6 Living, human density and environment

Contents

6.1 Adaptation and Accommodation

6.1.1 Human population

Adaptation and accomodation

This chapter deals with the adaptation of the human species to its habitat (adaptation), and the adjustment of the human habitat to the species (accommodation, technique)[49].
The unmatched growth of human population is due to its faculty of toolmaking and consequently, its accomodating capacity. That accomodating capacity happens to be the object of architecture and urban design.

Architecture and urban design as a part of ecology

So, the chapter approaches architecture and urban design as a part of aut-ecology, necessary to understand the distribution and abundance of this particular species and its remarkable artefacts on Global, European, national, regional and local levels. Syn-ecologically it is interesting to see how this species recently developed into a plague, ousting other species and changing the environment (environmental ecology). From a viewpoint of systems ecology its potential to survive on any level of scale in space and time could be studied, taking global resources into account. Cybernetic ecology could prove helpful for design and chaos ecology for management.

History as a laboratory

However, this chapter starts with a historical approach, because history is a kind of laboratory unveiling suppositions of our existence we are inclined to forget.

Anthropogenesis

For millions of years, human characteristics have been tuned to the natural environment in which people had to survive (adaptation). Therefore, it is useful to acquaint oneself with this ‘reference’ environment as such, and, now and then, to allow this nature to be the tutor of architectural (and mechanical engineering) forms. Even in the most advanced studies into the development of autonomous robots, the mechanics of insects are attentively observed. Also in the other development that is thought to be important for the future — biotechnology — nature is often ‘the tutor of art’ (‘Natura Artis Magistra’).

Human habitat

In the history of human origins (anthropogenesis)[a] , human adaptation and environmental determination have played a major role.
Approximately 6 million years ago, due to climatic and environmental changes in Africa, *Homo habilis* exchanged a forest habitat for savanna.[50] Approximately 2 million years ago, *Homo erectus* developed from this animal. In turn, different human-like animals developed from this creature and later became extinct. Fifty thousand years ago only two of these species remained, the Neandertalers and *Homo sapiens sapiens.* The Neandertalers became extinct at this time, leaving *Homo sapiens sapiens* as the sole survivor. For approximately 1 million years, this species’ use of tools has served as a criterium to demarcate humanity: the capacity to oversee a series of acts of which only the first (e.g. the making of tools) can be carried out immediately.[51]

Arboral adaptations?

The origins of the human race, preceding *Homo habilis*, has produced a large number of ergonomically interesting ‘aboreal pre-adaptations’ (adaptations to the former forest environment), such as the ability to grasp with the hands, stereoscopic vision, upright posture, the production of a limited number of offspring at each pregnancy, a lengthy up-bringing of the offspring, etc.[52] The tropical rain forest is then by no means as frightening as is it is made out to be. It is a fantastic experience to cut a path for oneself through this twilit environment: it feels as though one is returning home after 6 million years. All the senses are stimulated in a changing, yet balanced, way. One can

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[a] De opvattingen over de antropogenese zijn jaar in jaar uit sterk in beweging. De hier uitééngezette opvatting is ontleend aan het wat oudere maar voor ons doel vrij volledige boek van Harrison, G. A., J. S. Weiner, et al. (1964) Human Biology (Oxford) The Clarendon PressHarrison, G. A., J. S. Weiner, et al. (1970) Biologie van de mens (Utrecht/Antwerpen) Het Spectrum N.V..

seldom see further than 100 metres ahead and is constantly obliged to focus the eyes on objects both nearby and further away. Moreover, it is an environment similar to a Gothic cathedral: full of vertical light-seeking pilasters, in which, occasionally, the sun festively forces its way to the bottom. This demands continuous attentiveness, but, on the other hand, the senses seldom become overloaded.[53]

Savanna adaptations?

In this century, we are witnessing the clearance of the last primitive forest peoples and their culture and habitat. Nevertheless, a cultural-ecological study of these communities that are so closely linked with our reference environment could be of importance for future urban design.
The transition from forest dwelling to life on the flat savanna lands must have made the eyes lazy, but the hands and the head more diligent. It is particularly these border environments where people seek cover and where they build their own protective shelters.

6.1.2 Habitat, density and economy

With the help of technical resources, the human species nowadays can maintain and organise itself to suit its own wishes in every biotope (accommodation). In general, such accommodation results in pioneer, grassland and brushwood vegetations. Sometimes, mankind changes the dominance relationships in the landscape to such an extent that, in places, the old situation remains protected (nature conservation) or new successions are allowed to come into being (nature development).

Habitat and density

Different populations live in different densities (Fig. 816)[54].

HABITAT	% total land area on earth	% total world population	inhabitants per km^2
Dry lands and deserts	18	4	10
Tropical forest/ shrub crops	15	28	60
Grassland areas	21	12	20
Semi-forested areas	7	39	190
Mediterranean shrub overgrowth	1	4	130
Temperate to cold area	10	1	3
Arctic/tundra area	16	<1	1
Living area in the mountains	12	12	30

Harrison, Weiner et al. (1964); Harrison, Weiner et al. (1970)

Fig. 816 *Population densities in different habitats 1970*

Habitat and economy

Each habitat has resulted in different forms of household management (Fig. 817).

	Food-gatherers	Hunters	Pastorales	Nomads	Simple cultivators	Advanced cultivators
Equatorial forests	Siamang	Pygmies, Melanesians			Amazone, Nw.-Guinea	Indonesia, Java
Tropical forest and scrub	Grand Chaco indians	the Bantu	the Bemba		Indo-Dravidians, South Americans	Bantus
Tropical grasslands (savannahs)	Australoids	Hadza (East Africa)	Nilotes		North American Indians	Hamites
Drylands and deserts	Bushmen and Australians			Bedouins, Tuaregs	Oasis dwellers	Oases (riverine)
Temperate forests	Australians, Mesolithic Europeans	Tasmanians, Predmost	Iron Age Europeans		Chinese	Peasant Chinese
Mediterranean scrub	Strand lopers	Californian Indians	Balkans	Berbers	Neolithic Iron Age, Maori	Medieval Europe
Temperate Grasslands	Paleolithic Europeans		Mongols	*boerjaten,* mongols	Siouan Indians	Pawnee indians
Boreal	Fuegians	Samoyeds		Lapps		
TUNDRA		Eskimos		Lapps		

Harrison, Weiner et al. (1964, 1977 p 398) Harrison, Weiner et al. (1970)

Fig. 817 *Habitats, economies and cultures*

From this it appears that there is no simple relation between habitat and household management, as believed by physical determinists at the end of the last century.(Claval, 1976). However, there is some relation between household management and population density (Fig. 818)[55].

Density and economy

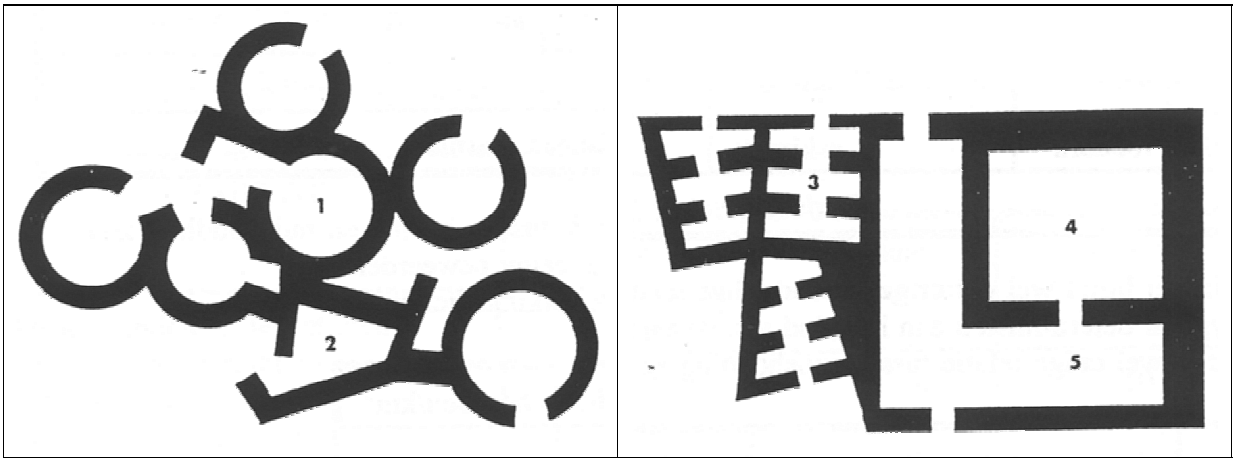
POPULATION	km^2 per head	heads per km²	for 100 people	
			km radius	nominally
Food gatherers				
Upper Palaeolithic (Eng.)	500	0,002	126	100
Australian aborigines	60	0,017	44	30
Tierra del Fuego islanders	20	0,05	25	30
Andamen Islanders	1	1	6	10
Developed hunters/fishermen				
Eskimos and Indians	500	0,002	126	100
Eskimos (Alaska)	80	0,0125	50	30
Mesolithic man (Eng.)	25	0,04	28	30
Pampas Indians	5	0,2	13	10
British Columbians	0,1	10	2	3
Arable farmers and nomads				
Neolithic man (Eng.)	1	1	5,6	10
Pastoralists and nomads	0,25	4	2,8	3
	0,03	33	1,0	1
Iron Age man (Eng.)	0,25	4	2,8	3
Middle Ages (Eng.)	0,05	20	1,3	1
Middle Age man	0,02	50	0,8	1
Swidden farmers	0,001	1000	0,2	0,1

Harrison, Weiner et al. (1964); Harrison, Weiner et al. (1970)

Fig. 818 *Economies and population density*

In the last two columns, the areas are translated into the radius of a circle with the same or almost the same area for a group of 100 peopl[56]
The same approximated sizes will play an important role in comparing different urbanising models.

From hunting into agriculture
The transition from hunting to agriculture has had enormous societal consequences.
In the village Beidha, in Jordan, the floor plan of dwellings changed from round to square during the 500 years from 7000 BC. This reflects a probable social development towards more task division and functional differentiation in living (Fig. 819).[57]



1 Living room
2 Storage places in the neighbourhood

3 shops
4 community building
5 inner courtyard
living in storeyed buildings

Leonard (1974)

Fig. 819 *Historical floor plans of dwellings that reflect the transition from hunting to agriculture*

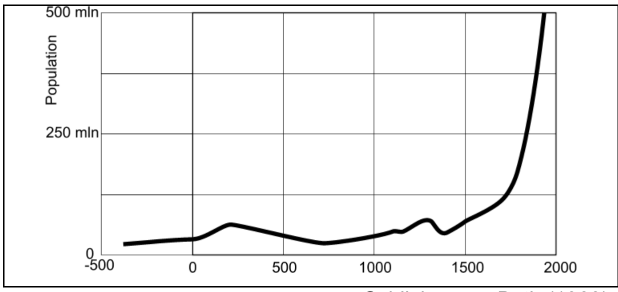
6.1.3 Population growth

Agriculture
If an animal or plant species gains dominance in a new habitat, then, initially, the population of these species can increase unhindered, but sooner or later it comes up against boundaries in the carrying capacity of the environment (in terms of Opschoor and Weterings (1994) and Koten-Hertogs, Beckers-de Bruyn et al. (1995) environmental utilisation space (milieugebruiksruimte), or (in the case of human beings) boundaries, which they themselves fix, within the existing biocoenosis (ecological community). If we couple the beginning of mankind with the use of tools, then the species is approximately 1 million years old. Agriculture (the Neolithic revolution)[58] was invented 10,000 years ago (1% of 1 million!). By means of agriculture, the species was able to enlarge, single-handedly, the carrying capacity of the environment and thereby to increase its population according to from approximately 4 million to 200 million by the height of the Roman Empire in Europe and the Han Dynasty in China.

Overcropping and agricultural innovations
Round about the beginning of our era this growth appeared to have slackened off, but, in the last 1000 years, growth has occurred again, which, as yet, appears to be exponential (see Fig. 820).
The slowing down of growth around the beginning of our era can be explained by the fact that all available agricultural land was in use at that time. Erosion occurred due to overcropping, forcing some human communities to leave their homelands, and tribal migrations began to take place. Because of the limitations of agricultural land, people learned to be more careful with the soil by implementing two- or three-year rotations, by applying fertilizers (nitrate cycle), by improving the plough and the storage (of the produce), etc. After the Neolithic Revolution, the next big revolution came with the mastery of inanimate energy (Industrial Revolution beautifully described by Cipolla (1970)). Each technological revolution created the conditions for far-reaching economic, demographic, cultural and political revolutions and these, in turn, had enormous ecological consequences[59].
Technical, agrarian and hygiene innovations can counteract the original environmental limitations and allow unlimited population growth for a time Jong and Priemus (2002) discuss these and other approaches.

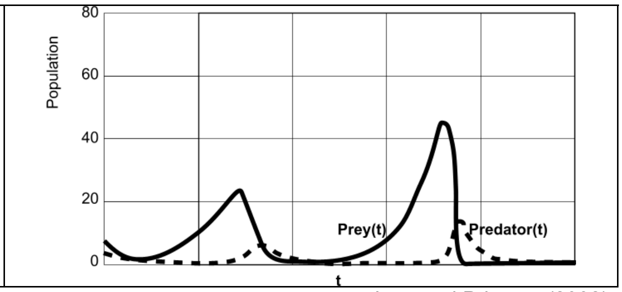
Medieval fluctuations

Fig. 820 shows that in Europe, during the Middle Ages, significant population fluctuations occurred partly because of erosion and starvation, and partly because of (pest) epidemics.[13]
The new exponential growth has mainly taken place after the Middle Ages, after technological developments had made their influence felt in the fields of agriculture, trade and hygiene.
Illness, such as the enormous pest epidemic around 1300 interferes with population dynamics in a similar way to the activities of predators in a population of their prey[60]



Schlicher van Bath (1960)

Fig. 820 *The anticipated developments in population numbers in Europe.*

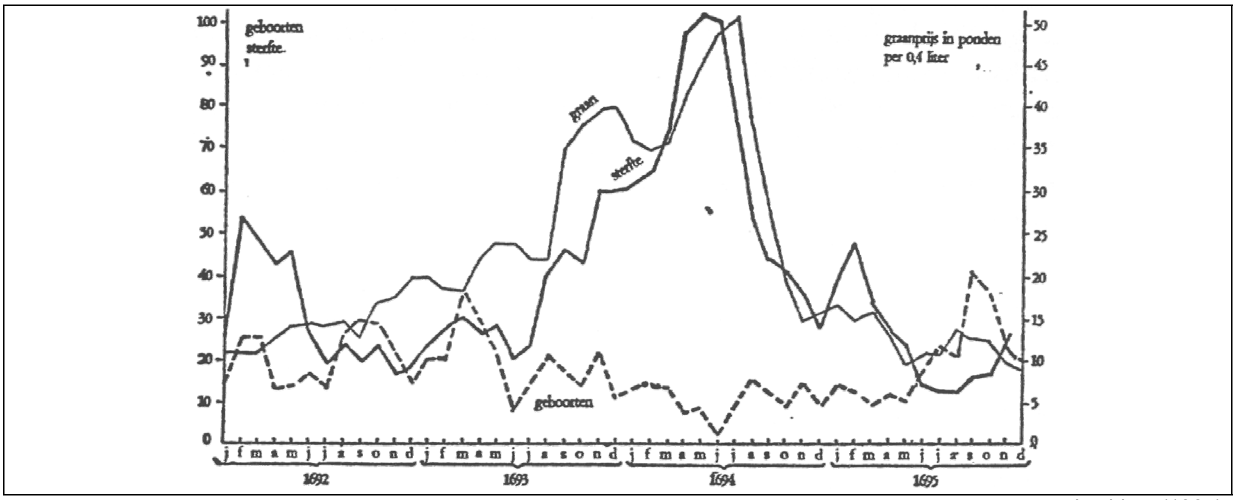


Jong and Priemus (2002)

Fig. 821 *Predator and prey according to Lotke-Volterra*

Hunger

Historically, hunger is recognisable by the number of deaths, and is often related to the staple food. Increases in the price of grain are generally followed by more cases of death. Then, once the crisis periods have ended, the numbers of births increase again. This relationship is not only evident in history, but is still actual today, and will become more evident as the current world population develops[61].



Lachiver (1964)

Fig. 822 *Demographic crisis in Meulan, near Paris 1693-1694*

Unlimited and limited growth

If there was no immigration or emigration, and the death rate remained constant, then population growth would be completely dependent on the number of children born. If the number of children *k* born to each individual was 1, then the population would remain constant, if *k*<1 then the population would decrease, if *k*>1, then it would increase. The total population *y* of parents y_0 and children ky_0 is then y_0+ky_0 (Fig. 823).

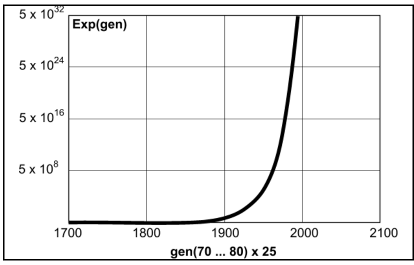


Fig. 823 *Unlimited growth*

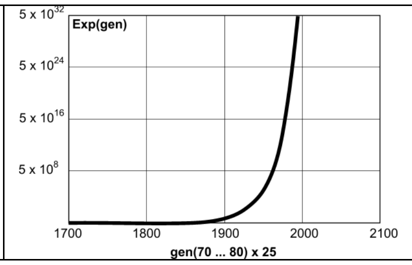


Fig. 824 *Adapted by parameter*

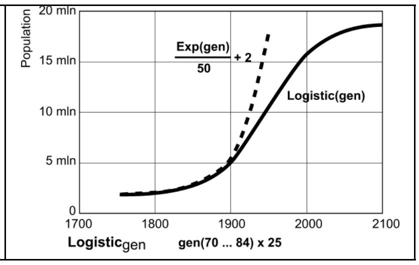
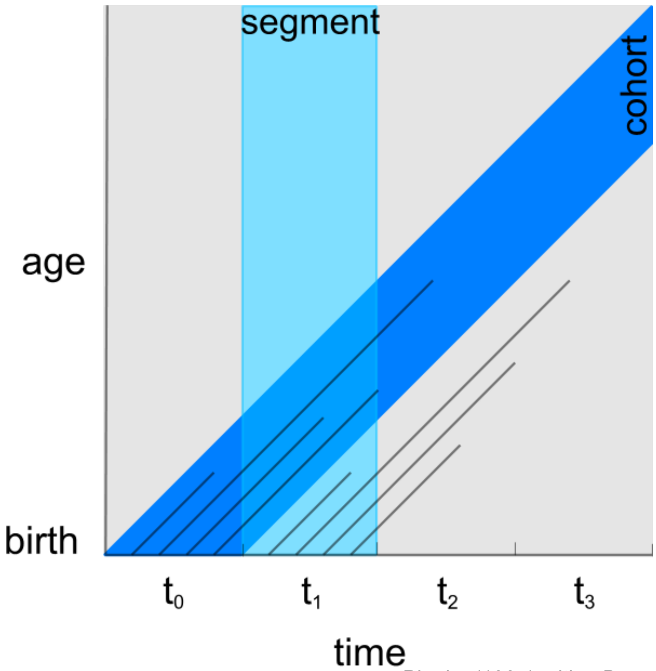


Fig. 825 *Limited growth because of carrying capacity*

Demography

Where death rates vary per generation, there is also a variation in birth rates. To contain these variations within one model, it is no longer sufficient to use a time-segment approach. Instead, one has to examine the population per cohort (Fig. 826). The branch of science that concerns itself with these activities is called demography.



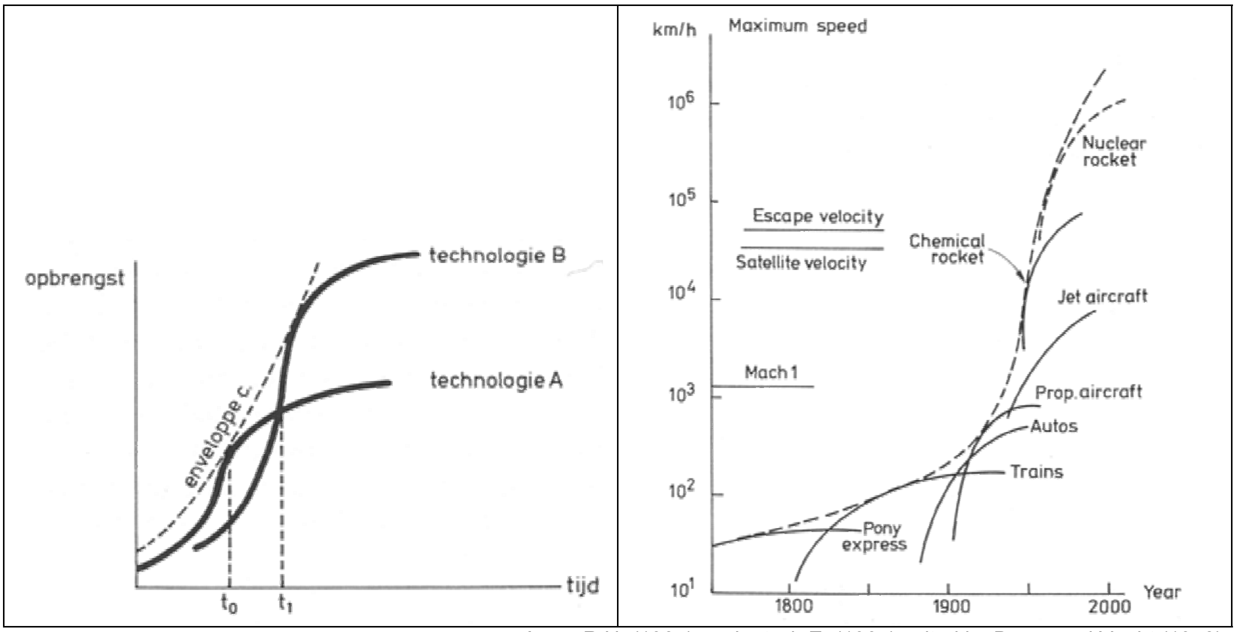
Pianka (1994) citing Begon and Mortimer citing Skellam

Fig. 826 *Population in a certain period and per generation (cohort).*

Growth that is limited by the usable area of environment, or the carrying capacity of the ecosystem, is represented by a logistic curve (Fig. 825). Should we, for the time being, interpret the future of our population as one of unlimited or of limited growth?[62] Many people like Meadows, Meadows et al. (1992) think or hope, in view of limited raw materials, that growth will be limited. The logistic curve works beautifully for fruit flies, but when applied to the population of the United States, based on the demographic statistics from 1790 to 1910, reality proved this mathematical approach to be incorrect after 1950: growth is still exponential.

Technology

From technical history, we have learnt how a succession of technological innovations, in its totality (the 'envelope curve') can be reinterpreted as exponential growth (Fig. 827).[63]



Ayres R.U. (1965) en Jantsch E. (1967), cited by Doorn and Vught (1978)

Fig. 827 *The envelope curve and an example for transport technology*

Chaotic growth

Fig. 828, and the following figures, illustrate a reflexive chaos function $chaos_{i+1} := a \cdot chaos_i - a \cdot chaos_i^2$ for example with $chaos_0 := 0.0016$ and i := 0 … 15 that looks similar to a logistic curve on a=2, but which shows chaotic shifts on higher values of the parameter a [64].

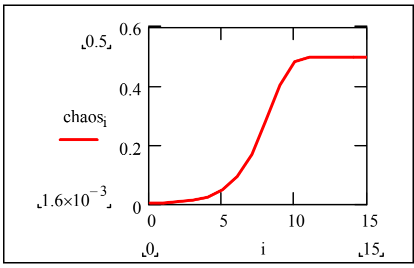


Fig. 828 Chaos using parameter *a* = 2

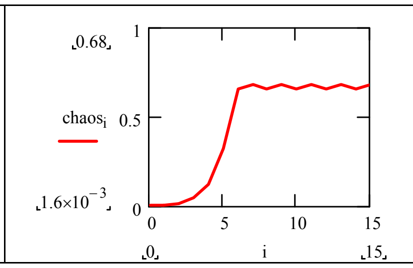
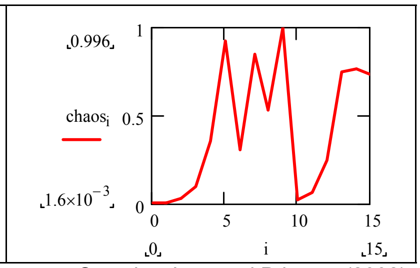


Fig. 829 Chaos using parameter *a* = 3



See also Jong and Priemus (2002)

Fig. 830 Chaos using parameter *a* = 4

Limits to growth

Death has been largely and lastingly restricted by improved food, hygiene and medical science to older age groups, although not everywhere to the same extent. The most important variable factor that determines world population growth is the fertility or reproduction factor. Worldwide, of course, immigration and emigration play no role at all. The big question is: When will the current exponential-like growth in population level off again? The Earth is still able to feed a multiple of the current world population, but the distribution is so uneven that an unacceptably large proportion of this population is starving and dying. In time, not only will distribution be a problem, but the total amount of food will become insufficient.[18]

At the same time, during the last 25 years, erosion has made 10% of the agricultural land unusable. Rising world temperatures will intensify this process by causing more deserts to form.

Changing predictions

According to CBS calculations (see Fig. 831), the Netherlands can expect population numbers to flatten off after 2030.[65].[a] In 2002 a maximum of 18 million was expected, in 2006 a maximum of 17 million, declining after 2040.

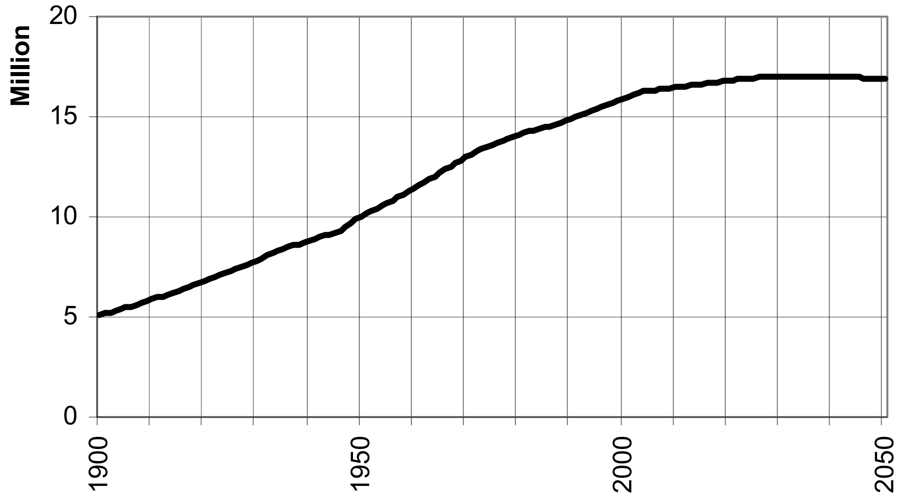


Fig. 831 *The CBS population prognosis for the Netherlands, 2006*

This development is expected in most Western countries, due to the decreasing number of births. Elsewhere in the world, so long as children are seen as the only form of health and pension insurance, this flattening off of numbers is not expected. The ecological crisis can then largely be seen to be linked with development problematics.

