o'clock. For many people (probably not the rare readers of this thesis), these hours are both boring and stressful. These experiences must be compensated for after work through a sudden change from public functioning into private seclusion in the home. There, looking for connections with family, television, internet, telephone or outdoors, a kind of indecisiveness may emerge. These possibilities do not allow anything *in between*, where you can hesitate. Aldo Van Eyck criticised modern architecture for its lack of 'in between realms':

> '*Bird's nest and bird's flight and bird.*
> Take off your shoes and walk along the beach through the ocean's last thin sheet of water gliding landwards and seawards. You feel reconciled in a way you would not feel if there were a forced dialogue between you and either one or the other of these great phenomena. For here, in between land and ocean – in this in between realm, something happens to you that is quite different from the seaman's alternating nostalgia. No landward yearning from the sea, no seaward yearning from the land. No yearning for the alternative – no escape from one into the other. Now there is nothing wrong with the seaman, as long as we realize that he is always wanting to go home both ways.'[a]

Why could you not *sit* in a door, enjoying both the inside and the outside of your home.
Why not postpone your decision to connect or to separate?
The simple experience of a walk in a diverse environment is a continuous exercise of separation and connection, leaving behind what you passed, and exploring what is in front of you. Such experiences of give and take exercise the art of selection.

[a] Eyck;Parin;Morgenthaler(1968) *Ecology in Design / Kaleidoscope of the mind / Miracle of Moderation / Image of Ourselves* (Via 1) p 129