Contraception

One of the most harrowing Western influences is that, so long as the mother breast-feeds her child and carries it with her, natural contraception is broken off.[20] If the mother stops feeding her child for just one day, then she immediately becomes fertile again. A mother can feed her child for more than three years, but the Western example of laying a child in a cot and feeding it with a bottle has gained a higher status. The result is that a woman can become pregnant every nine months.
Western influence has not only brought about higher fertility in the Third World, but also a harrowing neglect of children still in their first phase of life. Every time a new child is born to its parents: the youngest child always receives the most attention.

[a] http://www.cbs.nl

Contraceptive devices are used by almost all 'primitive' peoples.

	infanticide	abortion	restricting coitus
Food gatherers and hunters			
Australian tribes (the Aborigine)	+	+	-
Tasmania	+	+	-
the Bushmen	+	-	-
Indians	+	+	+
Eskimos	+	+	-
Arable farmers			
Indians	+	+	+
Africa	+	+	+
Oceania	+	+	+
+ = number of confirmed cases - = no reported cases			

Harrison, Weiner et al. (1964); Harrison, Weiner et al. (1970)

Fig. 832 *Methods of restricting the population used by 'primitive' peoples*

Medieval population reduction

In the Middle Ages, hard measures were taken to reduce the population. If an area of land became over-used, at the very least or mildest, people were forced to move to marginal land. The history of marginal small-holders, tinkers, bandits, in short 'the destitute' ("ellendigen", "uitlandigen" exactly meaning: 'those who have been turned off the land') has never been written. The army, the cloister and the celibate can be seen as forms of contraception in the Middle Ages.
In this way, one can also explain how social norms in a farming community can be tightened (traditional costume!). People who were unable to live by such high norms were 'excommunicated'. The exaggerated norms were used as 'a stick to beat the dog'. Up to as late as the 20th century, in Staphorst, the black sheep was actually forced into a cart and driven out of the village[66].

6.1.4 The urban environment

Industrial revolution

The biggest mass migration ever was (and is) the movement from the country-side to the towns that resulted from the Industrial Revolution. The spatial and social consequences of that process are summarised under the term 'urbanisation'.
A progressive division between production, exchange and consumption (working, transport, living and recreation) has taken place, both in space and time, so that monofunctional spaces and interfunctional activities (activities that are only useful within a series of activities) have come into existence. This division of functions does not only take place between households, but also on the level of the individual households themselves. For everyone, there is a separate time for living, working and enjoying recreation. The household is losing its traditional functions such as providing training, religion, assurance and by that size and coherence.[67].

The use of time

How people spend their time gives a good indication of their daily lives and their use of space. Less and less time is needed to sustain life. Apes and people who currently live at subsistence level, and many households in the past, need(ed) to spend 40% of their time on that. Nowadays, by dividing tasks, we only spend approximately 8% of our time earning our daily bread, if one includes children, pensioners and others exempt from paid employment.

Misfit

The fact, that communities whose main activities are unrelated to the environment to which they have become attuned in the course of their history, can lead to long-term, unbalanced, over- (or under) stress in the organism. Insufficient adaptation to this stress causes lop-sized development. For example, one can wonder why hardly anyone has perfect teeth or cannot see clearly, without artificial aids, by his fiftieth birthday.

Crowding and disease

Living in closer proximity to others increases the risks of spreading infectious deseases, anonimity, loss of social control and new forms of criminality, even though according to Freedman (1975) the psychic effects appear not to be too adverse. A new biological tendency has come into existence that causes isolation, strongly polarising life into public and private spaces as Bahrdt (1957) described[68]. Accommodating to abnormal climates also sets physical demands on this isolation. The resulting 'inner environments' not only become a new habitat for humans, but also for birds, rats, mice, fleas, mites, fungi, bacteria, pets and house plants. Asthma, as the third largest cause of death after cancer, heart and vascular disease, is a problem mainly in temperate climates.

Stress

In addition to physical illnesses, there are also psychiatric disorders that can be linked with the new living environment, such as more frequent instances of schizophrenia in inner cities, although the cause can also be said to lie in the attraction of inner city areas for sufferers of schizophrenia[a]. Although many tests have been carried out on sensoric deprivation (the lack of sensory stimuli)[b], one should perhaps talk instead of 'motoric deprivation' in the modern urban environment, in other words, the lack of accompanying motoric sensations from the muscles, and, more generally, the awareness of one's own body and thereby of non-fictitious 'reality'. The time spent in the car, in front of a television screen, at a sports competition arouses all sorts of sensoric emotions which have no logical motoric counterpart. Stresses cannot be resolved motorically by physical exertion. This is one of the causes of obesity, heart and vascular disease. Where people live in close proximity to each other and where internal spaces are fragile, the 'motoric sequel' becomes systematically suppressed, from childhood onwards. This could provide an explanation for the popularity of sport and violence. Specialisation and the division of tasks splinter the unity of life, not only spatially (this happens here, and that there), but also in time (first this, and then that). The number of interfunctional activities is growing and is laying a heavy claim on tolerance to frustration, both for individuals and groups of people.[69].

Division of space and time

People, animals, plants and apparatus need space and time to remain functional and to realise their aims or possibilities. At a certain level of intensity of use, they start to restrict each others' space and time so that displacement and waiting times occur, respectively. Systematic planning (spatial) and organisation (temporal) in the functioning of human beings and society become necessary as soon as either people or apparatus start to carry out, for example, more than 0.01 hr/m^2 of activities per year at a particular site (the present levels for agriculture in the Netherlands). If an activity takes place somewhere (a series of undertakings to meet a certain aim), then no other activity can take place on that same site and time. Therefore, if the intensity of use is greater than 0.01 hr/m^2, one has to separate any two activities in space (planning) or in time (organisation). If a separation is made on a certain scale level, it is also necessary to connect it to another scale level when, from time to time, activities such as natural or economic cycles need to be linked. This combination of separations in general, and connections here and there, and now and then, is a form of selection. Each wall with a door, town wall with a gate, every prohibition with exceptions is a selector[70].

Separation

Separations in space and time can come into being because of physical regulations or by territorial and prodecural consensus ('you here, me there; now you, then me'). At higher scale levels, arrangements prevail; at lower levels, physical measures prevail. Consensus can be in the form of an order ('forbidden access'), which, in a democracy, is founded on delegating authority to give orders within certain areas of responsibility. Consensus can also be promoted by conducting an information or advertising campaign ('stop certain activities in this nature reserve' or 'come to the meeting').
As soon as activities can be divided by barriers, walls, arrangements or more informal consensus (culture) and then by (spatial or temporal) selective links brought into association with each other again (logistics!), then much higher intensities of use than 0.01 hr/m^2·year are possible.[71].

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[a] Het verhoogd voorkomen van bepaalde ziekten zoals schizofrenie in bepaalde delen van de stad is in de jaren '70 geregistreerd door de GGD van Rotterdam. Daarbij kwam ook een andere causaliteit aan de orde. De omgeving leidde niet zozeer tot een ziekte, maar selecteerde de immigratie van probleemgevallen op andere kenmerken, zoals inkomen.
[b] Sensore deprivatie, het verstoken blijven van zintuiglijke prikkels, is dikwijls experimenteel onderzocht. Zie voor een kort overzicht van het onderzoek tot 1978: Jong, T. M. d. (1978) Milieudifferentiatie; Een Fundamenteel Onderzoek Faculty of Architecture (Delft) Delft University of TechnologyJong, T. M. d. (1988) Milieudifferentiatie (Delft) DUT Faculteit Bouwkunde.

The intensity of use

Intensity of use is an important factor. It is one of the factors that determines to what extent an environment can be supplied with facilities (density of investment), by guaranteeing a certain level of utilisation. The intensity of use also determines the speed of aging, and is related to the contribution made to the national product, energy density, ecological pressure, and the risk factor in dangerous situations, etc. Nevertheless, this measure is not used very much in Environmental Planning because it is difficult to estimate the use of time and to bring this to the same denominator as the use of space.[72]

In 1983, the intensities of use of various spatial functions were, approximately like Fig. 833[73].

	hr/resident·year	m^2/resident	hr/m^2·year
ACTIVITY			
In and around the house	6552	137	48
Learning away from home	374	6	62
Moving	387	91	4
Social/cultural	539	8	70
Recreation	162	47	3
Sport	36	17	2
Shopping	238	2	135
Agriculture	11	1667	0.01
Exploitation of minerals	1	5	0.3
Industry	185	30	6
Public utility companies	8	10	0.8
Building firms	71	20	4
Trade	51	3	17
Transport & communication	33	2	22
Other services	77	4	19
Government, etc.	61	1	102
Use of time: both paid and unpaid			

NNAO, Ontspannen scenario, MESO Den Haag 1986

Fig. 833 *Use of time/use of space = intensity of use*

Urban uses of time

Residents optimise their use of time to achieve a balance between maximising their income and the availability of free time and space. They have thereby long been prepared to accept travelling times of three quarters of an hour twice a day between their homes and their work. Because of this, a tentative effect analysis can be made of the various urbanisation alternatives in this optimalising process. By doing this, however, an impulse is given to far-reaching analyses of the economic, cultural and managerial effects.

Choices on different time scales

The use of time can be judged on different time scales: the daily rhythm, the weekly rhythm, the yearly rhythm and lifetime. On the first three time scales, the above-mentioned optimalising process leads to recognisable questions of priority in everyone's life in the daily, weekly or yearly rhythm (see Fig. 834).

Am I going home early or late today?	Do I give priority to (a) the family or (b) to work?
This weekend:	will I be (a) at home or (b) am I going out?
This year:	will I be (living and enjoying recreation) (a) with someone else or (b) alone?

Fig. 834 *Setting priorities in the use of time*

Tradition- or opportunity directed preferences

The (a) variants of Fig. 834 give more free time and strengthen the argument for national distribution and for Bundled Deconcentration; the (b) variants are conducive to more income and individual free space, thereby strengthening the argument for concentration in the Randstad and for a Compact City strategy. Eight alternative uses of time can now be distinguished (Fig. 835).

	<tradition-directed						opportunity-directed>	
rhythm	A		S1				S2	B
daily	a	a	a	a	b	b	b	b
weekly	a	a	b	b	a	a	b	b
yearly	a	b	a	b	a	b	a	b

Fig. 835 *Alternative uses of time*

These possibilities of using time lead to different opinions about how space should be organised. Political schools of thought can also be positioned in this scheme. Traditionally (<) oriented parties (such as the CDA) will choose (a) variants in all time scales (A); opportunity (>) oriented parties (such as the liberals) will choose (b) variants (B); and the socialists will differentiate the variants into ‘blood groups’ (S1 and S2) that are, respectively, more <tradition- or opportunity> oriented.

Dispersion of time in space

.
Within the Randstad, however, there are boundaries to the maximalisation of collective free space within the opportunity-oriented> perspective of urbanisation.
The process of specialisation and division of tasks in urbanisation, splinters the unity of daily and weekly life, both spatially (this is happening here, that there) and in time (first this, then that).
In contrast to this, large and new freedoms have come into existence. We become about twice as old as we did at the beginning of the last century, and, in addition, have about twice as much free time. According to CBS (1994) since World War II, the number of people per dwelling has halved, from 5 to 2.5 people, so that, within a radius of 10 metres (R = 10m), we have at least twice as much space. Within a radius R = 100m, we have small areas of green, and within a radius of R = 1000m, large areas of green. We are suburbanised *en mass* in order to have a magnificent view close at hand. And there the story comes to a halt, because on each higher scale level, the emptiness disappears.

Political parties choose different ‘accords’ of dispersion

Historically, the preferences for traditional- or opportunity-oriented uses of time can best be read against the aims of political parties with respect to space, expressed in their programmes over a period of 40 years as th University of Amsterdam once found out. They can be styled in ‘accords’ of the concentration (C) and deconcentration (D) of urban areas on national, regional and local levels (see *Fig. 836* and Fig. 693)

In a radius of	100km	30km	10km
	(sub)national	regional	subregional
Liberal	C	D	D
Socialistic	D	C	C
Christian-democratic	D	C	D
‘Purple’	C	D	C

Fig. 836 Political ‘accords’ of dispersion

Traditionally, the liberals have wanted a national concentration of urban areas, because that would benefit the competitive position of the Randstad. On regional and local levels, however, they have always preferred deconcentration to allow free choice of place of residence or establishment. In contrast, up to the 1980s, the socialists favoured deconcentration on the national level to encourage a fair distribution of residence and employment opportunities throughout the country, but concentration on the regional and local level for the benefit of public transport and the political cohesion of minority groups. To preserve the historical identity of the provinces, the Christian Democrats have favoured national deconcentration. On a regional level, they have favoured concentration in order to have provincial capitals with recognisable regional religious and civil administrations. On local levels, they again favoured deconcentration (suburbanisation) because, in their view, only small communities can offer a caring society in which the family, the corner-stone of society, can flourish. In this way, freedom, equality and brotherhood become recognisable and controllable in different design principles and on various levels of scale.

Changing preferences in national plans

But policies change by different coalitions as you can see in the successing National Plans in the Netherlands (see *Fig. 837*)

In a radius of	300km	100km	30km	10km	3km
2nd National plan 1966	Bundled Deconcentration				
	theory		C	D	C
	practice		D	C	D
3rd National plan 1983	Structuurschets Verstedelijking 1978: 'new towns' ('PTT naar Groningen')				
Socialist period		D	C		
	Structuurschets Stedelijke Gebieden 1983: 'growth towns'				
Liberal period		C	D	C	
4th National plan 1988	Compact city: nodal points				
	C	C	D	C	

Fig. 837 Changing preferences in national plans

The result of these changing policies is urban sprawl (see Fig. 694).

Freedom of choice supposes diversity

The largest number of possibilities for future generations will be achieved by realising maximum diversity in environments. Determining which scale levels require which forms of diversity (legends), is the most important task that urban architectural research has to face. The composition of the population and the life cycle of every individual provides changeable patterns of time-use, and, for this, specialised spaces are needed. One 'best' overall solution is the worst solution. The intermediary forms between On-going Deconcentration (D_{100km} ... D_{10m}) and Complete Concentration (C_{100km} ... C_{10m}) probably offer more possibilities than these extremes in themselves, but they also eliminate future possibilities for the Randstad, such as the availability of free space of the size of the Green Heart that can only be achieved where there is complete concentration. However, that, in turn, interferes with the identity of towns and cities, would require abandoning buffer zone politics.

6.1.5 Mobility between urban populations

Forces of attraction between masses

According to Newton (1687, beautifully described by Feynman, Leighton et al.,1977,1963), the attracting force F between masses M_1 and M_2 is inversely proportional to the square of their distance d:

$$F(d) := G \cdot \frac{M_1 \cdot M_2}{d^2} \text{ (Newton, 1687), } \quad \text{while } G := 6.67259 \cdot 10^{-11} \cdot \frac{m^3}{kg \cdot sec^2} \text{ (Cavendish, 1798)}$$

The factor G was measured by Cavendish with a precision of 1% and until now again and again with greater precision. The formula inspired traffic engineers to formulate the travel benefit between urban populations in a comparable way.

Traffic flows by attraction

Human behaviour is more difficult to model than lifeless matter, but, because of their large numbers, in the long term, people's improbable individual choices cancel out one another statistically into a main probability. So, traffic between urban units can be modelled reasonably well in proportion to their population, taking into account their mutual distance.

If we represent moving people between sites of departure and destination according to their masses, then the Newton formula can be adapted to actual reality. For example it can be adapted by taking a power in the denominator of Newton's formula (see page 539) other than the square '2'.

Calculation traffic according to Newton's formula

Completely according to Newton, the power of attraction between two urban units would be proportional to their populations p_1 and p_2 and inversely proportional to the square (b = 2) of their mutual distance d. But if you make G=a=1, you take the mass of both poles as 100 and change the power b into 3 or into 7, then the function starts to look like the use of different slow (b=7, like bikes) or fast (b=3, like cars or trains) means of transport (see Fig. 838).

$$f(d,b) := \frac{a}{d^b} \cdot p_1 \cdot p_2$$

a:=1
b:= {3,7}
p_1:=p_2:=100

another notation is:

$$f(d,b) := \frac{a}{e^{\ln(d) \cdot b}} \cdot p_1 \cdot p_2$$

because d can be represented as a power of e = 2,718 : $e^{\ln(d)}$

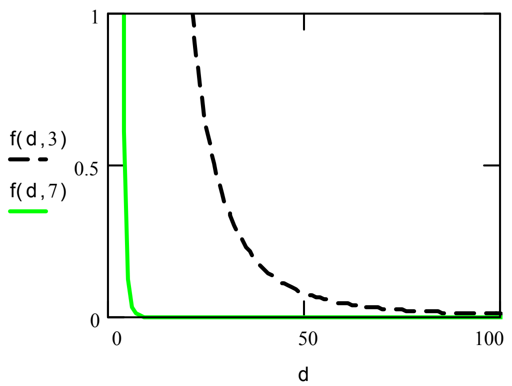
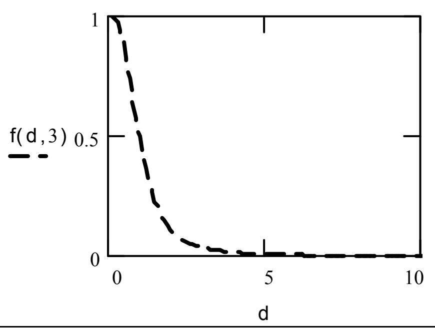


Fig. 838 *Traffic according to a modified Newton formula*

However, according to this graph, direct neighbours must exert a strong, almost infinite, force of attraction, like lifeless matter does. In the case of humans, this would mean that every desire to travel further would disappear, because the benefit of staying home is infinite. Consequently, for travel calculations the coefficient a / $e^{\ln(d) \cdot b}$ of the populations p_1 and p_2 has to be adapted.

Adapting the coefficient of the populations

To make that coefficient maximally equal to scale factor 'a' taken as 100% (a = 1), we have to make the denominator minimally 1 by adding 1: a / 1+$e^{\ln(d) \cdot b}$. Then, if scale factor a = 1 and the distance $e^{\ln(d) \cdot b}$ is zero, the force of attraction is 1 or 100% (see Fig. 839).



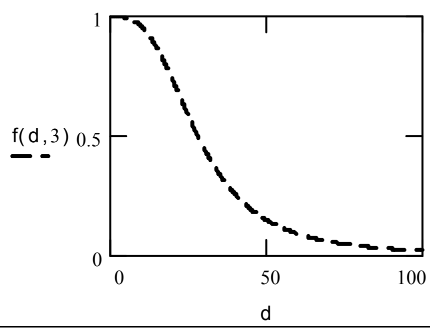


Fig. 839 $f(d,b) := \frac{a}{1 + e^{\ln(d) \cdot b}}$

Fig. 840 $f(d,b) := \frac{a}{1 + e^{\ln(d) \cdot b - \beta}}$

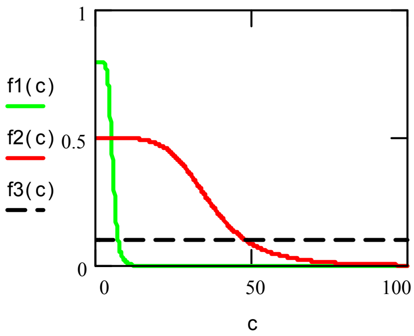
The graph now starts beautifully at 1 at a zero distance, but by a growing distance the attraction by fast traffic decreases to zero already below d = 5 in Fig. 839. To stretch the graph you can subtract a constant β from the power: $e^{\ln(d) \cdot b - \beta}$ (see Fig. 840, where β=10). In the mean time, this application shows the advantage of using the power of e instead of a power of d.

Attraction reduced by costs and distance < 30km

In addition, the model also has to take into consideration that not only the distance, but also factors such as congestion or useless delay, can reduce the effect of masses attracting each other. All such 'costs', including travelling time, partly increasing due to distance d, are summarised in current traffic models by the term '*travel resistance*' *c* (costs, see Bovy, P.H.L. and N.J. van der Zijpp 2000). Between two populations, this travel resistance is operationalised in the travel benefit function *f(c)* as an effect of *c* (including distance d). This function reduces the attraction of the masses: the higher the costs, the smaller the travel benefit.

Travel benefit related to costs, calculated by traffic engineers

If the parameters are chosen well, *Fig. 841* is supposed to fit in with the current empirical reality. In the graph, the travel cost *c* can be largely identified with the distance travelled in kilometres.

		Determining parameters		
		starting point 0 < a < 1	stretching 3 < b < 7	deflection 12 < β < 20
Bicycle $f1(c) := \frac{a1}{1 + e^{\ln(c) \cdot b1 - \beta1}}$ Car $f2(c) := \frac{a2}{1 + e^{\ln(c) \cdot b2 - \beta2}}$ Train $f3(c) := \frac{a3}{1 + e^{\ln(c) \cdot b3 - \beta3}}$		at 0.8, the function starts at 80% of the height. a1 := 0.8 a2 := 0.5 a3 := 0.1	at 7, the function deflects for the first time. b1 := 7 b2 := 5 b3 := 3	at 20, the function reaches its zero value for the last time. β1 := 12 β2 := 18 β3 := 20

(Bovy, P.H.L. and N.J. van der Zijpp 2000)

Fig. 841 The type of log-logistic travel benefit function that is used in the WOLOCAS model, with which new VINEX districts were calculated

Thus, one can read from this that the travel benefit of a car is, on average, greater after about 5 km than that of a bicycle. After about 50 km, the travel benefit of a train is greater than that of a car.

Modal split

However, at zero distance there is of course no traffic, and looking at empirical statistics of different traffic modes (see *Fig. 842*), the curves do not look like the log-logistic utility curves of *Fig. 841*.

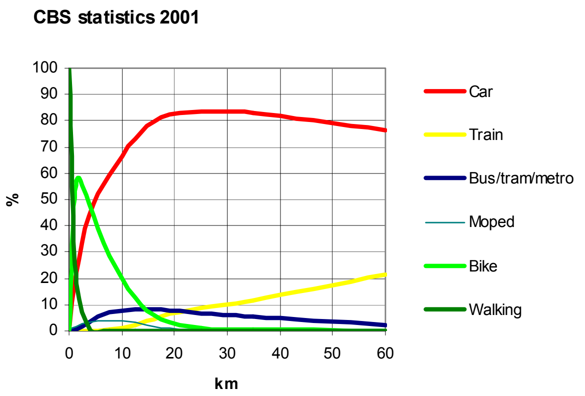


Fig. 842 Modal split

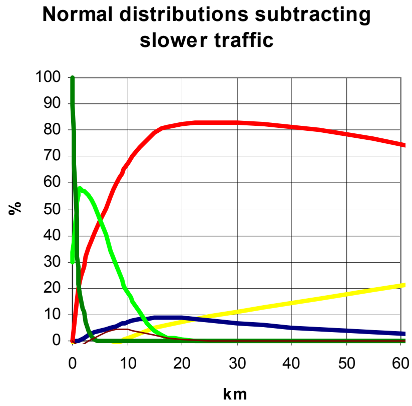


Fig. 843 Simulation of Fig. 842

They look more like normal distributions drawn crooked to the zero distance border. If you simulate them like that, the walking pedestrians and bikes look like a halve of such a normal distribution. The curve of the car can be simulated as a normal distribution, partly diminished by subtracting the curves of walking pedestrians, bikes and mopeds like *Fig. 844* shows.

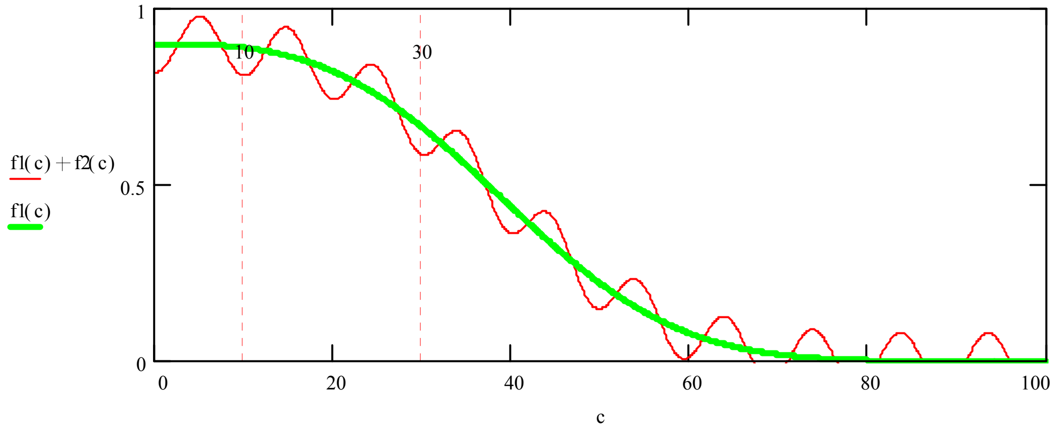
	walking	bike	moped	car	bus&	train
vertical scale factor	100	1000	100	15800	10000	11500
average at	0	0	7	25	-30	100km
standard deviation	1,5	6,4	5,5	76,0	100,0	100,0
subtract walking		20%	0%	75%	40%	30%
cycling			10%	75%	41%	40%
moped				0%	15%	30%
car					32%	27%
bus, tramway, metro						40%

Fig. 844 Figures, used for the simulation of Fig. 843

6.1.6 The urban field is not homogeneous

In between two highway exits or (public transport)stops

In practice, the travel benefit formula does not always decrease with an increasing distance or 'travel resistance' by costs *c*. The formula is true in a homogeneous field, but not in a heterogenous field of a network with exits or (public transport)stops. Everyone knows that taking a exit further on can sometimes result in more travel benefit. Suppose that the mesh width and exit distance of local highways is 10 km on average. Suppose from my departure point, it is a 5 km drive to the next local highway. Then, after 10 km, I am on the motorway, between two exits. In that case, the travel utility of 10 km is smaller than that of 15 km. The graph could therefore fluctuate when a radial motorway has an exit every 10 km (see Fig. 845).

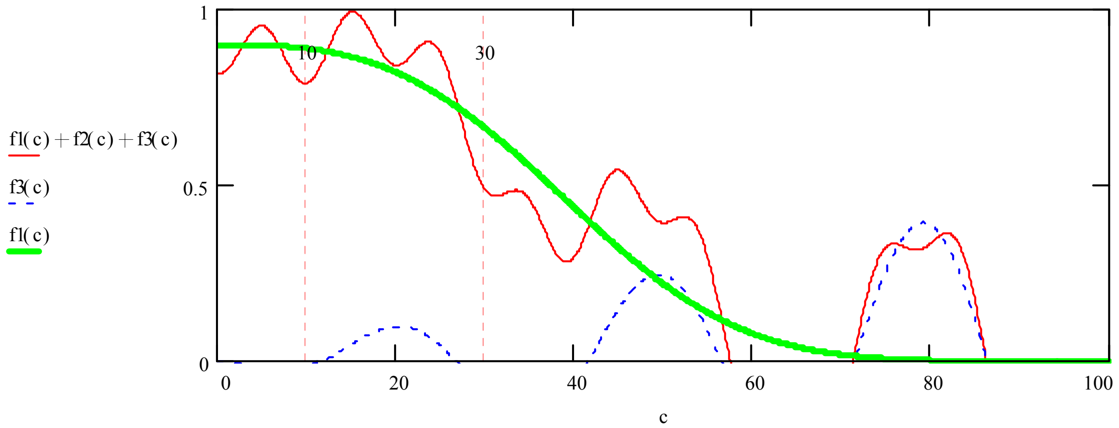


Here, $f1(c)$ is the log-logistic travel utility, and $f2$ is a sine with a period of 10 km superimposed on it.

Fig. 845 *Fluctuations of travel utility with a periodic infrastructure of 10 km*

Useful destinations increased by distance

For a train, these fluctuations are caused by the station stops: I cannot end my train journey between stations in the event of my seeing no utility any more in continuing the journey. With regional tracks occurring regularly, every 30 km, even more fluctuations with a 30 km period are superimposed on them.



$f3(c)$ is a sine with a period of 30km and increasing amplitude

Fig. 846 *Fluctuations of the travel utility with a periodic infrastructure of 3 and 10 km and with increasing travel utility*

Passing rarified zones without direct utility

It is clear that, in this case, travelling 50 km has more utility than 40 km. In addition, the higher design speed on these speed-specialised lines, less plagued by stops and exits, lowers travel resistance, so that the kilometres used to calculate *c* shrink in travel time. I will leave these sorts of mathematical complication to more experienced calculators.

The conclusion could be that well-thought-out construction or improvement of fast infrastructure results in rarified zones designated as green areas, which are positioned radially around human masses in the direction of other masses, and have a greater travel utility for intersections situated further away than for the pure log-logistic decreasing travel utility functions without fluctuations. This is a beginning of the traffic concept for an interregional network city.

Broadening the travel horizon increases the number of attractive destinations
Without a division of tasks, broadening the travel horizon in a homogenous urban field increases the accessible area, and thus the destination possibilities by the square of its radius. The proportion of these possibilities that is actually utilised within an available budget in the form of money, means of transport and time, is the scale factor *a.* That factor becomes smaller the further (and faster) I travel to obain these possibilities. One can take this increasing travel utility into consideration as an effect on the costs of primarily decreasing travel utility function *f*(*c*), with an increasing amplitude of stops or exits situated further and further away. In Fig. 846, it is thus assumed that, at the first and second exit or stop on these lines, the utility, and thus the amplitude, will increase due to increased destination possibilities. This effect is strengthened by interregional task division.

Attraction between regions charged with task division benefit
In the current model philosophy, a positive travel utility is expressed more purely as a factor of the power of attraction of the masses, than just by the mass-effect-reducing travel utility function *f*(*c*). For each urban concentration, a traffic model can apply separate empirically determined corrections to the mass effect. However, in the case of interregional task division that is not logical. The power of attraction between regions, due to increasing interregional task division, appears to be more like electromagnetic attraction caused by a difference in positive and negative charges, which supplement one another. However, where there are more than two tasks, there are more sorts of charges than + and -, and the range is greater. It is essential that the attraction is not a characteristic of a mass, itself, but of its specialisation compared with other masses that are charged differently. Alternatively, equal charges cause repulsion. For this, a separate, not necessarily reducing, but accrediting, specialisation function will perhaps have to be devised.

Making lost time useful
Then, in working out the travel resistance *c* itself, the travel time as a cost post will be taken as being almost synonymous with distance and other inconveniences. However, travel time can be used as contact, work or rest time *en route*. In particular, it will be possible to facilitate work time in the future by means of communication technology. The remaining travel time does not always increase with distance, but is mostly due to slowness and delays when changing from one form of transport to another, and this can be included in *c.* This is why the design of multimodal intersections and means of transport, and their multifunctional, urban integrated and communicative equipment, is the primary project for a Delta metropole. At the same time, the most important item on the agendas of managers, designers and key actors is the mutual determination of the identity of regions, agglomerates and towns with respect to growth in task division. The new public transport between them must not eliminate chance, but organise it. One cannot confine oneself, then, to adapting *c* in existing models on the basis of empirical starting points, when some costs can be changed into benefits by shrewd design.

6.1.7 The force of specialization

Attractions >30km
About 90% of all traffic movements are kept within a radius of 30 km (region) around the departure address. It is natural that traffic modelling focuses on that section. Commuter traffic generates the problems that traffic specialists are hired to solve, so they gear their models to these.
As far as I am aware, there is still no model for the individual and collective benefits interregional traffic (> 30km radius), caused by regional specialisation. The attraction of mutually specialised masses should be greater than that of mutually unspecialised masses. Why would people travel at all, if there is no difference between departure and destination? And if a difference far away promises great profits, how important is distance then? If functions are specialised on a larger scale traffic benefit can increase with distance.

Exchange, traffic implies specialisation
Trade rests on that principle, and so does the ecological division of tasks between land and water, and between male and female flowers that exchange their life experiences with the help of insects, the travellors. On every scale level, life itself shows the evolutionary effects of specialisation: combination by exchange. The attraction of Disneyland has another travel benefit function than commuter traffic, certainly when Parisians are becoming bored with it.

External specialisation by internal integration

In the Dutch Golden Age, Zaandam[a] produced ships, Amsterdam used them. Amsterdammers with initiative felt more at home in Indonesia than in Zaandam near by. Regular destinations far away create an unknown zone close by, also recognised for commuters by Groenman (1960) as 'ijle zone'. But that zone has its functional integration by other specialised populations. During the period concerned, Amsterdam, already a metropole with 100,000 inhabitants, became a world city with a national web of punctual towing boats (Vries, Jan de 1981). About 1600 AD the organising of the VOC by Van Oldenbarneveldt (Romein, J.M. 1938,1971) gave each of the United States of The Netherlands its own commercial part of the world changing mutual competing and conflict into cooperation. It was external specialisation by internal integration. Disneyland in Paris is a similar improbable example of organisation and offshore entrepreneurial spirit. Organisation is a matter of specialisation and combination.

External effort outgrowing internal integration

However, our colonial past gives reason for us to be ashamed of expansion, certainly if it costs too much energy. Ever since Stadtholder Willem III, setting sail from Hellevoetsluis, exported our commercial democracy to England by conquering it, in a final effort, with an armada three times larger than that of the Spanish, (Israel, Jonathan I. 1995), we would rather stay closer to home. Ever since Thomas Jefferson visited our country in order to study our republican constitution (Eskens, E. 2000), the roles have been definitively exchanged with Anglo Saxon players. From Scherpenzeel (birth place of Peter Stuyvesant), no one will establish a New Amsterdam again, if there is still enough space in neigbour village Munnekeburen. Now investments from New York are welcome. Whether foreign investments will come or not, again depends on the percentage of key actors who, sometimes by chance, discover that it would be better to grow (for example) coffee outside one's own region, than at home. If people are alert, this will not lead to exploitation this time, but to cooperation.

Travel benefit fluctuating by distance

Between the region and the world, however, there are still a number of scale levels on which the travel benefit can be increased for some destinations by including rarified zones, for example green areas close to home. If we show a collective will for fast lines of interregional public transport, communication and decisionmaking, then the travel benefit function in the travel models can be adjusted. However, the question is: On what level do we want to spread our towns and green spaces? Bundled deconcentration within the region (NRO2, RPD 1966, see Fig. 693 and explaining text) has been disposed of since 1983 (NRO3, RPD 1983, see *Fig. 837*): it broke up the green spaces in urban landscapes. Its variant, a regional network town, breaks green spaces into even smaller pieces.

Declining specialization by local congestion

The compact city (RPD 1988, see *Fig. 837*) increases travel resistance locally due to congestion, whereby the strength of cooperation between the big cities decreases in full accordance with prevailing traffic models. That is a self-fulfilling prophesy. Wings that do not divide their tasks, but without sufficient coordination go their own way, are probably unable to make an international flight. Moreover, in the unintentionally expanding compact city, green areas are only accessible by car. In addition, on public holidays, part of the free weekend is claimed by traffic jams. That can only be compensated by holidays in further-away places that make a joke of the travel utility function. The result is a vicious circle of local travel resistance and less cooperation based on reliable specialisation.

External competition by internal cooperation

The Delta metropole is not a regional, but an interregional network city. It is a world city not because of its masses, but because of spatial specialisation. Urban masses become more attractive, if better and faster decisions can be made than elsewhere in the world. That saves the energy of interregional competition for attracting international acclaim. International power is achieved through interregional cooperation, based on a division of tasks. In doing that, one aspires to create an international site and expansion base for business establishments with extensive green and blue spaces within cycling distance from home.

[a] In Zaandam the Russian Tsar, Peter the Great, learnt to build ships.

Regional division of tasks

The classical *trias urbanica* of management, culture and market is recognisable in the centre of every medieval town, where townhall and church made space for the market. This is where the surrounding consumption and production converge, managed in the town hall, reflected in church. This territorial division of spaces by task has, since then, been subject to scale enlargement. Until after World War II, Bonn, Cologne and the Ruhr area, The Hague, Amsterdam and Rotterdam had divided these tasks interregionally to give managerial, cultural and economic accents, respectively. Due to the movement towards a service economy after the war, cultural identity came to have more of an economic meaning.

The right diversity on the right scale

A culturally equipped town or city furthers the chance of a productive meeting. Thereby, Amsterdam, gained better chances of being chosen as a place of settlement by the key actors responsible. Rotterdam and the Hague regained a cultural identity by means of international film and jazz festivals, unmatched architecture, and decision-making culture. Making faster and better decisions requires the lubricant of cultural eye-opening. In the much smaller, but more central, inland Utrecht, the 'captains of service' confer at the crossroads of polders, rivers and forests, with dunes and harbours on the horizon. Here too, the converging peat, clay and sand diversify ecosystems while from here they determine more uniformly the ecology as far as the Urals (Constandse, 1967). Also in the opinion of the youngest generation, growth should not be concentrated there.

Direct, distribute, disperse and concentrate on the right level

There, key actors from the heart of Europe are shown a route via the Rhine axis in their Delta over the Mondriaan-like network called Holland (see Fig. 847).

Jong and Paasman (1998)

Fig. 847 *Potential continental, fluvial and national network systems .*

In addition, in the Delta, rail and road transport via the south and east can be brought together on an even greater scale along the European coasts to choose our water and air space as main ports (and the reverse). This will be achieved, if the foreign actors are received in a well-considered, cooperative network of towns, each suited for its own task, attractiveness as a place to settle and with it own identity. There are large projects with small consequences and small projects with large consequences. The Delta metropole is not directed towards projects in which the one section expects to dominate the other, but, in the end, steals an advantage.

Limitation shows the master

Does one section choose projects that deprive the other of success, or can people delegate among eachother so that, together, international functions can be given the best position in the whole network? The latter requires subnational decision-making skills, regional loyalty and again local decisiveness. If one chooses non-traditional regional solutions, using traditional national means, the Delta's inherited urban constellation can be turned into an international novelty. One can grow interregionally by trimming regionally, integrating by mutual specialisation, by accepting one-sidedness in order to excel, and by developing the rest elsewhere.

Specialisation as a paradox of scale

Managerial initiative, innovation, growth, integration and versatility are a question of scale. In contrast, on another scale, they require loyalty, tradition, trimming, specialisation and one-sidedness.
The implicit presuppositions of the Stedenland perspective (VROM 1998) that preceded NRO5, illustrate this kind of scale paradox. They are made explicit in Fig. 849. That perspective supposes national initiative and subnational laissez-faire, national tradition and regional innovation, national division of tasks, subnational integration, national concentration, local dispersion.

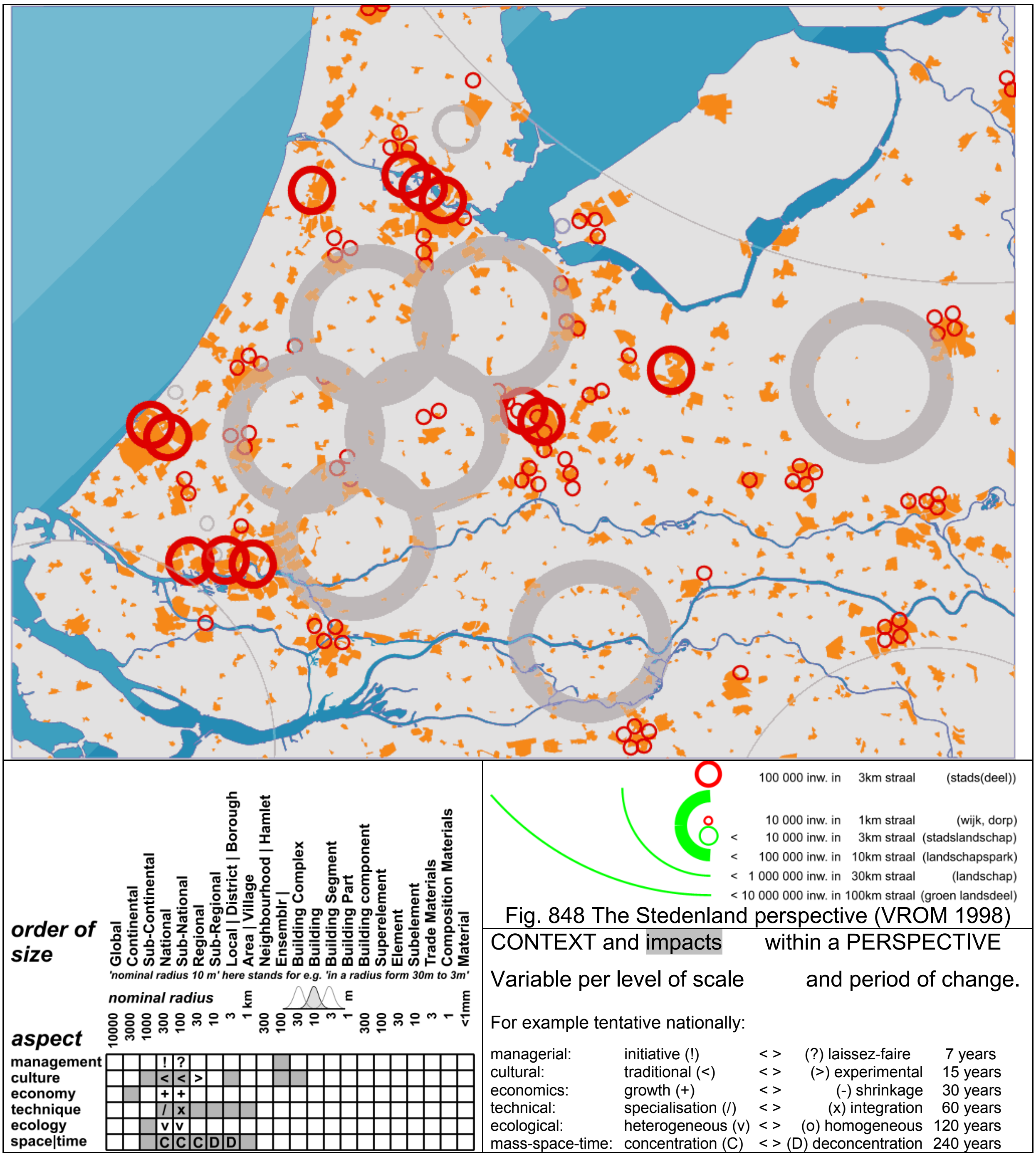


Fig. 848 The Stedenland perspective (VROM 1998)

Fig. 849 *Context organ (example: the Stedenland perspective (VROM 1998) and effects (grey))*

According to the combinatorial system, it is possible to play 10^{65} other chords/accords on this organ. The Delta metropole accord is much the same. The difference is that subnational deconcentration and a great effort to achieve technical integration that facilitates the division of national tasks has been requested (VROM 2001, 2002).

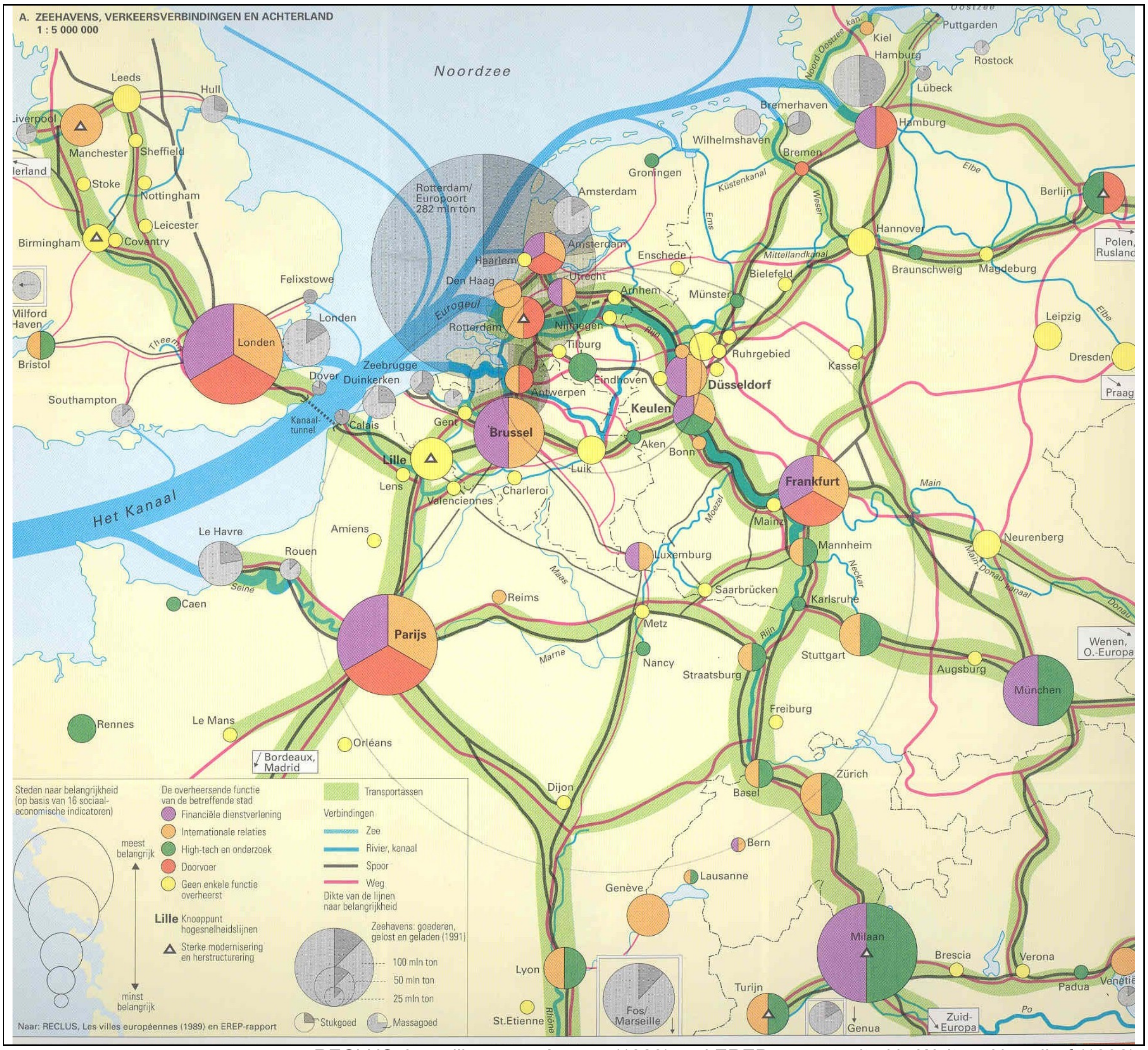
Specialisation supposes exchange

The division of tasks consists not only of where projects are established, but also the network. A didactive rule of thumb that, for each higher unit of road system, an approximately three times larger mesh width should be maintained, turned out to be more realistic than was first thought. It has been calculated in three different ways that, by doing this, an optimum of accessibility and construction costs is achieved (Nes, R. van and N.J. van der Zijpp 2000). However, this would mean that, in the Netherlands, there would have to be nine orders, each with its own design speed and exit frequency (Jong, T.M. de and M. Paasman 1998): continental, fluvial, national, regional, local motorways, urban motorways, district, neighbourhood and residential streets drawn with a mesh width of 1000, 300, 100, 30, 10, 3, 1, 0.3, 0.1 kms, respectively, if one draws the same mesh length and breadth. The first three are drawn in Fig. 847, and if one styles the remainder, then one gets a typology of dry connections with square meshes, as shown in *Fig. 481*. These can be stretched using the same mesh density as shown in *Fig. 484*.

Calculating missing links or simply drawing them?

In the absence of exact knowledge about departure sites and destinations, designers can sketch in the missing links with transparent, squared elastic paper. The design will alternatively consider first the network as the directing force and then the settlement site (Angremond, Kees d', Pieter Huisman et al. 1998; Jong, T.M. de 1998). However, very many exits would have to disappear to improve travel times and safety (Reuzer, Bart and Marijn Schenk 1999). Though, especially within towns, the national strategy is to reduce the number of orders at the expense of travel time, but in favour of an assumed safety (Duurzaam Veilig; Sustainable Safety Project). Therefore, the current travel benefit function remains calculable and negative. Is that what we want?

Networks between specialised cities



RECLUS, Les villes européennes (1989) and EREP-rapport, cited in Wolters-Noordhof (1996)

Fig. 850 *Population, socio-economic weight and connections in a radius of 1000 km.*

Fig. 850 gives a global impression of the population of central Europe in 1996, with the highest densities shown along the Rhine. This figure also shows those centres that score highly in a large number of socio-economic factors. The highest scores are for London, Paris and Milan. Centres of secondary importance are Brussels, Frankfurt and Munich. Amsterdam and Rotterdam are aligned with a large number of centres of tertiary importance. The beginnings of a 21st century network, with a mesh width of approximately 100 kmG are also visible in this figure. Southern Europe and the large population of eastern Europe are attempting to join this economic network. Railways parallel to the northern and western coasts form a forerunner and starting point for, what is still, a hypothetical 300 km grid (see Fig. 847.[74]

The Netherlands is situated in the corner of this grid, as a terminal with main ports for transfer to air and water.

6.1.8 References on adaptation and accomodation

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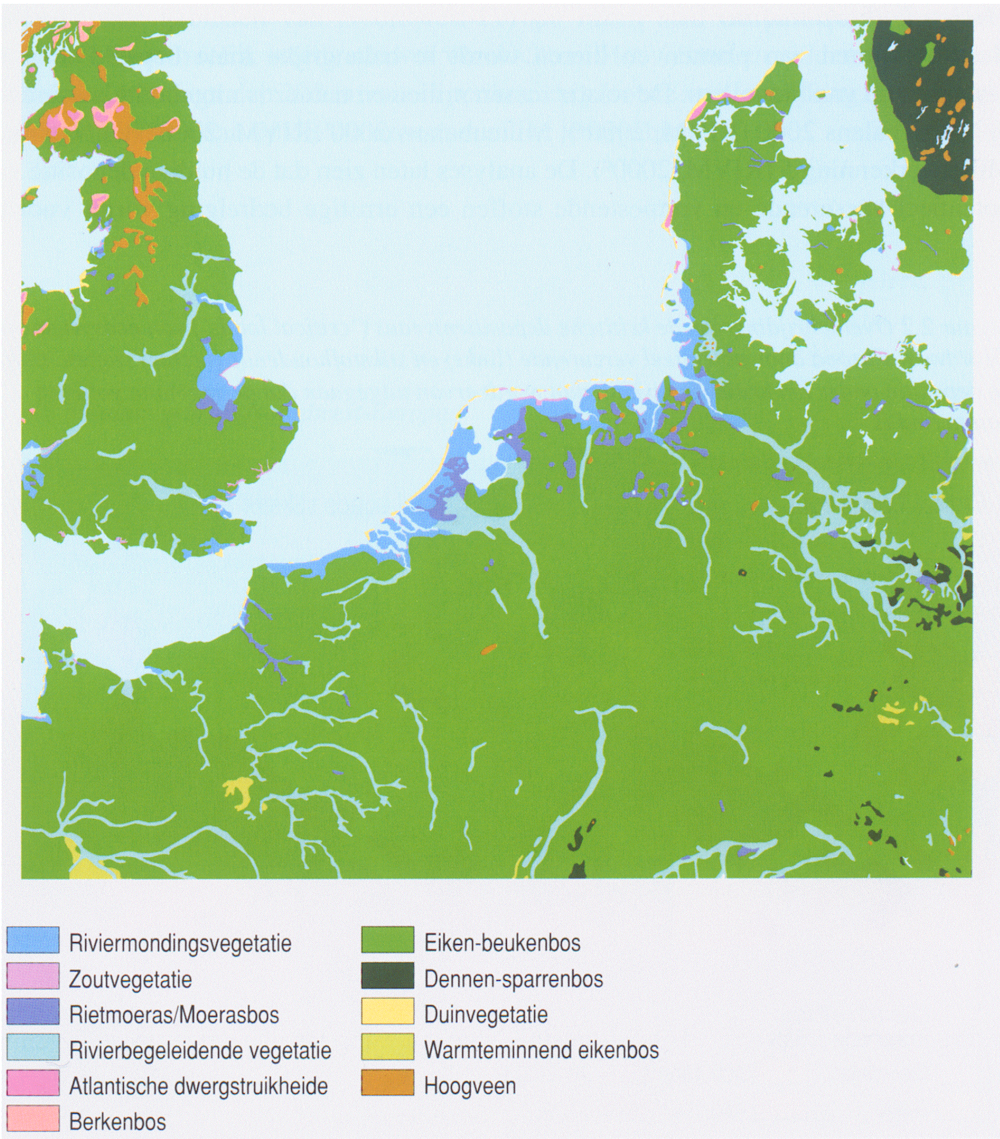
6.2 Habitat

6.2.1 Dutch heritage

The physical identity in Europe

At the end of the 20th century, due to a reduction of its market coupled with higher productivity, agriculture lost its primary position in national self-sufficiency. Globalisation leads to a division of tasks internationally as Steekelenburg (2001) elaborates. The main task for the Netherlands is trade and the conservation of rare natural areas.



RIVM (2001)

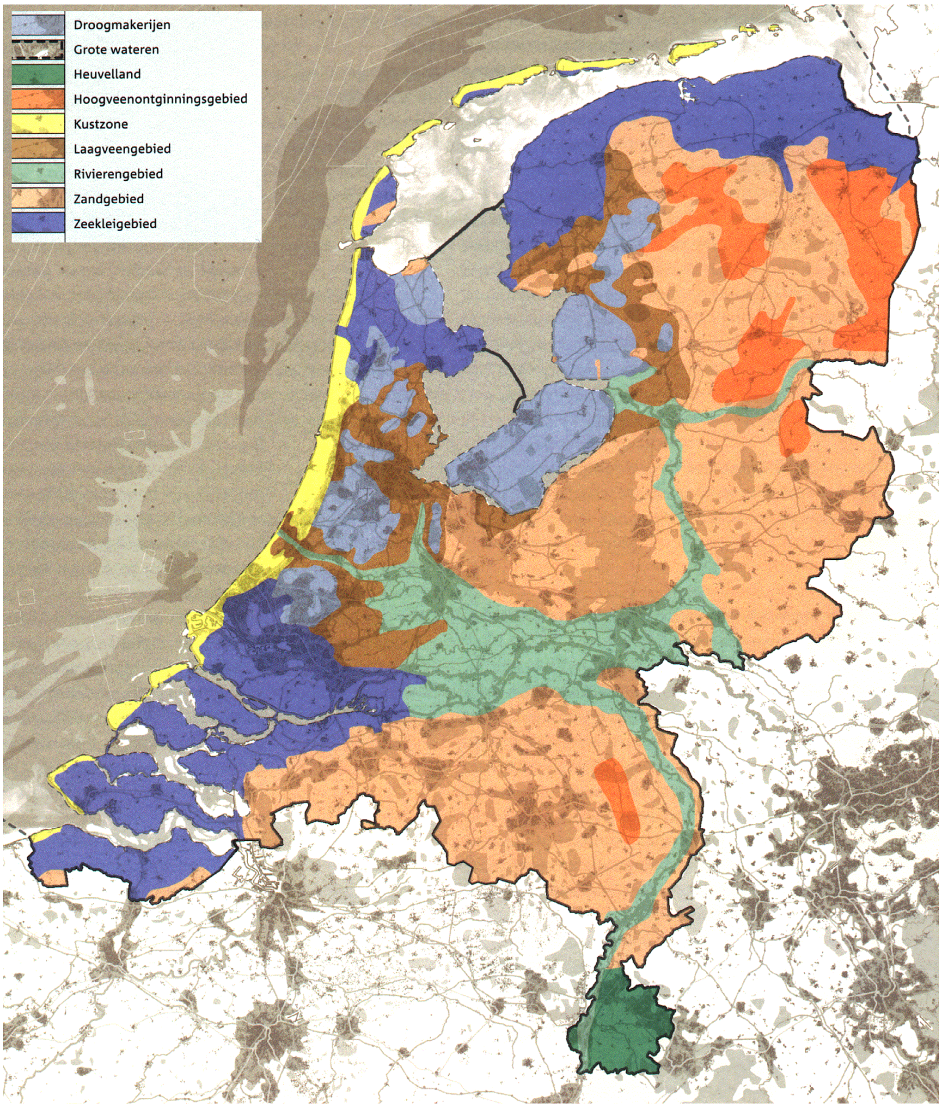
Fig. 851 *Potential natural vegetation*

The lowlands of Zeeland, Holland and Friesland as a whole, with a boundary consisting of young dunes and older ones, up to 5000 years old, together with their potential vegetations, are viewed as rare on a European scale, within a radius of at least 1000 km. Dyke construction has enlarged the area and diversity of the land in the course of a 1000 years, with Old Marine Clay polders and reclaimed land, albeit to the detriment of rare saline plant communities. By doing this, the largest area of potential estuarine vegetation in north-western Europe has come into being.

Further inland there is a just-as-rare and irreplaceable zone of potential reed swamp / swamp forest. 'From Amersfoort to the Urals, one does not encounter another landscape that is so full of big surprises' (Constandse, A.K. 1967). Further up-stream lies the largest, though less rare, area within this radius, of river-dependent vegetation.

Rare in The Netherlands, common in Europe

The sandy soils, situated on higher ground, form the beginnings of a potential European oak-beech forest. Although not a rare form of vegetation, these forests are highly valued nationally as recreation areas. Ecologically, pine forests in our country are viewed as recent, artificial anomalies.

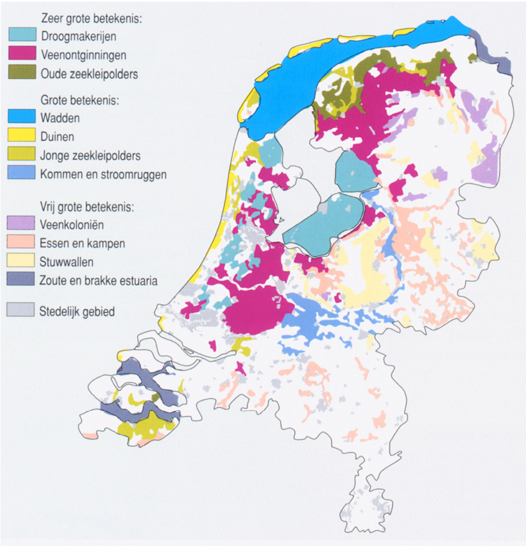


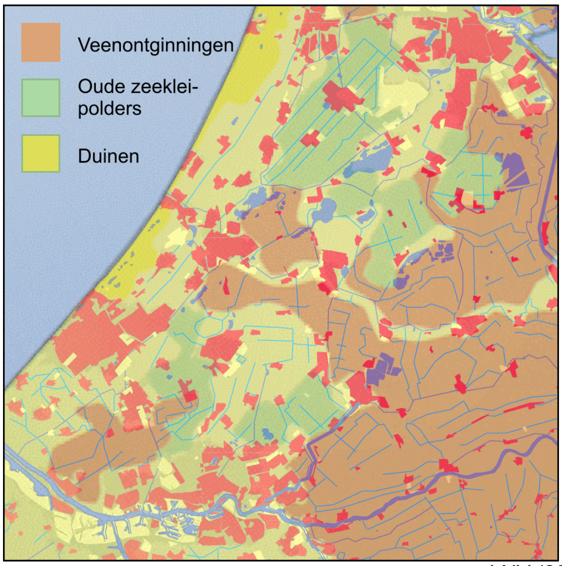
LNV (2002)

Fig. 852 *Nine types of landscape*

Rare in Europe, common in The Netherlands

If one looks in more detail at these important international possibilities (in a section of 60 x 60 km), then the landscapes of very great significance that one recognises are the Old Marine Clay polders, the reclaimed land and the peat exploitations in our country in the neighbourhood of Leiden. In addition, the mud flats (Wadden), the dunes, the Young Marine Clay polders, fluvial basins and ridges are also of great international importance. The landscape types identified by LNV show the Old Rhine to be an extension of the fluvial area, surrounded by areas of peat lying below the present water table (*laagveen*), bordering on areas of Marine Clay.On both sides of the Old Rhine there is an interesting series of potential transitions.





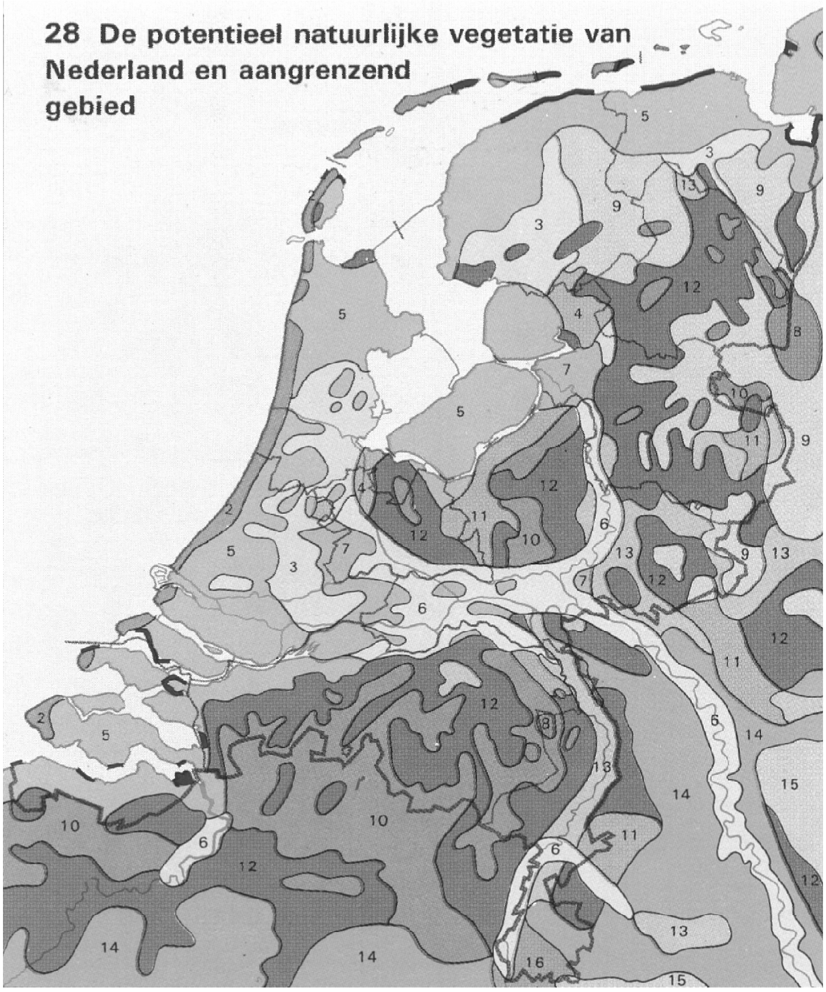
RIVM (2001) page 16 LNV (2002)

Fig. *853 Internationally important landscapes*

6.2.2 Human impact

The Netherlands undisturbed

If, apart from providing a stable system of water management, the Netherlands would be left undisturbed by human beings from now onwards, then the following forests would come into existence:



Legends

1	salt-marsh vegetation with, among other plants, sea lavender and salt-marsh grass: transitions from a salt to fresh-water environment.
2	dune heath, -grassland and -thicket, dune birch forest and dune oak forest, birch– common oak forest
3, 4	marsh fern–alder swamp, and similar
5, 6, 7	ash–elm forest, and similar
8	blanket bog, and similar
9	moist alder, birch, common oak forest
10	dry birch–common oak forest
11	moist durmast oak forest, and similar
12	dry durmast oak, and similar
13	oak–hornbeam, and similar
14	millet grass–beech, and similar
15	woodrush–beech forest with oak
16	beech forest, alder- and ash natural forest, and similar

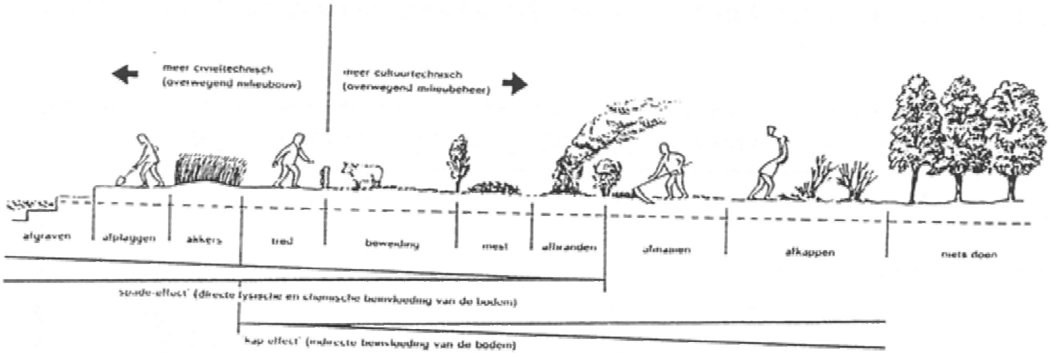
Sticht.Wetensch.Atlas_v.Nederland, Piket et al. (1987) page 13

Fig. 854 *Potential natural vegetation*.

Only where water floods the land regularly or for a lengthy time, where wind moves sand, and where grazing animals keep meadows in forests open[a] would vegetations other than forest be able to maintain themselves.

Human impact

Against the background of this 'nil variant', in the following paragraphs the effect of human intervention is demonstrated in images that have been developed by the University of Utrecht (see Fig. 26)[75].
The influence of humans expresses itself in draining, raising, hardening, digging up, treading upon, burning, systematic grazing, mowing, ploughing, harvesting, fertilising and polluting. Because of these activities, earlier stages of plant successions are kept in existence artificially.[76]

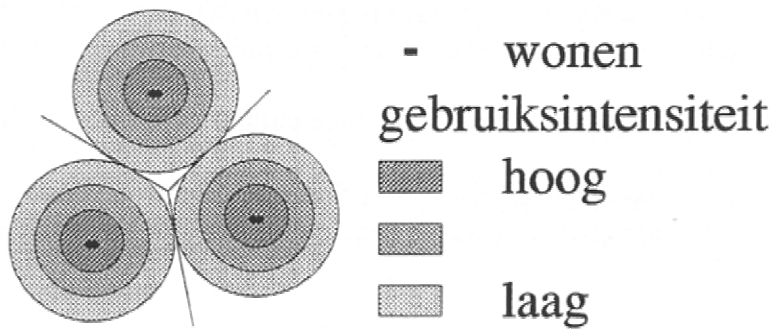


Leeuwen (1971)

Fig. 855 *Human interventions in relation to dynamics.*

Decreasing 'culturalness' around settlements

For centuries, this 'anthropogenically added dynamic' decreased with the distance from residential buildings



Thünen (1921), Leeuwen (1973)

Fig. 856 *Intensity-of-use gradients around farm and town*

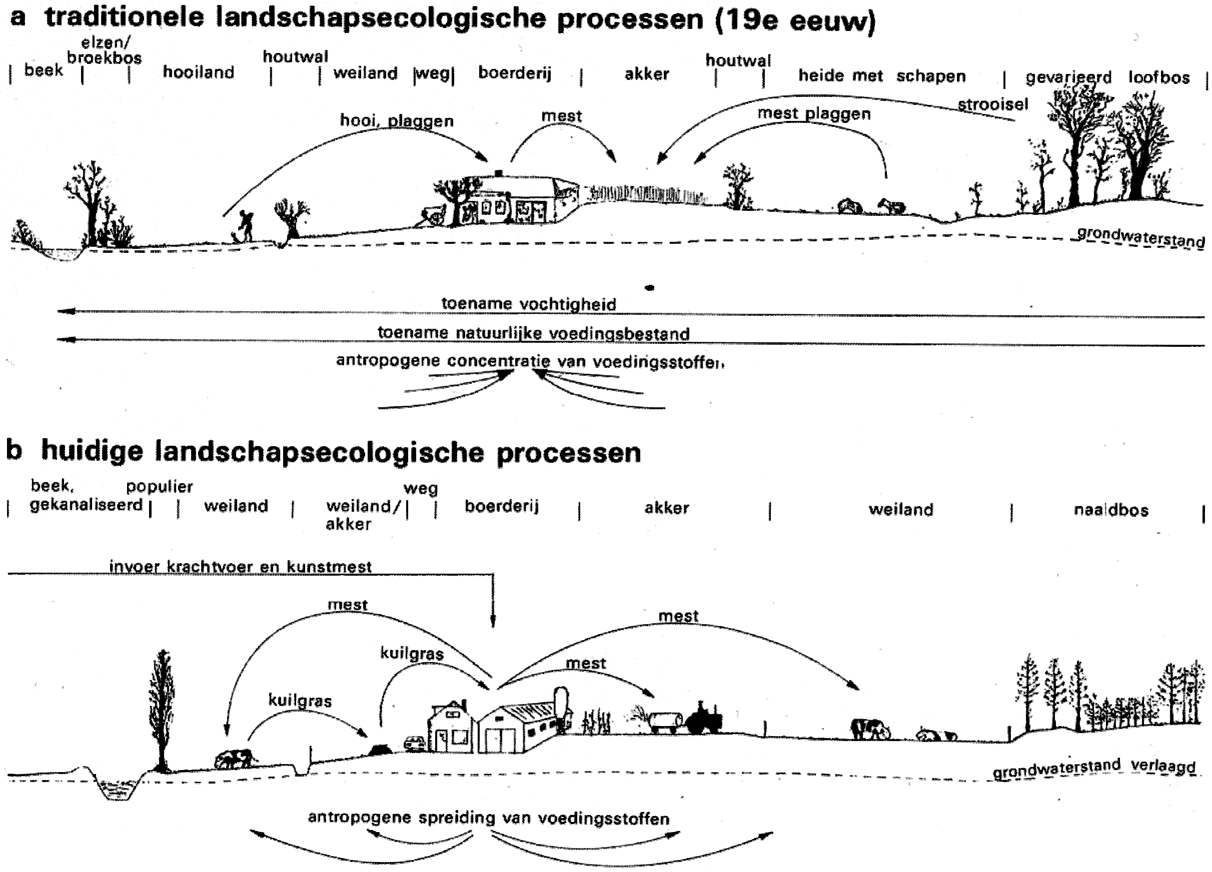
The intensity-of-use gradient around farms and towns was strengthened by a mineral gradient. For centuries, traditional agricultural systems have enriched local soils with minerals to the detriment of poorer soils further away, that thereby leave behind specialised, and thus rarer, types of vegetation, such as hay fields, heathlands, shrublands and forests. Where people stored minerals for use in agriculture, only a few rapidly maturing species grew there. However, where people removed them, an increasing diversity of slow-growing, but uncommon, specialist species, cooperating of necessity in ecosystems, grew undisturbed and in scarcity. Over the centuries, this has led to an increase in the number of plant species.[77]

Living between dry and wet

Farms and settlements on the high, infertile sandy soils were mostly situated along rivers and streams. On slopes between the lowest wet soils (known as 'green soils' in animal husbandry) and higher, drier

[a] Vera, F. (1997). Metaforen voor de wildernis. ('s-Gravenhage) Ministerie van Landbouw, Natuurbeheer en Visserij.

soils ('common lands' used as arable land) the nitrogen cycle used in mixed husbandry gave the best chances of survival. Fights took place to secure these scarce sites, so that, once established there, the tendency was to concentrate, organise and defend the common land. The result was a village (*esdorp*, in Dutch) built around a village green or *brink*. This concentric village shape contrasts sharply with the 'linear village' (*lijndorp*, in Dutch) from which, along both sides, and at 90º angles to the village street, strips of fertile but wetter peat soils were colonised and drained. In the *dijkdorp,* farmsteads, also positioned at 90º angles to the street were built on the higher, drier ground at the side of the street, which followed the highest line of the dyke.



Atlas van Nederland Part 16:18)

Fig. *857 Traditional and present-day ecological processes with respect to landscapes*

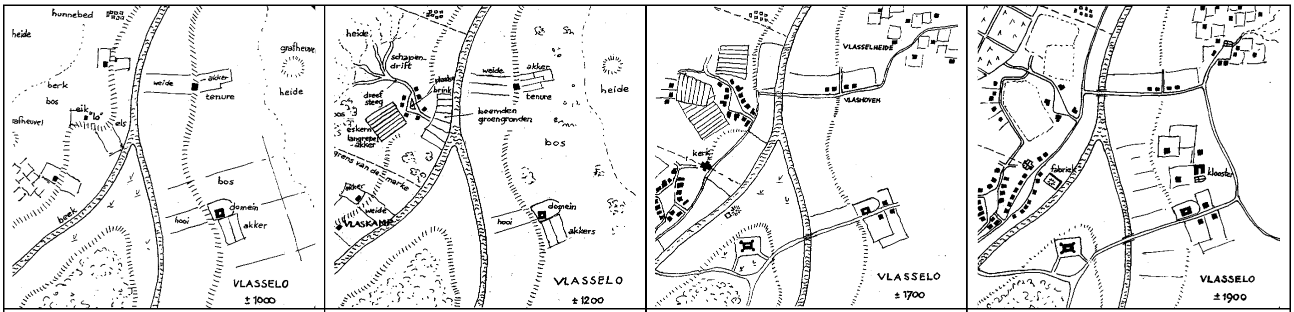
Homogeneity by artificial manure

Modern agricultural methods, especially the discovery of artificial manures round about 1900 have changed these developments drastically from rare, infertile and thus species-rich biotopes into biotopes that are equally fertile overall and thus to biotopes that are predictable, but with few species.[a]
78

[a] Nederland heeft overigens van nature een aantal zeer voedselrijke gronden zoals rivierafzettingen, zeeklei en loss.

Settlements on sandy grounds

In Fig. 858 Steegh (1985) designed a concept for the development of settlements on sandy ground



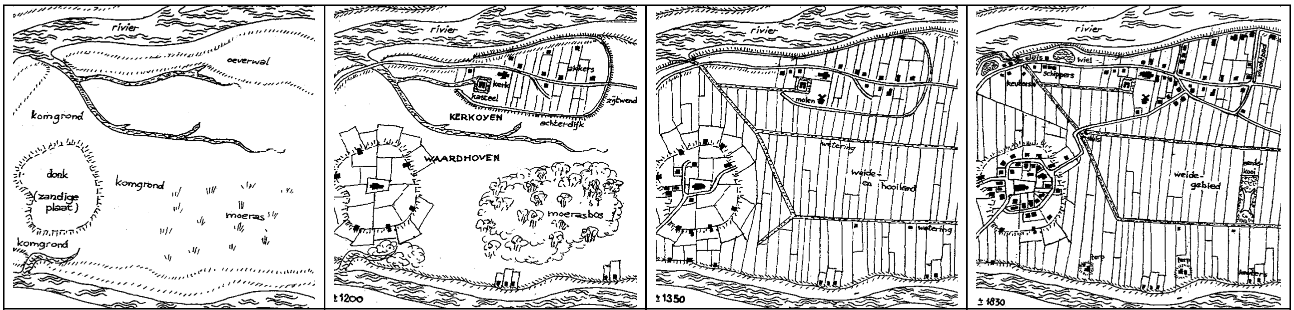
1000 na Chr.	1200	1700	1900

Steegh (1985)

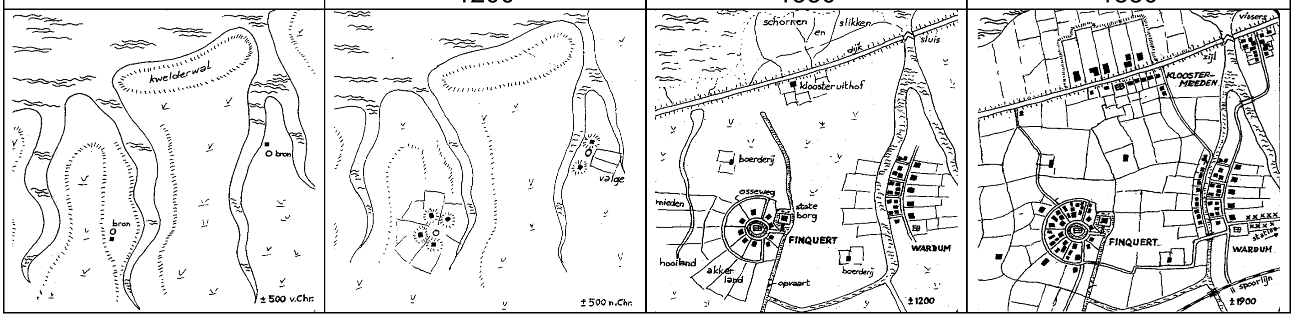
Fig. 858 *An ideal-typical development of a settlement on sandy ground.*

Terp villages on Marine Clay areas

However, the oldest settlements that are still recognisable date from Roman times. Since those times, churches, farms, and sometimes settlements, in coastal areas, especially in Groningen and Friesland, have been built on raised mounds of earth (a *terp*).(Fig. 859).



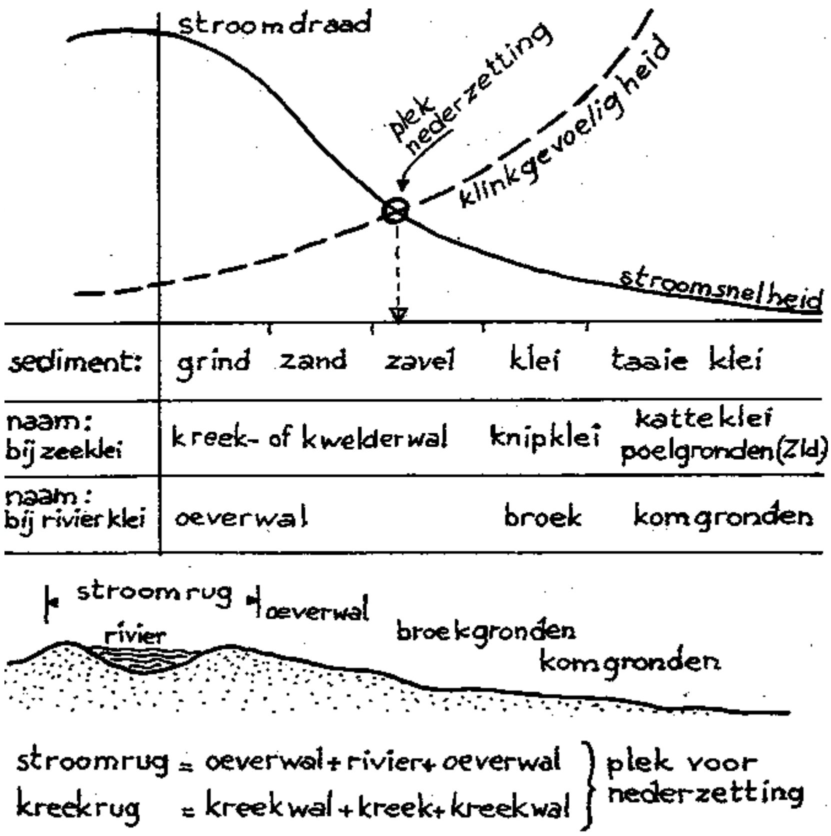
	1200	1350	1830



500 v. Chr	500 n. Chr	1200	1900

Steegh (1985)

Fig. 859 *The ideal-typical development of terp villages on Marine Clay areas.*

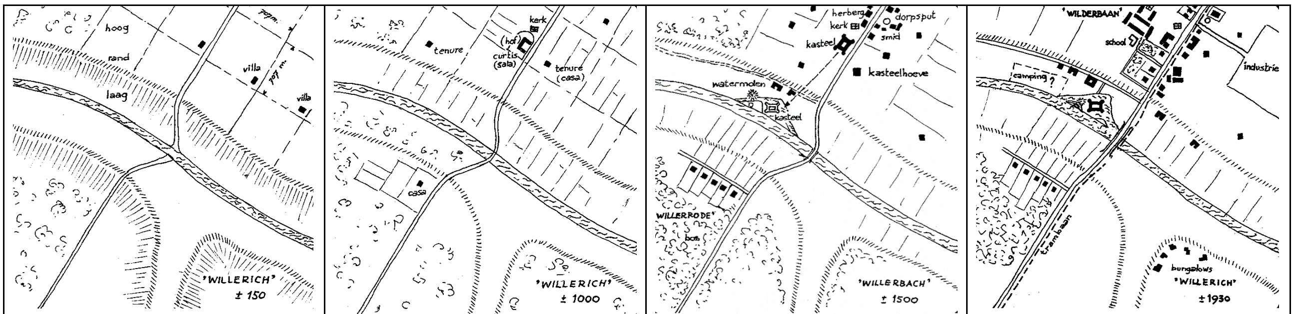


Steegh (1985)

Fig. 860 Historical conditions for situating settlements along the water's edge

Roman settlements on the loess soils of South Limburg

The best preserved land surveying outlines from the Roman times are of the loess region of South Limburg: an underlying NW-SE and NE-SW grid of 707 x 707 metres or fractions of this. By creating lots of land by cutting it into blocks ('quadrangulation') in this rational way, Roman army veterans were rewarded with a villa as a retirement present. Steegh (1985) shows how these developed further in his ideal types 'Willerich', 'Willerrode' and 'Wilderbaan' (Fig. 861).



150 na Chr.	1000	1500	1900

Steegh (1985)

Fig. 861 *The ideal typical development of settlements on the loess soils of South Limburg*

Development of these settlements in feudal times around 1000 AD

Following the decay of the Roman Empire, the feudal court system began to use material from the most strategically situated villas (not too high, not too low, along a road crossing a nearby stream or river) to build a *curtis* or *sala* with an encircling wall in the form of a shield from which the farms (*tenures* or *casae*) around were managed. The agrarian surplus was sent to the Lord of the Manor via the old Roman road. Since the time of Charlemagne, one tenth of the produce had to be given to the church, so the local manager built a church to collect these tythes himself and so that he only needed to maintain a priest. A smithy, brewery and safety-seeking small-holders formed a compact village centre and the *curtis* became the castle.

Development of street villages around 1500 AD

Wetter areas allowed a larger number of village wells to be dug, so these villages had a more dispersed shape. A tenant farmer, whose land bordered on water, who later gained independence, would divide his land among his children into a larger number of units. In this way, a street village was formed, comprising easily defendable ‘closed courtyards’. This is still a well-known type of farm building, even today, in the landscape of South Limburg. Millers’ dwellings were added to the water mills and the lord of the castle built a new castle with gardens bordering the water, thereby displacing a number of farms that had occupied that land.

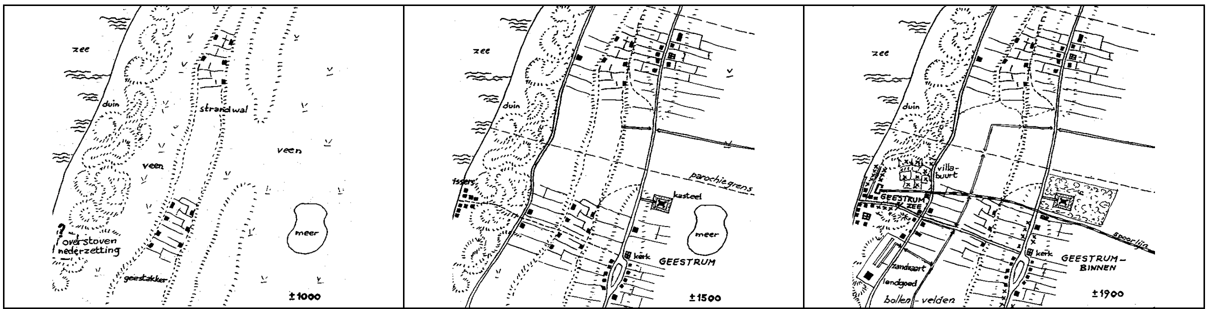
Later developments

Sometimes, the Lord of the Manor systematically developed waste ground into a street village such as ‘Willerrode’. The church remained on the site of the old castle in the centre of the village, where now the lord levied tolls, and an inn to accommodate the post stagecoach was built. After centuries of stagnation, the construction of a tramline to the coal mines in the vicinity brought about far-reaching changes. The inn became a centre for the mineworkers. The higher personnel built houses along the tramline and a mineworkers’ colony, ‘Wilderbaan’, grew up with its own shops, a new church and a patrons’cloister, financed by the mine owners, with boys and girls schools. Supply industries established themselves there with workers’ districts and bungalows built on sites which had the nicest views. On pages 161-162, Steegh (1985) names many villages where elements of ideal typical ‘Willerich’ are recognisable.

6.2.3 The last millennium

The Netherlands about 1000 AD

Round about 1000 AD, the human population lived on *terps* (in Friesland), along the rivers, behind the dunes, and, in a more dispersed form, on the sandy soils.



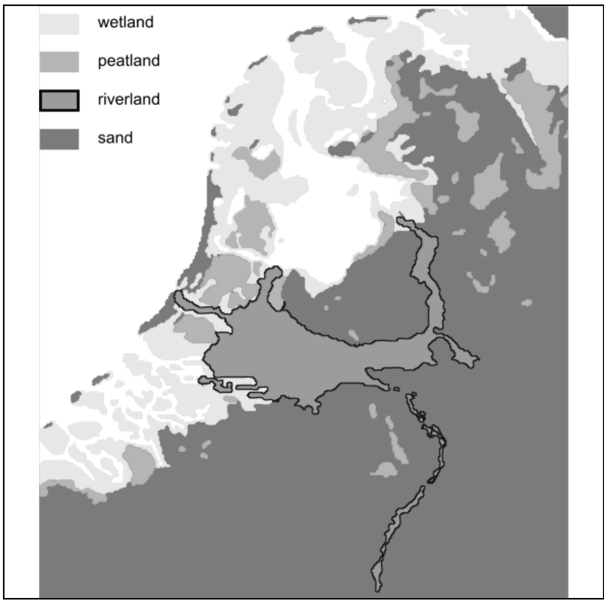
1000	1500	1900

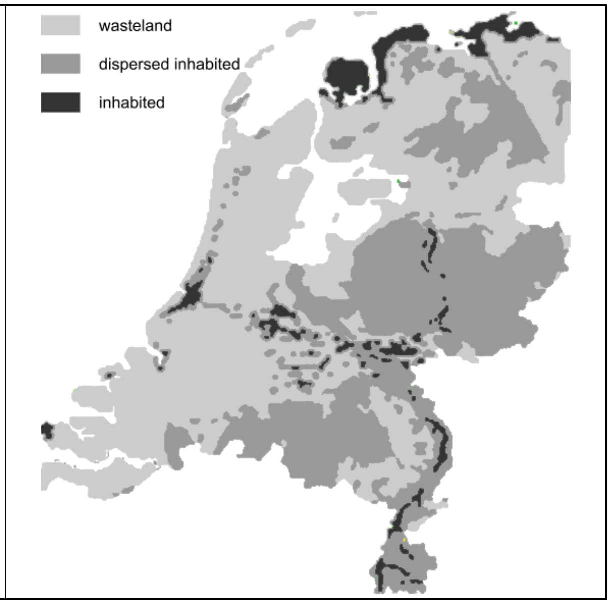
Steegh (1985)

Fig. 862 *The ideal typical development of settlements on sandy soils behind the dunes*

After 1000 AD

From 1000 AD onwards it is people who have determined the appearance of the Netherlands. No longer they adapted their life to the country, they started to accommodate the country to their life (see Fig. 26, *Fig. 863* and *Fig. 864* are enlargements).





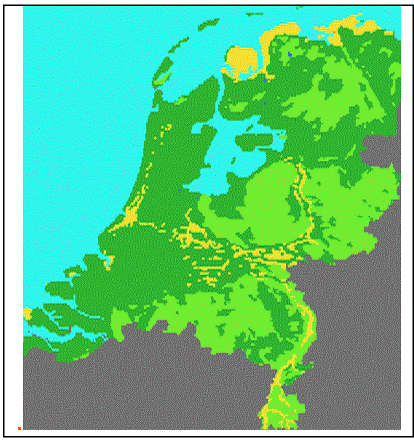
University of Utrecht

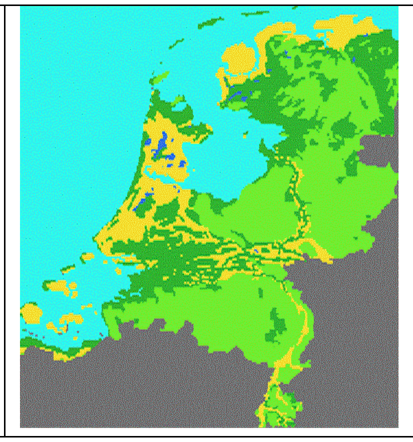
Fig. 863 Natural regions before 1000 AD

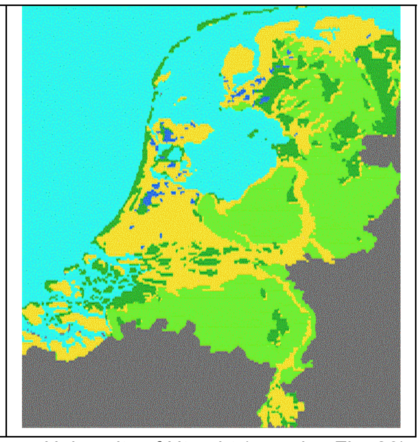
Fig. 864 Settlements in the Netherlands about 1000 AD

Rising sea level

After about 1000 AD, the sea advanced in the south of the country. The Delta waterways came into existence, but the free play of water and land was prevented by dams built by the rapidly growing population.







University of Utrecht (see also Fig. 26)

Fig. 865 *(*Fig. 864*) 1000 AD.*

Fig. 866 *1100 AD*

Fig. 867 *1300*

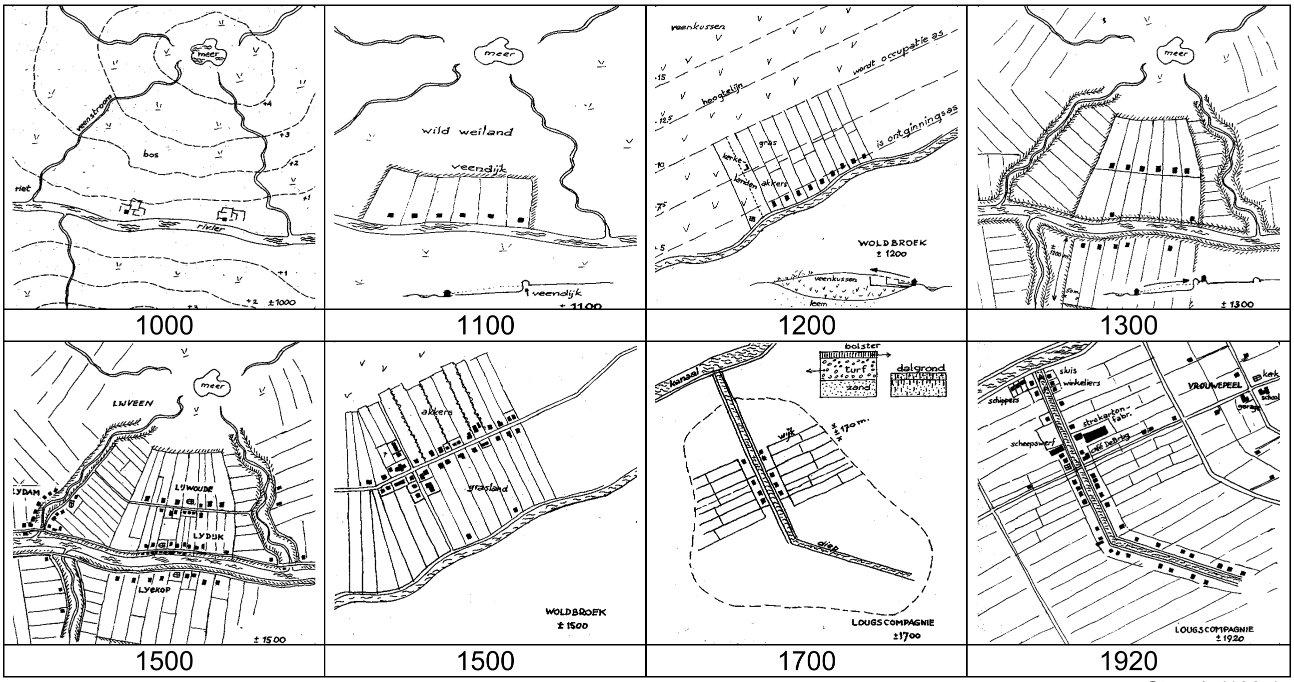
Land, no longer on loan from the Emperor: the end of feudalism

The ecological history of the low-lying lands is closely linked to reproduction, family links, illnesses and occupations, in short, to the ecology of the human species.
Count Dirk II married a descendant of Charlemagne and, in 987, was granted full ownership of his fiefdom in North Holland by Emperor Otto III. Dirk III extended the fiefdom to include wet lands in the south. The only people who lived there at that time, were those living along the Old Rhine and at its mouth, at Leiden (Lede, water course Vries (1962)). In 1063, Dirk V was the first to adopt the title

Count of Holland, but it was not until approximately 1100 that the name Holland came to be used for the whole county. What happened during that century?

Making your own land

There is evidence of an enormous expansion in agriculture and settlement in the centuries immediately subsequent to 1000 AD. In particular, people learnt how to reclaim and cultivate peat bog (fen).

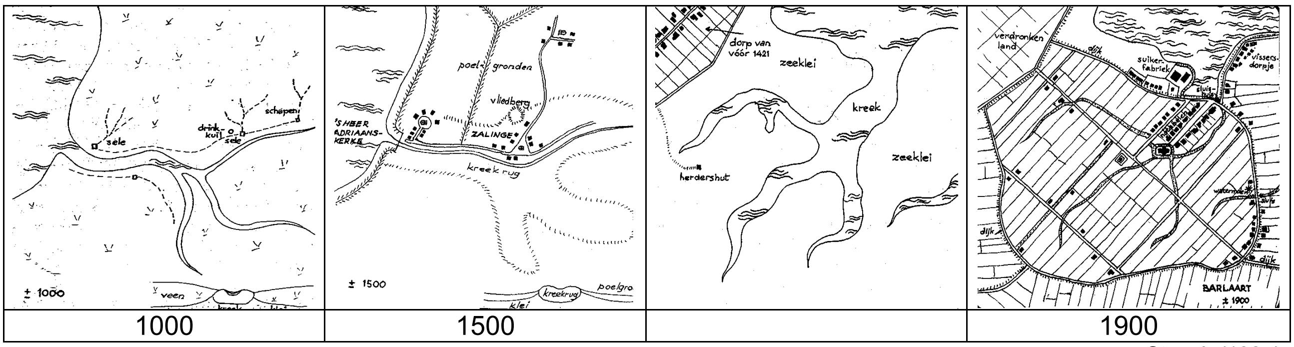


Steegh (1985)

Fig. 868 *The ideal typical development of old and new peat settlements*

Colonisation

In the course of a century, the Netherlands was far-reachingly colonised. There were a number of small towns at this time. Around 1300, these towns began to grow. There was also growth on the sandy grounds, and forests started to disappear. The sea retreated in some places and advanced in others. By about 1300, there was hardly any ‘nature’ left any more.



Steegh (1985)

Fig. 869 *The ideal typical development of new settlements on the clay soils*

The reconstruction made by the University of Utrecht for NNAO (see Fig. 26) shows an unmatched colonisation of these low-lying lands. The first dateable information about the participation of Dutch farmers in the colonisation of peat areas in eastern Germany (Hollerbroek) appeared in 1113. These farmers were especially welcome because of their skills in draining low-lying areas.

Democratic water boards
Dirk VII's brother, Count Willem I, had a grandson, Floris V, 'The blokes' God', who was married with Beatrix. By founding democratic water boards, he prioritised agrarian development that was based on the growth of population resulting from draining the land. He met with resistance from feudal aristocracy, such as Gijsbrecht van Amstel, who were becoming empoverished, which, in 1296, cost him his life.

Growing wealth replacing taxes by toll
Towns, and particularly Dordrecht, were centres for the toll system of Holland and needed to extend the trading basis on which they were founded. Most of them were granted their town charter in the 13th century. This was the century during which the influence of Holland grew to such an extent that Count Willem II became the Holy Roman King of Germany with his polder model. The Pope was making preparations to crown him as emperor when he was beaten to death on the slippery Friesian ice. However, his grand nephew, Willem III, was able to marry the daughter of the French king and arrange marriages for his own daughters to the English king, Edward III and the Bavarian emperor, Ludwig.

Feudal interference
However, that last-mentioned strategy led to renewed feudal interference. The emperor went fishing for the fattened cod that Otto III had allowed to slip off his hook (the Hook and Cod Disputes (*de Hoekse en Kabeljauwse Twisten*[a])). Struggling to free themselves from the aristocratic–feudal 'Hooks' were the 'Cod'-supporting farmers and citizens, such as those of Delft.

Ecological influences on trade economy
The County of Holland remained relatively free from the pest epidemics that had brought about a demographic reversal in Flanders and the towns of the Hanseatic League. Bruges partly lost its cloth trade to Holland (Leiden). The movement of herring shoals from the Baltic Sea to the North Sea, and herring gutting skills that had been discovered in the mean time, gave fishermen there an ecological advantage. They sailed to wool-rich England and gradually took over the freight trade. After 1500, partly due to the St. Elizabeth flood in 1421, Dordrecht was forced to relinquish its position as main port to Delft, Rotterdam and Amsterdam. After the Treaty of Utrecht in 1475, the towns of Holland took over the Baltic trade from the Hanse as Jansen (1995) describes. Counts became Stadtholders. For one more century Holland accepted a foreign head-of-state before starting to fight for definitive freedom.

Crucial waterways
The making of dykes, widespread partition of land and draining in Holland encouraged population growth. This caused the peat areas to settle and allowed little by way of occupation other than animal husbandry, fishing and shipping. For this reason, the Hollanders were dependent on grain from the regions around the Baltic Sea. Fortunately, the Hanse preferred to transport their Baltic goods via the, in the mean time deepened, waterways of Holland, to their entrepot in Bruges, than over the dangerous North Sea. In exchange for the much reduced damage to their ships by using this route, the Hanseatic League paid tolls to the Counts of Holland.

Tax relief, Republic and Public Works
This income for the Counts brought tax relief to the farmers. As they had made their own land, they no longer saw themselves as being bound by the requirements of the feudal system (Jansen (1965)). Uneven economic growth reduced any natural areas that still existed to a few areas of blanket bog. The low-lying peat bogs were used as fuel, and winds exposed the underlying Marine Clay. The Mast Forest in Breda was planted to provide shipping with masts. However, the impulse of Golden Age slowed down when people began to live off their private means instead of investing. This resulted in the wet land of Woud (1987)[b] being left behind and caused the French to establish a department of Public Works in 1798.

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[a] Jong, Taeke M. de (2004) Schaalgeleding bij Hoeken en Kabeljauwen (Zoetermeer) MESO http://team.bk.tudelft.nl/ > Publications 2004

[b] Woud, A. v. d. (1987). Het lege land. De Ruimtelijke Orde van Nederland 1798-1848 (Proefschrift). (Amsterdam) Meulenhoff informatief.

The first Republic since Rome: The United States of The Netherlands

Then, in 1585, Antwerp capitulated to the Spaniards, led by the Duke of Parma. Antwerp, with its multicultural way of life and its urban hinterland, had become the trading centre of the 16th century world. It was the northern entrepot for products from countries around the Indian Ocean as Bouman (1979) describes. This is where modern banking and economic individualism bundled into companies began. During the following four years, almost half (approx. 38,000 people) of its largely Protestant inhabitants fled to the north as Israel (1995) describes, thereby laying the *laissez faire* foundations of the partly immigrant-inhabited metropole of Holland and its trade emperium.The French did not help the young Republic gain acceptance and sovereignity, as the Orange's continued to hope, but they did help by diverting the attention of Philip II, and thus the Duke of Parma, southwards. That gave Maurits opportunities and Van Oldenbarneveld succeeded in bringing competing parties together to form the VOC. That Maurits continued to believe in predestination, and thus in aristocracy, cost Van Oldenbarneveld his life.

The early urbanisation of Holland

Around 1550: more than half of the population of Holland lived in towns that had grown up for the purpose of conducting trade.

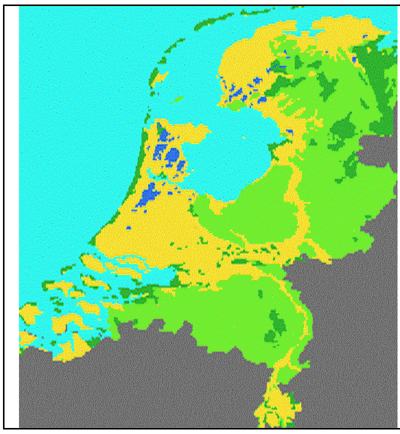
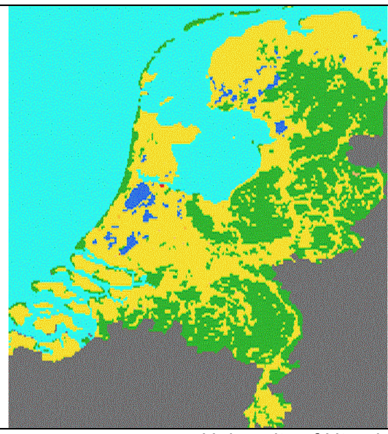


Fig. 870 *1550*

Fig. 871 *1675*



University of Utrecht

Fig. 872 *1800*

The Golden Age and the economic decline that followed.

Around 1675: the towns in the west had grown fast. A network of tow-barge canals had come into existence.[15] Development on the sandy soils had come to a halt.
Around 1800: following the impoldering of North Holland, large areas of blanket bog were reclaimed. More dykes were built. From a hydraulic point of view, the land was in a deplorable state.[16]

Recovering land and nature

This is how the relatively recent nature of the Netherlands, has come into existence. It is so different from anywhere else in Europe that a separate legend unit is needed to register it on the European nature map of Bohn[a] (see Fig. 851). The task of impoldering the land was completed with the use of the steam engine. To work on the remaining 'waste grounds', the Heide- and Grondmij were established at the end of the 19th century. These relatively new natural areas were later reduced again to provide employment during the 1930s, when unemployment levels were so high.

Artificial fertilisers

Artificial fertilisers were discovered round about 1900. Since then, fertilising areas of soils with low-mineral content has favoured rapidly maturing crops, to the detriment of slowly maturing specialist species. Animal husbandry, drainage and atmospheric deposition have all contributed to this process. Just as it is easier to dissolve sugar in coffee than to take it out again, so will much time be needed before these levels of fertilisation are cut down. For this reason, it is not just rarity expressed in

[a] Bohn, U., G. Gollub, et al., Eds. (2000) Map of the Natural Vegetation of Europe scale 1: 2.5 million BN Bundesambt für Naturschutz (Bonn) Federal Agency for Nature Conservation.

kilometres that counts, but also (ir)replaceability in years. One can use the product of these two values to gauge the value of natural areas against the rarity and replaceability of human artifacts.

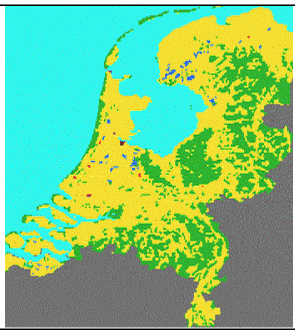
Recent centuries

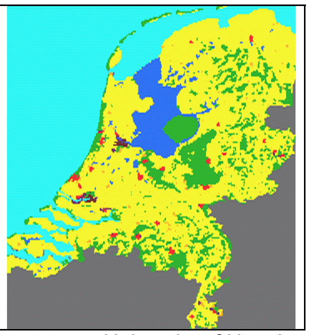
Around 1850: the growth of industry in Twente and in North Brabant. Impoldering of lakes caused by peat exploitation in the western fenlands. The digging out the peat of the blanket bogs of the higher eastern areas.

Around 1900: western areas were still the most urbanised. The population of Amsterdam exceeded 500,000. The railway network was completed.

Around 1930: industrialisation on the sandy soils reached a peak. Conurbations began to form everywhere.

Around 1960: land reclamation and the Delta works, in addition to large urban and industrial expansion.



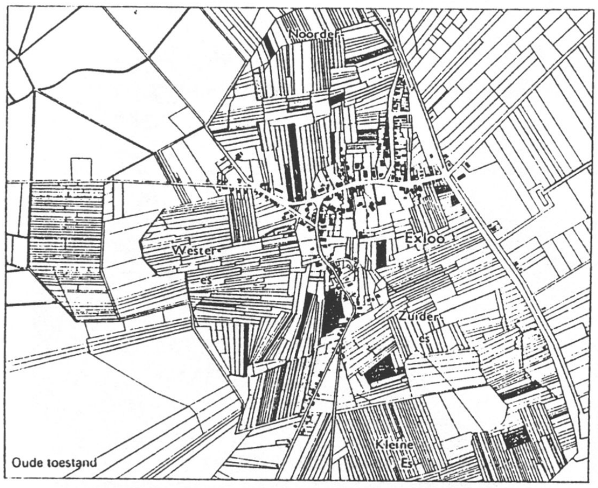
University of Utrecht

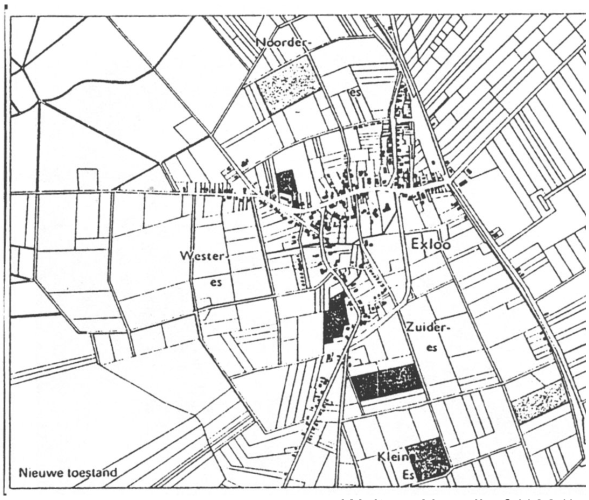
Fig. 873 *1850* Fig. 874 *1900* Fig. 875 *1930* Fig. 876 *1960*

In the second half of the 19th century, two cultivation associations, the Heidemij and the Grontmij were established to bring new nature areas under cultivation again, that had originated since the Golden Age.

Land consolidation and nature management

These associations played an important role in land consolidation (ruilverkaveling).

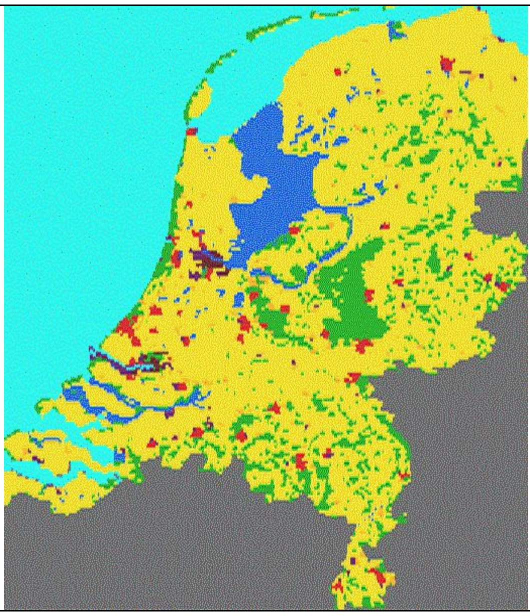


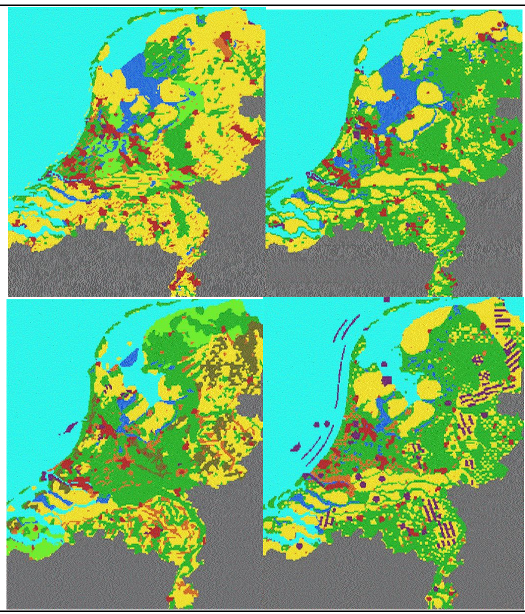


Wolters-Noordhof (1981)

Fig. 877 *Before land consolidation* Fig. 878 *After land consolidation*

An interest in nature conservation and management arose at the beginning of the 1900s. Since 1970, there has been an increasing interest in managing nature and in introducing policies to conserve nature by consolidating land. At present, land consolidation is also an instrument to nature conservancy policy-makers (in riverine and peat bog areas).
Road and air transport play a large new role, but a threatened environment requires a place of its own, too.





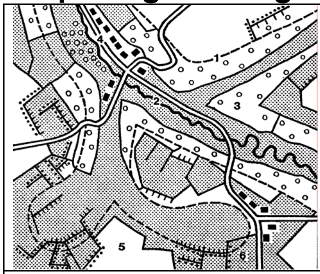
NNAO (1987; NNAO (1987)

Fig. 879 The Netherlands in 1989

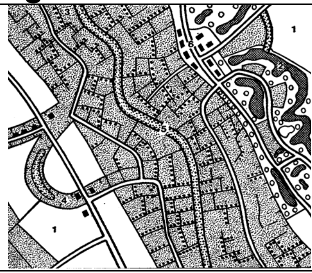
Fig. 880 *Ideas for 2050*

6.2.4 Reading topographical maps (Visser)

Map images of higher grounds in The Netherlands

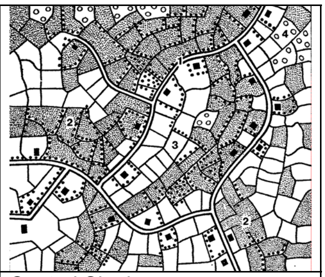


South Limburg
1. edge of valley
2. stream
3. wooded side of valley
4. settlement
5. arable land
6. grassland with wooded banks

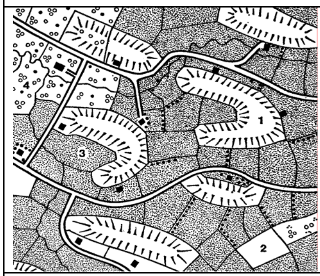


North-Limburg
1. arable land on a fluvial terrace
2. old fluvial dunes
3. hedged landscape
4. old fluvial beds
5. river
6. settlement

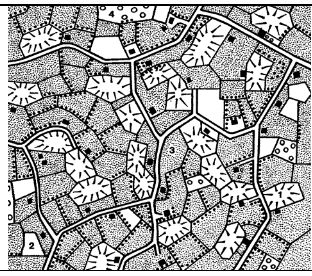
North -Brabant
1. dune ridge (duinrug)
2. small peat bog/fen mere
3. stream
4. woodland along a stream
5. settlement on old arable land
6. fluvial- or water meadows
7. cultivated land outside the valley of a stream
8. planted forest



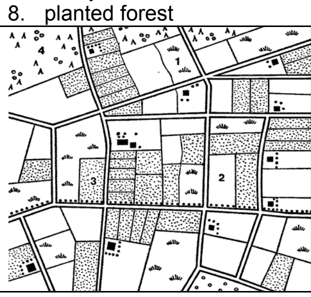
Central Slenk
1. road
2. grassland
3. arable land
4. remains of a woodland



Wind-borne sand dunes
1. parabolic-shaped sand dune
2. small arable field on flatter terrain
3. grassland between hill ridges
4. woods on a country estate



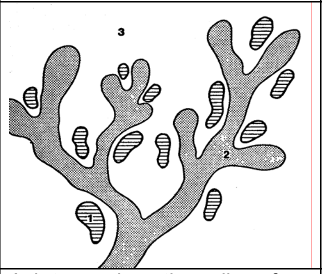
Achterhoek
1. hill with old arable land
2. little field on plain surface
3. grassland of lower grounds
4. little wood



heathland reclamation
1. heath
2. field
3. grassland
4. wood

Lateral moraines of East-Twente
1. contour of lateral moraines (stuwwal)
2. old farmland on flank of lateral moraine
3. grassland surrounded by wood on moisty grounds
4. settlement
5. wet woods (broekbos)
6. grassland of younger relamations
7. farmland of younger relamations
8. planted coniferous wood

Lateral moraines of West Twente
1. contour of lateral moraine (stuwwal)
2. meltwater ridge
3. settlement
4. old farmland on Eastern flank of lateral moraine
5. grassland on moisty plans
6. heath
7. planted coniferous wood

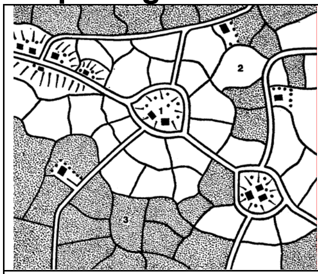
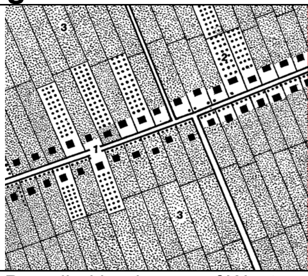
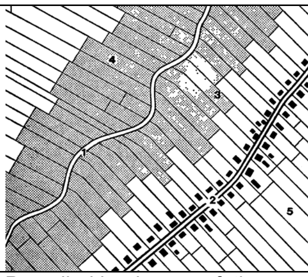
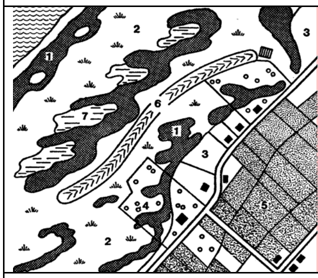
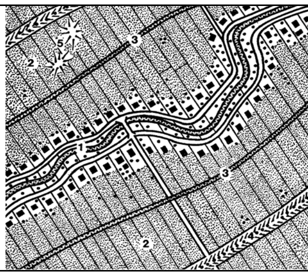
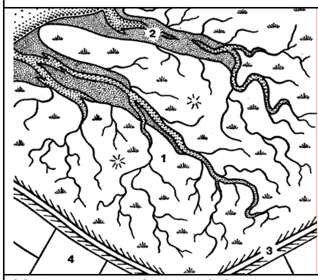
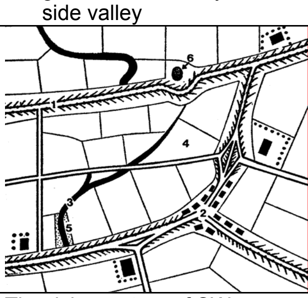
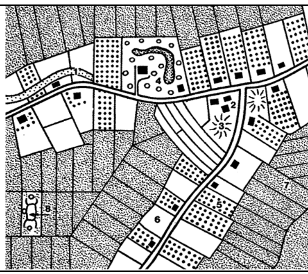
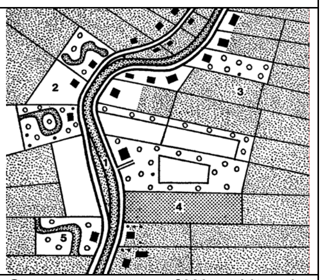


Ash trees along the valley of a stream
1. field (es)
2. stream valley (beekdal)
3. tableland

Visscher (1972)

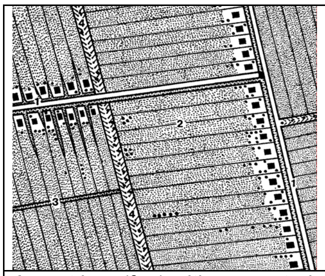
Fig. 881 Landscape elements on maps of higher grounds in The Netherlands

Map images of lower grounds in The Netherlands

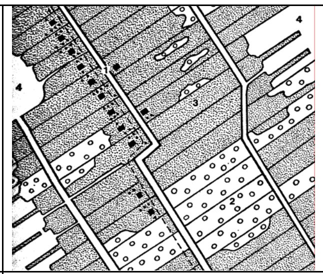
			
terp landscape 1. terp with buildings 2. field 3. grassland	Parcelled landscape of West Friesland elongated lots 1. regional village (streekdorp) 2. orchard 3. grassland	Parcelled landscape of the northern Netherlands (slagenlandschap) 1. stream 2. road village (wegdorp) 3. lot border 4. grassland 5. farmland (bouwland)	
			
Water collection on dune landscapes 1. dune ridge 2. lower part of dune area 3. digged perpendicular watercourse (dwarswetering) 4. small wood dyke (houtkade) bordering village area 5. surface dune relic (donk)	Beach banks between Leidenand Haarlem (strandwal) 1. road village 2. country estate on ridge 3. wet wood on sea side valley 4. canal for shipping digged sand 5. bulb field on digged part of sea side ridge 6. grassland in moisty sea side valley	peat bog area with peat stream 1. stream with regional village 2. grassland 3. digged perpendicular watercourse 4. small wood dyke bordering village area 5. surface dune relics	
			
Nature areas beyond the dyke(s) in South West Netherlands 1. salt marsh (schor) 2. mud flat (slik) 3. sea dyke 4. farmland	The dyke system of SW Netherlands 1. dyke planted with trees 2. dyke village 3. creek relic 4. farmland 5. grassland on creek bed 6. pool as relic of bursting of the dike (wiel)	Fluvial landscape 1. abandoned river bed 2. settlement 3. raised old arable land 4. country estate 5. orchard 6. field 7. grassland	Country estates of West Utrecht 1. river 2. field 3. grassland 4. orchard 5. country estate

Visscher (1972)

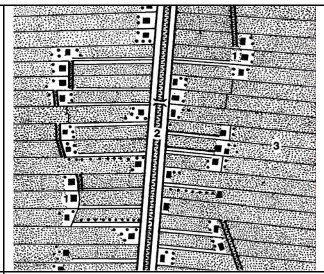
Fig. 882 *Landscape elements on maps of lower grounds in The Netherlands*



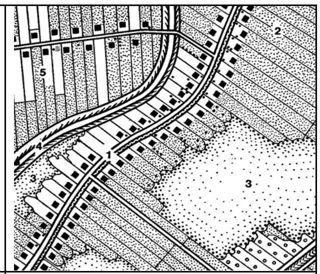
A peat bog (fen) with excavated waterways
1. regional village
2. grassland
3. digged perpendicular watercourse
4. small wood dyke



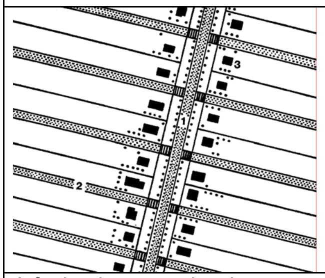
The peat bogs (fens) of NW Overijssel
1. water region village alongside watercourse
2. marsh wood (moerasbos)
3. grassland
4. pool from peat extraction



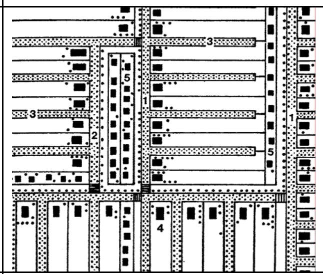
The peat bog (fen) at Kamerik
1. buildings on clay ridge
2. canal with rest of building alongside
3. grassland parceled out in strips



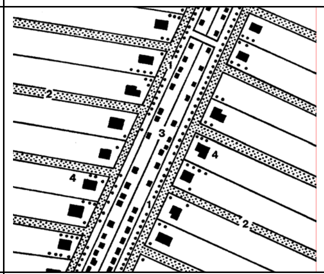
A peat bog (fen) with lakes and drainage systems
1. regional village
2. grassland
3. lake (plas)
4. ring-dyke
5. polder with grassland and field



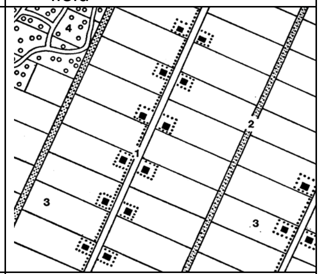
A fenland community along a canal
1. canal
2. perpendicular canal (wijk)
3. farm



Fenland communities along canals
1. canal
2. back canal (achterdiep)
3. perpendicular canal (wijk)
4. peat extraction with farm
5. strip with dwellings



Fen community along a canal that gives dual access '
1. road alongside canal
2. perpendicular canal (wijk)
3. strip with dwellings
4. farm



North-east polder (*Noordoostpolder*)
1. road with farms surrounded by wood belts
2. canal
3. fields
4. wood with unimproved roads

Visscher (1972)

Fig. 883 More recent landscape elements on maps of lower grounds in The Netherlands

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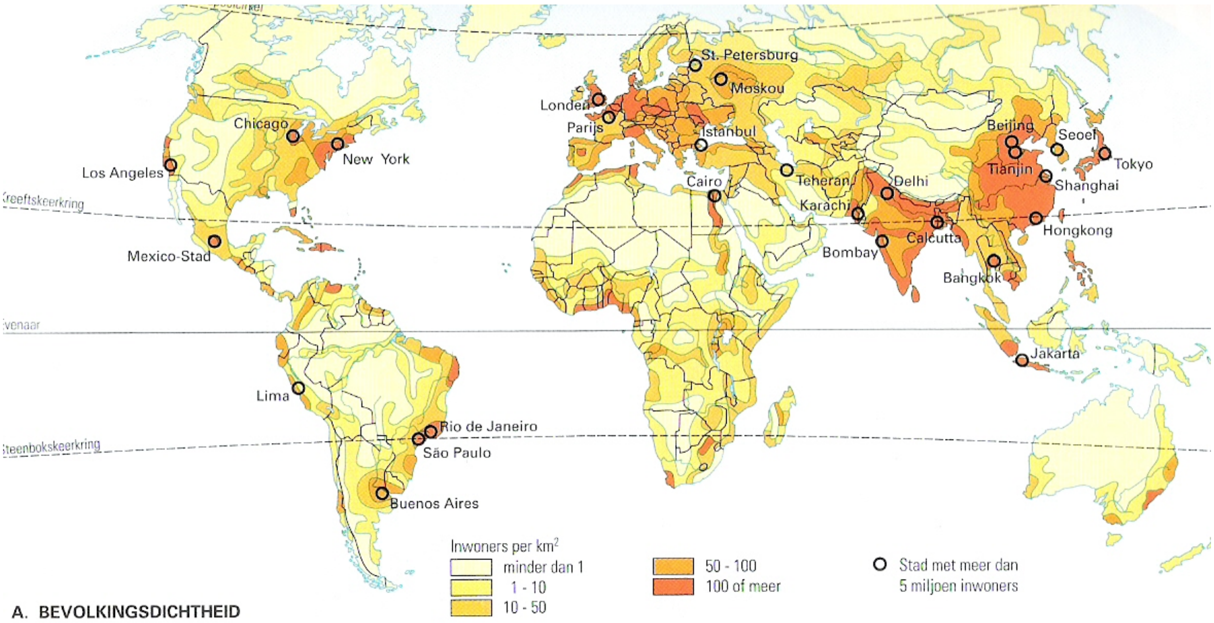
6.3 Density

6.3.1 Global densities$_{10\,000km}$

The Earth's surface counts 511 185 932 km^2 and 6 501 085 722 humans (estimation march 3rd 2006)[a]. So, the gross population-density is nearly 13 inhabitants per km^2 (nearly 8 ha per person).



Bosatlas(1996)

Fig. 884 Global density from <1 until >100 inhabitants per km^2

However, people usually do not live in the sea. The net population-density *on land* is about 44 inhabitants per km^2 (about 2 ha land per person), because about 29% of the Earth's surface is land. So, the measure of density is most dependent on the kind of surface you take into account.

6.3.2 Gross and net density

Having excluded the oceans as tare surface to measure globally net human density on the Earth's surface, the question arises if, on continental level, you should take all land into account, including the arctic areas, mountains, deserts, forests (continentally gross), or only the habitable land (continentally net). After all, for application in urban design, the aim is to compare inhabited areas. If so, what is habitable land? Looking at Fig. 884, many areas count less than 1 inhabitant per km^2, mostly useless for agriculture and sustainable settlement. We can call that 'tare surface' on a continental level (see *Fig. 885*). The remaining 'net surface' with a higher ('net') density, usable for any form of settlement, we can call 'habitable land'.

Higher level	**gross**		
	net		**tare**
Lower level	gross		
	net	tare	

Fig. 885 Net, tare and gross on different levels of scale

However, most of these habitable surfaces are actually used for agriculture, some for urban concentrations. These urban areas sometimes count more than 5000 inhabitants per km^2 (50 inhabitants per ha). Urban areas are most interesting to us if we would like to compare metropolises, conurbations, towns, districts, neighbourhoods and so on. Going on systematically with

[a] http://www.census.gov/ipc/www/world.html

the interval boundaries 1-10-50-100 into 500-1000-5000 in the legend of Fig. 884, the legend units of highest density would become invisible on the scale of the map. Moreover, the intervals are not equal. That means the shown pattern is accidental. The pattern is changing by the choice of intervals. They are chosen to produce the most striking pattern, but if population grows, the chosen intervals may become insufficient to see any pattern. Moreover, on an urban scale we are most interested in subdivisions between 1000 and 10000. So, changing scale to visualise details we have to skip the lowest densities calling them 'tare'.

6.3.3 A binary legend: net and tare surface

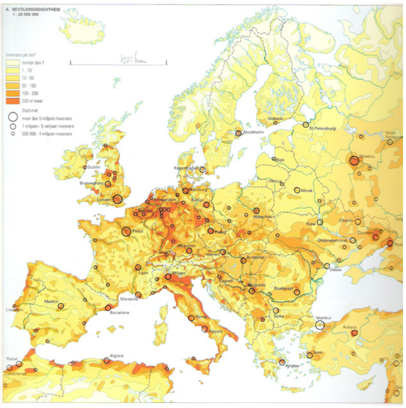
On any level of scale from the gross surface you can subtract relatively unused areas as 'tare surface', resulting in gross and net density. On a lower level of scale the net surface becomes gross surface from which you can subtract other kinds of tare. So, to compare densities properly, you have to distinguish levels of scale, each with its own legend (see *Fig. 886*) to determine gross and net density.

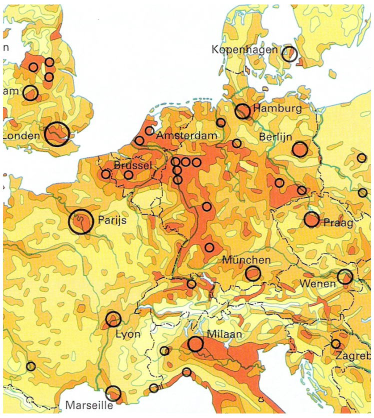
	m nominal radius		**binary legend**	
Name frame	**frame**	**grain**	**net**	**tare**
Global	10 000 000	1 000 000	continents	oceans
Continental	3 000 000	300 000	habitable lands	lakes and waste lands
Subcontinental	1 000 000	100 000	urbanised areas	rural areas
National	300 000	30 000	urban networks	landscapes
Subnationaal	100 000	10 000	urban regions	landscape parks
Regional	30 000	3 000	conurbations	town landscapes
Subregional	10 000	1 000	towns, quarters	town parks
Urban, local	3 000	300	districts, villages	district parks
District	1 000	100	neighbourhoods, hamlets	neigbourhood parks
Neighbourhood	300	30	ensembles	dispersed greenery
Ensemble	100	10	lots	opening up (access) area
Lot	30	3	houses	gardens, patios
Dwelling	10	1	living rooms, studies, bedrooms	inaccessible space, wet rooms, circulation and storage spaces
Room	3	0,3	sitting areas, dinettes, beds	walking area, cupboards, closets, windowsills
Place	1	0,1	action-surrounding space	commodities

Fig. 886 Fifteen levels of scale to distinguish 15 different kinds of density

6.3.4 (Sub)continental densities$_{3\,000 \text{ and } 1\,000km}$

On a European level of scale, adding an extra interval boundary of 200 inhabitants per km^2, you can observe a central urbanised axis of more than 200, surrounded by 'rural' areas of less than 200 inhabitants per km^2. However, at a regular distance within these 'rural' areas, there are some conurbations (London, Paris, Lyon, Milan, Munich, Prague, Berlin, Hamburg; see *Fig. 888*). Some of these do have the highest European density measured within a local radius of 30km.





Bosatlas(1996)

Fig. 887 Continental densities

Fig. 888 Subcontinental densities

Fig. 889 Legend

So, there are not only different *densities*, but also different *distributions*, producing patterns interesting from a viewpoint of design.

6.3.5 National densities and distributions$_{300km}$

Land use, the reciproque of population density

The Netherlands as a whole counts more than 42000km^2 (sea excluded) and 16300000 inhabitants, that is about 390 inhabitants per km^2 (about 4 inhabitants per ha) with extremes ranging from 0 to 20 000 inhabitants per km^2 if you take smaller areas into account.
The reciproque of population density is land use. The advantage of a land-use unit is that different destinations of use can be discerned. In the Netherlands, the land use is about 2700 m^2 per inhabitant, roughly divided as 1500 m^2 of agrarian land per inhabitant, 500m^2 of water, 300 m^2 of nature areas and forest, 300 m^2 of urban areas and infrastructure, 100m^2 industry and recreation.

Residential area, part of urban area

Of this 300m^2 urban area, only about 160m^2 are 'residential areas'. According to CBS's definition of ground statistics[a], these are homes with green areas, hardened surfaces and primary facilities, such as local shops, schools for pre-school and primary education, as well as other residential facilities such as caravan camps, house-boat harbours, service flats, etc.[79]

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[a] Tot het **woongebied** worden gerekend terreinen, die voornamelijk voor het wonen bestemd zijn, incl. primaire voorzieningen als winkels, scholen voor kleuter- en basisonderwijs en bijkantoren van o.a. banken, alsmede groenstroken, straten, parkeerplaatsen, grachten smaller dan 6 meter, erven, tuinen, trapveldjes en speelplaatsen. Wanneer woonwijken in bos zijn gesitueerd, wordt het gehele terrein als woongebied aangemerkt, d.w.z. indien er van een stratenpatroon sprake is. Lintbebouwing van overwegend niet-agrarische woningen wordt tot het woongebied gerekend zodra de afstand tussen de huizen onderling minder dan 50 meter bedraagt met een minimum van 5 woningen. Bij blokbebouwing mag de onderlinge afstand tussen de woningen maximaal 100 meter bedragen. Tot het woongebied worden eveneens gerekend woonwagenkampen (exclusief wrakkenopslagplaatsen > 0,1 ha), woonboothavens, service flats, studentenhuisvesting, woningen c.q. flats voor ziekenhuis personeel en studenten en bejaardenhuizen. Terreinen worden pas tot woongebied gerekend, nadat de woningen zijn opgeleverd.
Sociaal-culturele voorzieningen Hiertoe worden gerekend onderwijs (excl. kleuter- en basisonderwijs, dat wordt gerekend tot woongebied), internaten, conferentieoorden, ziekenhuizen, sanatoria, verpleeghuizen, psychiatrische ziekenhuizen, inrichtingen voor zwakzinnigen, verzorgingstehuizen, kerken, kloosters, musea (ook voor het publiek toegankelijke kastelen), excl. openluchtmusea, schouwburgen, bioscopen, concert- en congresgebouwen; culturele centra, wijkgebouwen, verenigingsgebouwen, jeugdsociëteiten en sociale werkplaatsen. Ook de bijbehorende voorzieningen zoals parkeerplaatsen en tuinen worden tot de sociaal-culturele voorzieningen gerekend. Bossen behorend bij deze voorzieningen worden als bos aangemerkt als zij 1 ha of groter zijn.

in dots of 100 m^2 per inhabitant.

Fig. 890 *Residential area per COROP area*

Fig. 890 shows the distribution of this residential part of the urban area, divided over 40 statistical (COROP) areas, expressed in the absolute sense and per inhabitant according to CBS (1994) .

The residential area per inhabitant varies in space. In the west of the Netherlands, an average of about 100 square metres of residential area is available per inhabitant; in East Groningen, about 300 m^2 ; and in a number of other places between those two extremes, about approx. 200 m^2 per inhabitant[80].

So, 'norms' for the number of m^2 of residential area per inhabitant differ regionally. That also applies for other facilities, such as (daily) recreational areas or drinking water basins. Apart from variation in space, land-use norms also show a variation in time: they change.

So, the use of Planological Index Numbers for the amount of space needed for facilities is relativised by these spatial and temporal variations.[81]

Population density divided by the number of occupants per household

If one divides the density of inhabitants by the local average number of occupants per household, then one arrives at the local density of homes. However, since WW2, the number of people per household, especially in the towns, has dropped from about 5 to 2.5; and this number continues to fall. This, by the way, was the main reason for scarcity of housing in the later post-war period, and for the urban explosion after 1960. There are not only great variations in time in the number of people per household, but also large regional differences. The number of people per household is the lowest in the Randstad and here the numbers have decreased the most rapidly in the last 50 years. In Fig. 694, the urban areas in the Randstad in 1965 are compared with those in 1995.[82]
During this period, the Randstad hardly grew in numbers of inhabitants (from 5.3 million to 6.1 million). The extension of urban area was caused, among other things, by fewer people living in one household (family dilution).

Floor space is more reliable than the number of houses

The objects to be counted should be equal. That is why the floor surface, to be measured in m^2 is much better a measure to get a ratio of climatised volume per earth area than the number of houses of different size (as often done). For example the Dutch housing policy Secretary of State 1973-1977 Van Dam approximately doubled the number of houses produced per year in the Netherlands by halving their floor surface. Coincidentally the demand of one person households for smaller houses was increasing. It was a great political succes, but few politicians realised that Van Dam did not increase the newly built floor surface (and building effort) substantially.

Drawing the real measure dot distribution

The regional spatial effect becomes obvious when you redraw the map in real measure units of 100,000 and 10,000 inhabitants, counting 300m^2 per inhabitant (the approximate overall urban spatial use mentioned on page 573). In Fig. 694 these are shown as circles with a radius of 3 and 1 km, respectively. Read: '3 km radius' or '3 km in the round' and say: 'town'. Read: '1 km radius' and say 'district' if part of a town or 'village' if separate. If circles overlap, then one has to conclude that the urban density is higher than the average national density. If there are about ten 3km circles (1 million people) within a radius of 10 km, then you can talk of 'conurbations' and draw them as one circle of 10km.

Growing conurbations by growing land use

According to this representation, the old situation of 1965 (Fig. 694) was characterised by three large and three small conurbations and only a few small (separate) towns. In 1990, the first thing that strikes one is the dilution of households: the conurbations had grown, sometimes even losing inhabitants into suburban settlements. One can call this form of expansion 'deglomeration'.[83] This drastically influences not only the built-up areas, but also the open areas in between.[84] As soon as urban areas are no longer surrounded by rural areas of the same order of size as the urban area, a reversal in the image of the urban area occurs: the town is no longer situated in the countryside, but the countryside is now enters the town, a reversal pointed out by Tummers and Tummers (1997,see Fig. 787)

Fragmentation of urban and rural areas

The fragmentation of urban and rural areas on different scale levels can be visualised in the legend in Fig. 769.[85] The figures shown in this table are not absolute. They can be interpreted with a tolerance of up to the previous or the next figure shown in that column. The legend units shown in red are represented as circles with a size that reflects the present average urban spatial use in the Netherlands of approx. 300 m^2 per person: 160 m^2 urban residential area, 60m^2 working area[a] and 80 m^2 of infrastructure (a part of it lies outside the built-up area and therefore does not need to be regarded as an urban area).

Dry and wet infrastructure

For linear-shaped legend elements, a similar sort of semi-logarithmic series is possible. *Fig. 481* shows nine levels of access.[86] Something similar is possible for drainage (*Fig. 480*). 'Without information to the contrary', in the (former) low peat areas, the legend units are considered to be completely filled with the named networks. In clay aeas the lowest orders with higher network densities disappear. In dunes, nature conservancy areas, and higher sandy grounds, even more lower orders disappear. In urban areas, ditches and drainage channels disappear. Their function is taken over by a relatively fine-meshed underground drainage network.[87]

Distinguish existing and future population

Fig. 769 shows a legend for representing the dispersion patterns in a stylised manner on a regional scale. On the basis of this, regions can be compared. The estimated economic, cultural and/or managerial efforts needed to realise the areas drawn into the design can be indicated using different thicknesses of lines. The thinnest lines represent existing areas. This more or less reflects the importance of the element in the design. At the same time, this provides an elegant way of distinguishing existing areas from the new ones proposed (the 'planning layer'). Apart from this, the legends are literally 'open' in the sense that the circular legend units can still be coloured with functional accents or identities. For the time being, the circles can be seen as 'little magnifying glasses' which conceal unfilled-in details of towns, villages, hamlets, landscaped parks, urban

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[a] **Delfstoffenwinning** Hiertoe worden gerekend de terreinen die in beslag genomen worden, voor het winnen van grondstoffen bij zowel diepte- als oppervlaktewinning, zodra met de proefboring en met de exploitatie is begonnen. Ook tot een lokatie behorende gebouwen, opslagplaatsen van winningsprodukten alsmede van afvalstoffen (bijv. mijnsteenbergen, uitgezonderd de beboste mijnsteenbergen van 1 ha en meer) worden eveneens hiertoe gerekend. De ontstane gaten in het terrein worden tot delfstoffenwinning gerekend, zolang dit de hoofdfunctie is. Zodra een gedeelte van het terrein een andere hoofdfunctie krijgt wordt het tot de desbetreffende categorie gerekend, zoals water met een recreatieve hoofdfunctie, dagrecreatieve objecten en terreinen, water en agrarisch gebruik. Terreinen, die al wel in concessie zijn gegeven (veen, grind enz.) maar waar de winning nog niet daadwerkelijk is begonnen worden niet tot de delfstoffenwinning gerekend. Tot grondstoffen worden gerekend aardgas, aardolie, gesteente, grind, klei, leem, mergel, veen, zand (niet de winning in bestaande meren, plassen en rivieren) en zout.
Bedrijfsterreinen Hiertoe worden gerekend bedrijven en terreinen (inclusief de bijbehorende op- en overslagterreinen, parkeerterreinen, magazijnen, dienstwoningen, werkstraten en kantoorgebouwen, vloeivelden e.d.) zoals fabrieken, haventerreinen, veilingen, tentoonstellingsterreinen, veemarkten (al dan niet overdekt), groothandelscomplexen, opslagterreinen voor de handel (ook grondverwerkende bedrijven) en garages (incl. parkeergarages). De reeds door deze bedrijven aangekochte, gehuurde of in erfpacht genomen reserve- en uitbreidingsterreinen worden eveneens tot de bedrijfsterreinen gerekend, voor zover deze grenzen aan bestaande bedrijfsterreinen en voorzover deze al zijn onttrokken aan het oorspronkelijke gebruik. Niet tot deze categorie behoren braakliggende al dan niet bouwrijpe bedrijfsterreinen, terreinen waarop door bedrijven een optie is genomen, maar die nog niet zijn uitgegeven, havenbekkens, tichelgronden van steenfabrieken en niet meer in gebruik zijnde bedrijfsterreinen.
Dienstverlenende sector Tot deze categorie behoren bedrijfsterreinen in de dienstverlenende sector zoals winkelcentra (ook al wordt daar boven gewoond), banken, verzekeringsmaatschappijen, ministeries, gemeentehuis (stadskantoor), kantoor openbare werken enz., grenskantoren (douane enz.), provinciehuis, politiebureaus, brandweerkazernes, rechtbanken, gevangenissen, goederenmarkten (indien twee of meer dagen per week voor dit doel in gebruik), bedrijven in de horecasector, garages van busmaatschappijen, laboratoria. Niet tot deze categorie behoren zijn de laboratoria, welke vallen onder de categorie 'sociaal-culturele voorzieningen' (onderwijs, ziekenhuizen, gerechtelijke laboratoria), 'overige openbare voorzieningen' (waterleidingbedrijven, waterzuiveringsinstallaties) en 'industrie'.
Overige openbare voorzieningen Hiertoe worden gerekend nutsbedrijven (gas, water, elektriciteit, stadsverwarming en centrale antenne-inrichtingen) inclusief de daarbij behorende terreinen, waterzuiveringsinstallaties en vuilverbrandings-installaties, alsmede de slibvelden, vloeivelden (behalve die behoren bij industrie) en opslagplaatsen, opslagterreinen ten behoeve van Rijk, Provincie en Gemeente (o.a. gemeentewerf) m.u.v. opslagterreinen voor het onderhoud van wegen, opslagterreinen van slib (bijv. baggerspecie en havenslib), militaire objecten, zoals munitiedepots, kazernes, mobilisatiecomplexen, radarposten en schietbanen exclusief de militaire oefenterreinen (deze worden tot natuurlijk terrein gerekend).

landscapes or urban parks. The drawings function as 'colouring pictures' that have not yet been filled in.[88]

6.3.6 Regional distribution$_{100 \text{ and } 30km}$

Drawing the existing situation

To draw the existing situation in different plan layers, one layer, the number of inhabitants per municipality, can be shown according to actual CBS statistics in real measure circles of 100,000,10,000 and 1000 inhabitants (see Fig. 891).

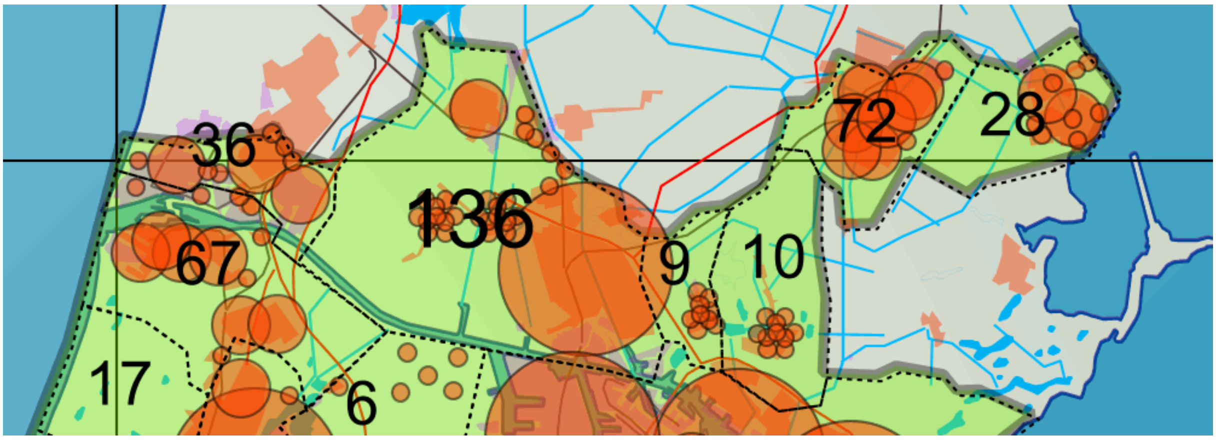
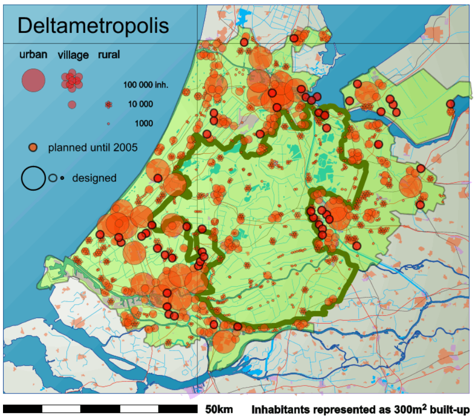


Fig. 891 *Population statistics per municipality, drawn as circles of 3, 1 and 0.3 km radius of 100 000, 10 000, and 1000 inhabitants (300m^2/inhabitant). These circles represent the built-up area such a population needs at average in The Netherlands. Their location is roughly determined by the urban topography read from the map.*

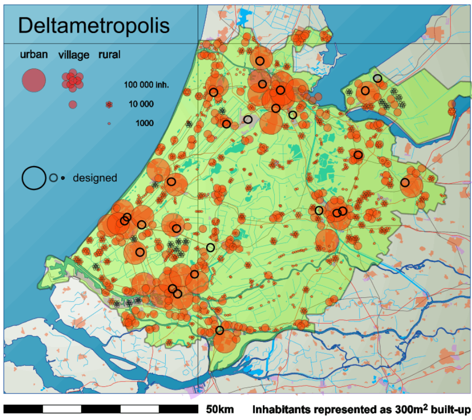
In such a pointillistic representation, a higher density than the current average in the Netherlands can be read off directly from overlapping circles. Dispersion within a municipality is quite accurately determined by the position of the built-up area on the map (see Fig. 891).

Adding existing local plans

To that has been added the capacity of existing municipal residential building plans, which, according to the New Map of the Netherlands 2000, is roughly estimated as being 570 000 inhabitants (see Fig. 892). This capacity has been aggregated with that of the existing built-up area to create a basic map for the year 2005, thereby making it possible to compare the designs. In this way, ten 1km units of 10 000 inhabitants (for example Amstelveen and Nieuwegein) could be aggregated into one 3km unit of 100 000 inhabitants. In a simple way, this represents locally increasing urbanisation, as distinct from expansion in general.



Nieuwe Kaart
57x10 000



NRO5
26x10 000
187x1 000

Fig. 892 *The year 2005: including existing plans*

Fig. 893 *The year 2030: NRO5*

Adding existing national plan NRO5

In Fig. 893 the remaining capacity of 5th National Plan of Spatial Policy NRO5 (intermediary scenario for 2030) has been drawn onto this background as a reference. That figure shows the mapped images of the existing situation, the plans that, according to the New Map of the Netherlands, are being carried out, and the part that remains after being subtracted from that for NRO5, according to the EC intermediary scenario (ABF).

Interpreting plans

Fig. 894 shows the interpretation of NRO5 used in Fig. 893. In the same way other plans can be added.

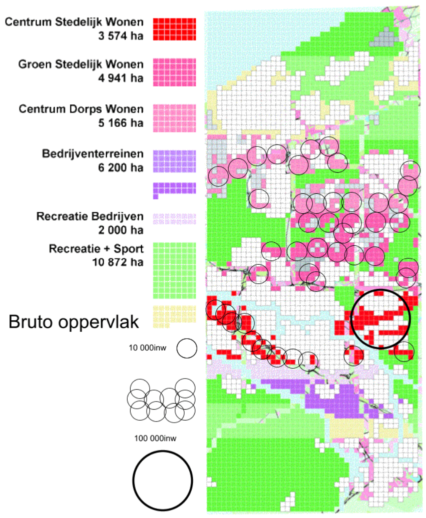


Fig. 894 *Interpretation NRO5*

Fig. 895 *Interpretation OMA*

In OMA, 7, 12 and 13 squares of 25 ha are converted into circles of 10,000 inhabitants (Fig. 895). Ten circles in the centre of Rotterdam, within a radius of about 3 km are aggregated to a circle with a radius of 3 km (100,000 inhabitants).

Adding complementary plans

OMA's and TKA's designs (see Fig. 895 and Fig. 896 respectively) are calculated back to the numbers of inhabitants from the design sketches, and, after subtracting the existing local plans, are distributed according to the topography of the drawings.

Fig. 896 *Interpretation TKA*

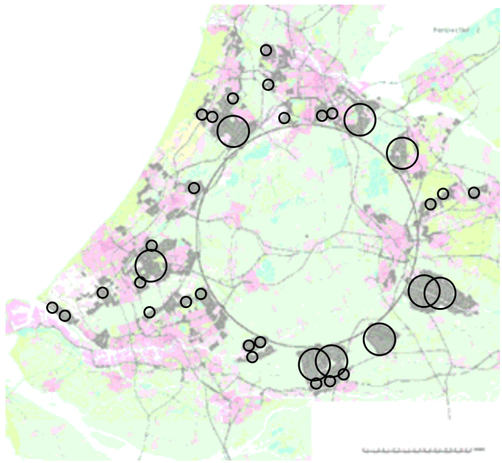


Fig. 897 *Interpretation Snozzi*

Summarising and comparing with an alternative

Snozzi's design is interpreted exclusively and globally from the drawing (Fig. 899). In H+N+S's design, ABF estimated the capacity of the Green Heart to be 51 000 homes. This means about 100 000 inhabitants, represented as one dotted circle of 100 000 inhabitants in the middel of the summarising drawing of Fig. 898, because although a dispersion of 100 inhabitants (shown by small dots) might be possible, it is no longer visible or discernible. OMA, TKA and H+N+S's designs could now be represented in one drawing (see Fig. 898).

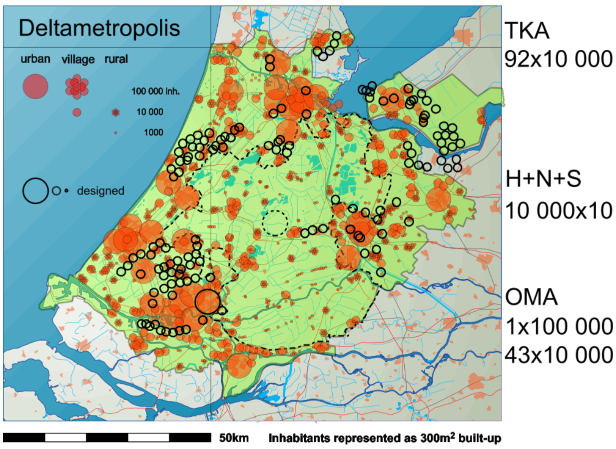


Fig. 898 *Three complementary designs 2050*

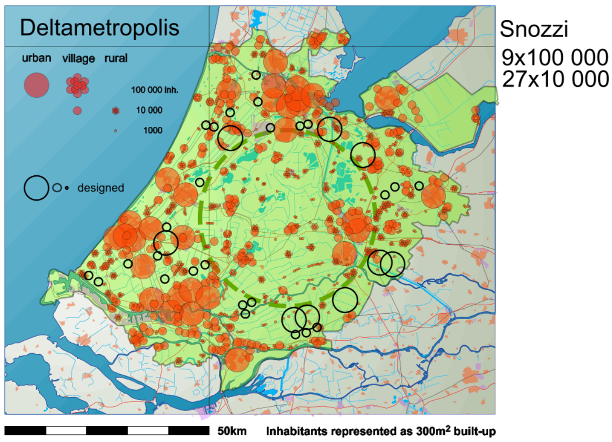


Fig. 899 *Alternative Snozzi*

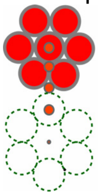
Snozzi's design includes the entire Delta metropolis and is therefore drawn separately (see Fig. 899) The legends are restricted to units of 100,000 (3 km radius) and 10,000 inhabitants (1 km). In the background, units of 10,000 inhabitants have been divided into units of 1000 inhabitants (300 m), where the topography requires it. This has not been done in the design layer, which improves overall comparability.

A comparison of quantities and rough morphology

Fig. 900 compares NRO5 with five alternatives: developing the South flank only, the Green Heart only, the North flank only, developing these three together, or following Snozzi's design.

Context

recognisable on the map as:



Name:	Population x 1000			OMA, South flank				H+N+S Green Heart				TKA, North flank				Total				Snozzi			
	Now present	Existing plans	NRO5-EC trend	100 000	10 000	1000	Inhabitants + existing plans	100 000	10 000	1000	Inhabitants, including existing plans	100 000	10 000	1000	Inhabitants + existing plans	100 000	10 000	1000	Inhabitants + existing plans	100 000	10 000	1000	Inhabitants + existing plans
	2000	2005	2030																				
Urban centre	710	700	988	1			800				700		8		780	1	8		880				700
Urban areas outside the centre	2818	2810	2448		11		2920				2810		25		3060		36		3170	9			3710
Urban green areas	415	410	655		16		570				410		35		760		51		920		3		440
Village centre	1337	1890	2090		16		2050				1890				1890		16		2050		24		2130
Rural living	251	400	505				400		10		500		24		640		34		740				400
Working area	512	380	454				380				380				380				380				380
Total	**6043**	**6590**	**7140**	**1**	**43**		**7120**		**10**		**6690**		**92**		**7510**	**9**	**27**		**8140**	**9**	**27**		**7760**

Fig. 900 *Five alternatives for NRO5 and their population specified to their urban or rural context*

It can be concluded from Fig. 900, that OMA already realises the NRO5 programme in the South wing, while TKA exceeds it already in the North wing. The three plans together exceed the NRO5 programme by 1 million inhabitants. Snozzi arrives at an extra capacity of over 600,000 inhabitants. These extra capacities are mainly achieved in urban areas outside the centre. Centres score lower than in the NRO5 design. To answer economic questions by this kind of representation further differentiation of the comparison into contexts of living and costs can be elaborated by calculation[a].

6.3.7 Density or real measure dots distribution

Misleading density comparisons if the compared surfaces differ

Density measures are abstract ratios of objects per area. To compare different areas, in principle, their surface has to be exacly the same, otherwise very different values could appear (see *Fig. 901*).

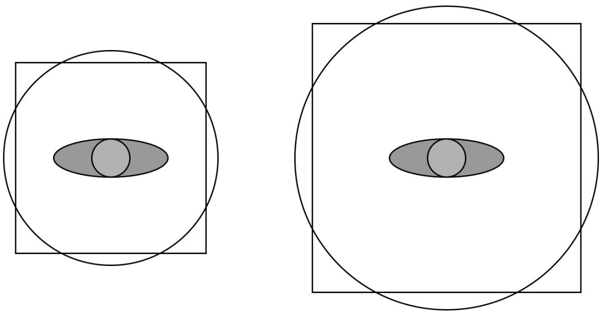


Fig. 901 The same person at 1 or 2 m^2 results in very different density values of 10000 or 5000 inhabitants per ha

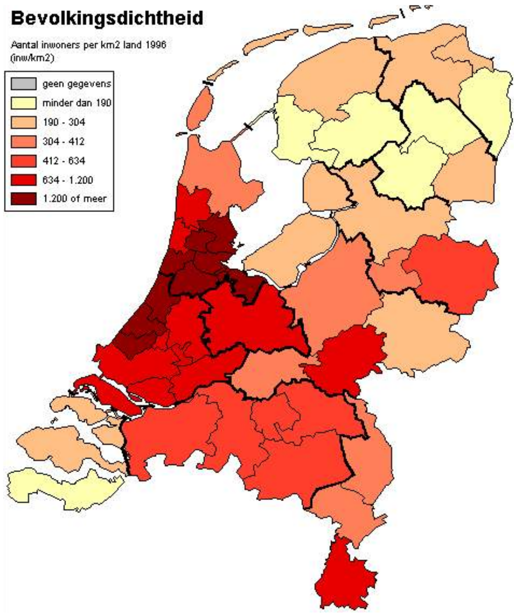


Fig. 902 Misleading image of densities applied on the different surfaces of COROP areas

[a] Jong ()

For example, the statistical COROP areas, based on temporary socio-economic and administrative boundaries, differ too much in surface to allow any comparison of variables like density with surface as a factor (see *Fig. 902*, where Rotterdam has a lower density than some smaller suburban areas).

A misleading regular GIS-grids

Even a regular, exacly equal square km grid applied in GIS-applications can produce misleading images. An occasional boundary could divide a concentration or not, leading into very different images and conclusions, loosing essential information and design qualities (see *Fig. 903*).
Data to compare contexts of living and their costs are lost in an average representation, while the easier to draw dot representation gives a more realistic image. Moreover, they can be counted per km^2 and by doing so, immediately translated in more abstract densities, while the reverse is impossible.

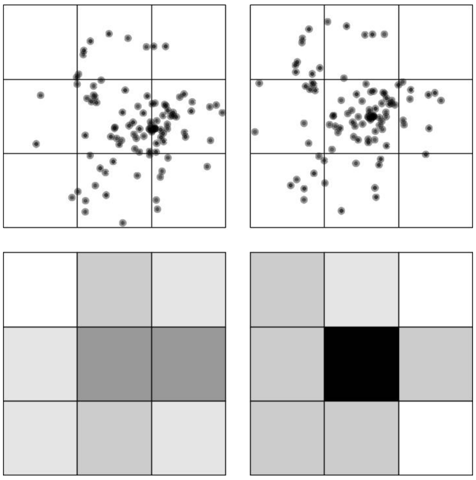


Fig. 903 Two average density interpretations of the same dispersion

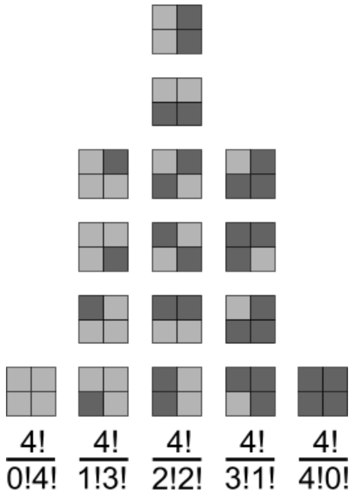


Fig. 904 Combinatorial possibilities of arrangement between emptyness and full coverage

From a viewpoint of design the grey values inbetween emptiness and full coverage give mathematically proven the most possibilities of arrangement (see *Fig. 903*, column in the middle) and probably the highest chance for high quality solutions. On page 589 we try to find other relations between density and quality, depending on the definition of quality.

Mistakes using densities as a standard

While more advantages can be found in a representation of real measure dots distribution, density has the advantage to express an attribute of a site in one single number. That is why density is still very popular by administrators, developers and managers to formulate standards for design.

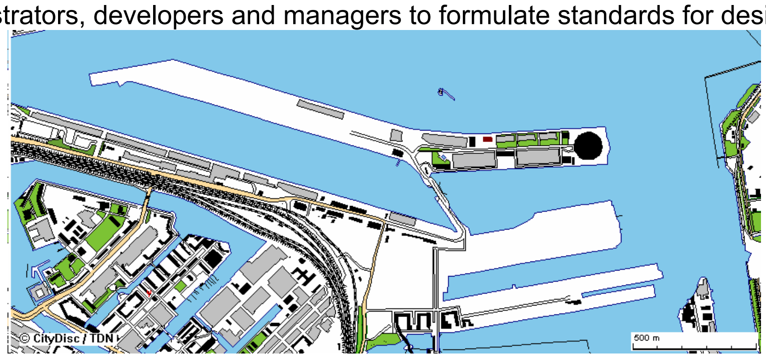


Fig. 905 The Amsterdam harbour islands, developed as residential area

However, densities are boundary-sensitive. So, if somewhere high densities are reached and used elsewhere, the comparison could be very disappointing. The residential plans for Amsterdam harbour islands (see *Fig. 903*) reached very high densities, often used as reference that such densities can be reached without loss of quality. However, when taking the surrounding water into account by measuring the reached densities, their value would become much lower considering the effect of *Fig. 901*.

Comparing designs by real measure dots distribution

Such mistakes can not be made representing plans by real measure dots distribution.

Normalisation into 4 visions of 50 000 new inhabitants within a square of 10x10km.

Zero variant TKA 'residential' Hosper 'recreation' H+N+S 'nature'

Fig. 906 Comparing plans for Almere Pampus

Three plans for Almere Pampus, normalised into the same capacity were represented that way. This representation gives a rough, but direct idea of the visions. For many kinds of specialists like travel engineers, housing specialists, civil engineers this representation gives necessary starting points for evaluation. For every desired square kilometre you also can find the population density or floor-space index (FSI), because every dot represents 1000 inhabitants, now drawn by a circle of 30 000 m^2 floor space (100m radius net dots). If you like to count more or less than $30m^2$ floor space per person, then the circles have to be drawn only a little larger or smaller.

Extreme gross and net dots

In Fig. 891 the dots of 1000 inhabitants had a radius of 300m (about 30 ha or $300m^2$ per inhabitant). These dots represent the average urban area an inhabitant needs for all urban facilities in The Netherlands according to the figures mentioned on page 573. However, in Fig. 906 they had a radius of 100m (about 3 ha or $30m^2$ per inhabitant, the average floor space you appoximately need for living only).

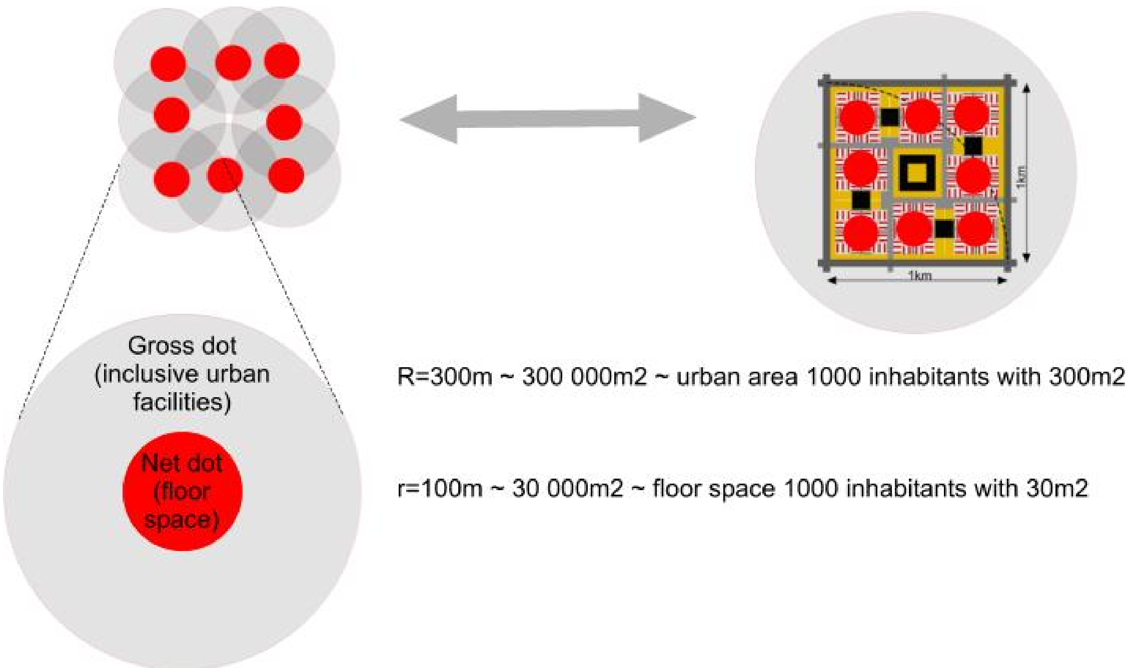


Fig. 907 Extreme gross and net dots

Within a district the gross dots of Fig. 891 would often overlap (see *Fig. 907*). Net dots already give some idea about the mutual arrangement of dwelling areas. In *Fig. 906* the urban facilities other than homes have to be imagined in between the 'net dots'. In *Fig. 907* the allotment of a district quarter is drawn showing the surface other than dwellings like surrounding facilities like green areas, pavement, schools and shops. However, the gross dots overlap, showing there is more than that, apparently outside the local district. So, measuring the density of a district with district facilities only (district tare) will be higher than the density of a town including town facilties (town tare). The same applies for any level of scale you take into account.

Comparable surfaces in urban areas

By counting the digits of the number of m^2, we could *name* these categories with a useful tolerance by their *nominal* radius (see Fig. 908). For example, you can name an area with a surface between 10000 and 99999 m^2 (5 digits): 'R=100m' (ensemble).

Digits	Min. area	Max. area	Min. radius	Max. radius	Nominal radius	Gross	Tare
	Smin	Smax	R_{min}	R_{max}	R_{nom}	name of area	including for example
	m^2	m^2	m	m	m		subtracted on lower level
10	1000000000	9999999999	17841	56419	**30000**	metropolis	landscape parks, metropolitan infrastructure and facilities
9	100000000	999999999	5642	17841	**10000**	conurbation	town landscapes, conurbarion infrastructure and facilities
8	10000000	99999999	1784	5642	**3000**	town, town quarter	town parks, town water, town infrastructure and facilities
7	1000000	9999999	564	1784	**1000**	district, district quarter, village	district parks, district water, district infrastructure and facilities
6	100000	999999	178	564	**300**	neigbourhood, hamlet	neighbourhood parks, small water, neighbourhood infrastructure and facilities
5	10000	99999	56	178	**100**	ensemble	small public green area residential public space
4	1000	9999	18	56	**30**	urban island, property, building complex	pavement directly opening up building complexes, open space in private parcels (lots, plots)
3	100	999	6	18	**10**	parcel, plot, lot or building	gardens, unbuilt places, patios
2	10	99	2	6	**3**	building segment,	rooms, unbuilt spots
1	1	9	1	2	**1**	building part	inaccessible spaces

Fig. 908 Ten different tare categories, ten different density measures

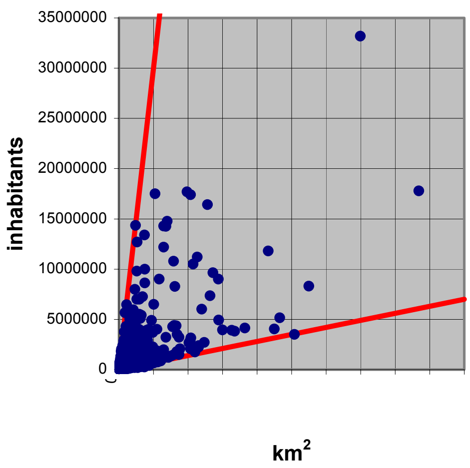
Though the range of surface difference is still a factor of nearly 10, this restriction is strict enough to get roughly comparable densities. However, even by that tolerance there are still ten different urban density measures to be confused. So, a gross density D_{100m} is something else than a gross density D_{300m}, but a net density D_{300m} in this scale range is the same as a gross density D_{100m}.

6.3.8 Metropolis density$_{30km}$

Tokyo-Yokohama is the largest metropole, counting nearly double the number of inhabitants of the next five between 15 and 20 mln (see *Fig. 909*). New York covers the largest area. However, the way the areas are counted may differ making the comparability doubtful.

Nation	Urban Area	Population	Km2	Density
Japan	**Tokyo-Yokohama**	33200000	6993	4750
United States	**New York**	17800000	8683	2050
Brazil	**Sao Paulo**	17700000	1968	9000
South Korea	**Seoul-Incheon**	17500000	1049	16700
Mexico	**Mexico City**	17400000	2072	8400
Japan	**Osaka-Kobe-Kyoto**	16425000	2564	6400
Phillipines	**Manila**	14750000	1399	10550
India	**Mumbai**	14350000	484	29650
India	**Delhi**	14300000	1295	11050
Indonesia	**Jakarta**	14250000	1360	10500
Nigeria	**Lagos**	13400000	738	18150
India	**Kolkota**	12700000	531	23900
Egypt	**Cairo**	12200000	1295	9400
United States	**Los Angeles**	11789000	4320	2750
Netherlands	**Amsterdam**	1100000	324	3400
Netherlands	**Rotterdam**	1325000	531	2500

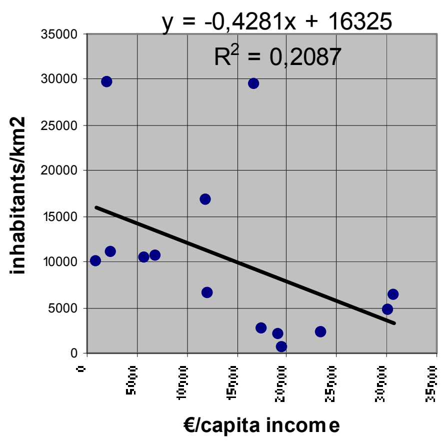
Fig. 909 The largest of 1200 cities listed by demographia.com

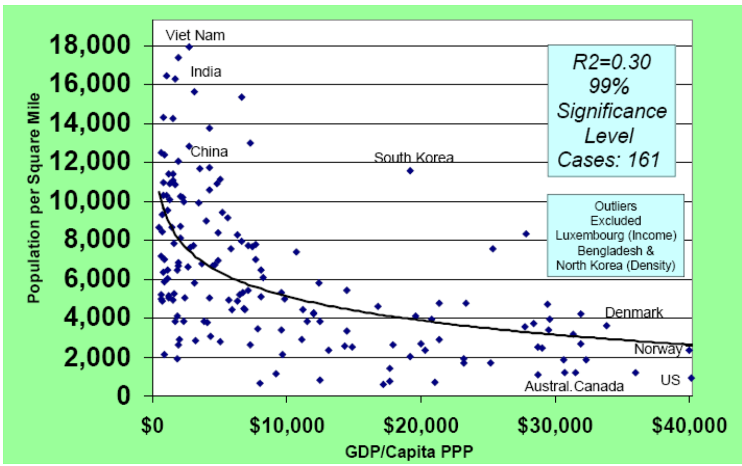


http://www.demographia.com/db-worldua.pdf

Fig. 910 1200 cities between the density lines 30 000 and 700 inhabitants per km2.

On the density lines of 30 000 and 700 inhabitants per km^2 (see *Fig. 910*) you find Mumbai and Atlanta as the largest cities, with incomes of €2 000 and €19 000 rper capita espectively. The €/capita income (see *Fig. 911*) and $/capita gross domestic product (GDP, see *Fig. 912*) are very roughly related to metrolopitan density.





http://www.demographia.com/db-worldua.pdf

Fig. 911 Density related to €/capita income in 14 cases

Fig. 912 Density related to $/capita gross domestic product in 161 cases

However the sources differ and the figures change rapidly. Van Susteren (2006) compared 101 metropoles on many aspects using different sources.

6.3.9 Conurbation density$_{10km}$

The municiality of Amsterdam has an average density of 4400, the municipality of The Hague 6500 inhabitants per km^2. Are these figures comparable? No. The administrative municiality of Amsterdam comprises more vast empty areas than The Hague. Such empty areas have to be subtracted as tare surface. In *Fig. 913* and *Fig. 914* the built-up municipal area is dotted, but if you count the adjacent municipalities with more than 50% commuters into the central city, comprising at least 15% of their working population (see conurbation definition page 603), then the densities of these ‘conurbations’ are lower (2700 and 3300 inhabitants per km^2 respectively).

Fig. 913 Population and floor space of Amsterdam

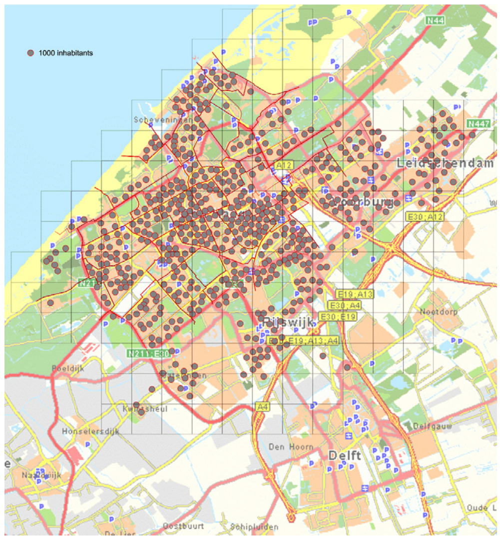


Fig. 914 Population and floor space of The Hague

Using population statistics per district and drawing dots representing 1000 inhabitants with a radius of 100m (30m^2 floor space per inhabitant), you can get an idea of the diversity of densities within these average conurbation densities (see *Fig. 913* and *Fig. 914*).

Deriving density from a distribution of dots

In *Fig. 914* a km grid is drawn. You can count the dots per grid cell to determine the local density per km^2. However that depends on the location of the grid (see *Fig. 903*). It is better to make a mask of 1km^2 and shovel that mask over the drawing to find the highest density. Multiplying that figure by 100 gives the density of inhabitants per ha. Dividing it by the average household size gives an estimate of the number of houses per ha.
You can also estimate the floor-space ratio (FSI: floor-space index) multipying the inhabitants by the used average (here 30m^2 at home, but you have to add other floor space, say 30+20=50m^2) per inhabitant. A hundred times FSI gives %floor surface on a conurbation level. High densities may suggest high rise buildings (at a smaller-scale map, the dots could be drawn piled-up to suggest high-rise). However that conclusion is put into perspective on page 591. Inbetween home-dots you have to imagine the tare space for urban facilties. The largest of these are industrial areas, parks and natural areas like dunes.

6.3.10 Town density$_{3km}$

Town densities are incomparable if you do not precisely define the boundaries of the towns compared. To determine the main national subsidies for municipalities the distance between buildings has to be less than 100m to determine the ‘built-up area’ as a factor in subsidy calculation. That mainly means excluding ‘open area’ like agricultural areas, natural areas and parks larger than 100m in any direction as tare surface of higher order. The question if you have to include national or regional highways and waterways crossing the town and other facilities derived from Enclosure 2 Ranking support of facilities The Netherlands 2000 on page 730 (see also Fig. 961) to calculate density has to be solved.

6.3.11 District density$_{1km}$

Many adminstratively bounded districts include such tare surfaces of higher order, not to be included to calculate district density. So, statistical figures about their total area are not reliable.

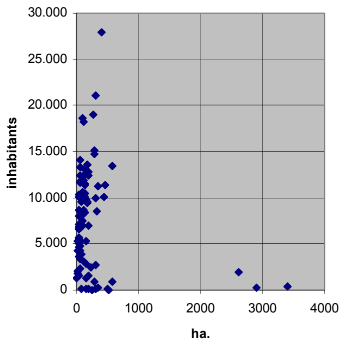


Fig. 915 Inhabitants and surface of administrative districts in the municipality of Amsterdam

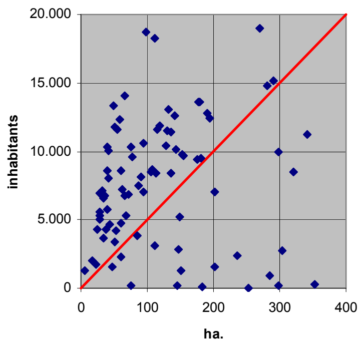


Fig. 916 The figures of Fig. 915 excluding districts of more than 1000 ha and 20 000 inhabitants

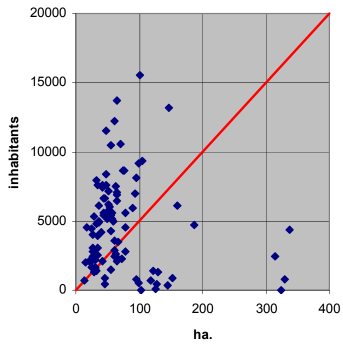


Fig. 917 The same figure as Fig. 916 concerning the municipality of The Hague

Fig. 915 shows the great difference in size of administrative districts in Amsterdam making these incomparable in principle. In *Fig. 916* districts of more than 20 000 inhabitats are excluded. They should be subivided to be comparable with the smaller ones.
In the rough approach of Fig. 908 you should exclude also districts with a surface counted in m^2 of more or less digits than 6, that is 2 counted in ha, but we can take an even rougher boundary. Excluding three districts of more than 3 digits (>999 ha) in *Fig. 916* already gives an interesting view, but the question remains if you have to include urban highways and waterways crossing the district, town parks and other facilities derived from page 730 (see also Fig. 961) to calculate density.

Rough boundaries of district density

In *Fig. 916* and *Fig. 917* the drawn line y=50·x ('inhabitants= 50·ha') represents the density of 50 inhabitants per ha. So, the slope indicates the density. In both municipalities there is a concentration of districts with a higher density above this line. If you draw a line from 0(0) into 20 000(50), then you get the line of density representing 20 000/50=400 inhabitants per ha. Below that line none of the districts appear. However, on lower levels of scale with closer fitting boundaries you may find higher densities. You can also estimate the floor-space ratio (FSI: floor-space index) multipying the inhabitants by the used average (for example $50m^2$) per inhabitant. A hundred times FSI gives %floor surface on a district level.

6.3.12 Neighbourhood density$_{300m}$

Boundaries

Subdividing a municipality in partial municipalities, districts and neigbourhoods (see *Fig. 918*) raises questions of financial responsibility for (re)arrangement and maintenance of public space. So, determining the boundaries of that units becomes increasingly important on lower levels of scale. The smaller the area, the more the boundary surfaces count in relation to the enclosed surface. That is why such boundaries are often drawn on the middle of a shared road or waterway. If they are drawn on one side, the other side has to pay for it.

Subtracting tare of a higher order

In the beginning, private plots are sold, also paying for the surrounding public space as designed. However, if their neigbourhood comprises surfaces used by adjacent neigbourhoods as well, the costs have to be shared (tare of a higher order). That applies on every level of scale, from national scale until common roofs and walls in buildings and common hedges in gardens. So, in the initial exploitation scheme of a district or neigbourhood, these surfaces have to be distinguished as tare of a higher order. A neigbourhood density calculation can use this financial distinction by subtracting such tare surfaces from the piece of map you take into account (the map cutting).

The result is a net neighourhood surface, which is, according to Fig. 908, the same as the gross surface of all ensembles involved (see *Fig. 920*). Politicians are still interested in the reached number of houses per ha, but they do not often distinguish these surfaces. By using the 'net house neigbourhood density' (in fact the average 'ensemble house density') you can name a higher figure than using the 'gross house neigbourhood density'. However, as argued on page 574, floor space is more reliable than the number of houses to determine densities.

Fig. 918 Partial municipality Osdorp of Amsterdam, divided in 5 districts

Fig. 919 The 500x500m neigbourhood indicated in the middle of Fig. 918

a **m^2 Map cutting**
b m^2 Non district surface of higher order
c m^2 Common district surface
d **m^2 Gross neighbourhood (a - b - c)**
e Number of houses
f Gross house density per ha (10 000 · e / d)
g m^2 Common neighbourhood infrastructure and facilities
h **m^2 Net neigbourhood (d - g)**
=m^2 gross ensemble surface
i m^2 Total floor surface

Fig. 920 Primary figures to know on neigbourhood level

Non residential surface

There could be many (political, social, financial, technical, ecological, spatial) reasons to distinguish residential and non residential surface. Non residential initiators may have to pay more for their plots per m^2, they may need more parking space or other public facilities, they do not contribute to the number of inhabitants supporting shops and so on. That distinction may be not primarily important to determine the total %floor surface your design offers, but the distinction is often asked, especially if the non residential area is a substantial part of the total area. If you would like to take up that distinction in your density calculation, you need to specify more (see *Fig. 921*).

h	**m^2 Net neigbourhood (d - g)**	p	Average dwelling occupation (inh./dwelling.)
i	m^2 Total floor surface	q	Inhabitants per hectare ((e x p)/(h/10000))
j	m^2 Non-residential surface	r	**Net residential surface (h - j)**
k	m^2 Non-residential private surface (ca. 60% j)	s	m^2 Housing floor surface (gf.+storeys.)
l	m^2 Total private surface (k + u)	t	Net house density (10000 e/r)
m	m^2 Ensemble public surface (h-l)	u	m^2 Private residential surface
n	m^2 Total built-up surface	v	m^2 Public paved residential surface
o	%built-up, 100xGSR or GSI (100·n/h)	w	m^2 Public green residential surface (r - u - v)

Fig. 921 Secondary figures to know on neigbourhood level

Subtracting the non residential surface (j in *Fig. 921*), including the surrounding public space) from the net neighbourhood surface (h in *Fig. 921*, mentioned earlier in *Fig. 920*)produces a third surface you can take as a basis to name an even higher house density: the net residential neighbourhood surface (r in *Fig. 921*).

Private and public space

Both total residential and non residential surfaces have to be distinguished in private and public space. If you do not want to measure the proportion of public space in a not yet designed non residential area (j in *Fig. 921*), you can take 60% as an approximation (k in *Fig. 921*), but you have to measure the private residential surface (u in *Fig. 921*) and the paved residential surface (v in *Fig. 921*) to check the third category, the green residential surface and water (w in *Fig. 921*).

Inhabitants per hectare

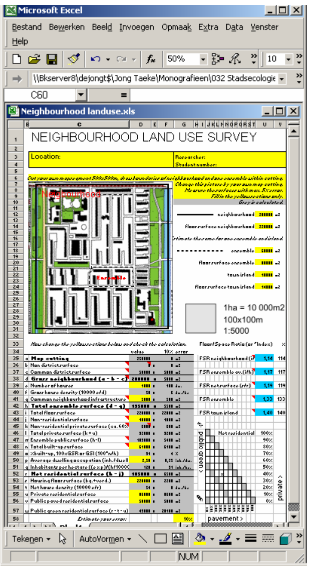
If you know the average dwelling occupation (p in *Fig. 921*) and the number of houses (e in *Fig. 921*) you can calculate the number of inhabitants on the gross neighbourhood surface (h in *Fig. 921*). If you know the housing floor surface (s in *Fig. 921*) and the average floor surface per inhabitant (for example 30m^2) you can divide them to get the number of inhabitants supporting the facilities of the neigbourhood.

Built-up surface and building height roughly determine the floor space

The %built-up surface (100xGSI, Ground Surface Index) is an important part of private surface to determine the kind of environment your design produces (think about shadows). It is much work to measure that surface in a neighourhood, but a free downloadble brain scanning computer application called ImageJ may help, if you have a topographical map in TIFF. format.[a] If you know the number of storeys you can roughly calculate the floor space by multiplying it by the built-up surface. However, some buildings cover open space loosing floor space to be subtracted.

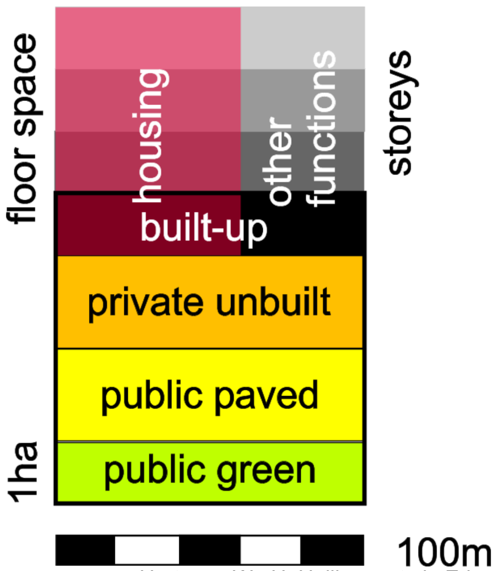
Measuring and calculating

The Excel sheet below[b] gives these measures of neighbourhood density in their mutual relationship to make calculation easy. But you still have to measure many surfaces from the map or drawing.



http://team.bk.tudelft.nl/ Publications 2003

Fig. 922 An Excel sheet calculating of different kinds of density



Hartman, W., H. Hellinga, et al., Eds. (1985)

Fig. 923 Amsterdam Kinkerbuurt visualisation of surfaces per ha.

The urban development office of Amsterdam study group Kinkerbuurt from the sixties of previous century found an elegant way to visualise key factors of neighbourhood land use (*Fig. 923*).

Five kinds of density

Fig. 924 shows the output of the Excel sheet: there are five kinds of increasing density you can distinguish, dependend on what kind of surface you take into account.

	for example	expressed as FSI
% floor space on gross neighbourhood (i/d)	114%	1.14
% floor space on net neighbourhood (i/h)	117%	1.17
% floor space on net residential surface (s/r)	119%	1.19
% floor space on a particular ensemble	133%	1.33
% floor space on a particular town island	140%	1.40

Fig. 924 The output of calculation: five kinds of density

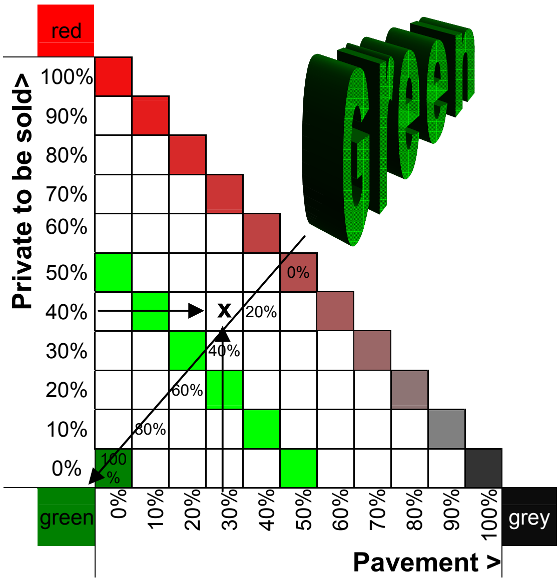
[a] http://team.bk.tudelft.nl/Databases/2004/GebruiksaanwijzingImageJ.doc
[b] Downloadable from http://team.bk.tudelft.nl Publications 2003.

If you do not only take the floor space, but also the housing density, then there are another five.

Private to be sold / public paved / green

The private surface P raises the profits to be maximised, the public space A-P the costs to be minimised. However, a high amount of green, parking space and easy acces by paved circulation space may increase the ground price per m^2 of private lots. So, the proportion privat / public paved / green has to be optimised according to local context.
Politicians, project developers, housing corporations, professional colleagues or buyers often want to know the proportion of private plots to be sold, public paved and public green surface in the net residential area, determining qualitative and financial characteristics.

If three factors total 100%, you can visualise the proportion in a triangular graph earlier done in *Fig. 646* for three soil components. The Excel-sheet creates such a graph in a necessarily orthogonal way giving a cross in the appropriate cell (see *Fig. 925*) to be interpreted as a very rough rounded off indication.



In the Osdorp neigbourhood example of Fig. 919 the 46% net residential private ground to be sold and 27% pavement resulted in 26% public green are calculated in the Excel sheet of *Fig. 922*.

However, the graph with three 100% corners rounds these figures off into 40/30/30. The surface public green and pavement are rounded off at the cost of residential private ground to be sold. The graph is pessimistic about the profits.

So, this graph only can be used for a very rough comparison with other neigbourhoods, or has te be redrawn in a more precise triangular way like *Fig. 646* according to the real figures given as well.

Fig. 925 40% Residential private ground to be sold, 30% pavement and 30% public green

6.3.13 Ensemble density$_{100m}$

Simplified dimensions

The division of a neigbourhood in ensembles mostly results in homogeneous residential or non residential areas. So, on this level that functional distinction will no longer play an important role.
We can concentrate on basic formal surfaces as total area A, built-up surface B, floor surface F, private surface P, non-specified public surface A - P and average building height or average number of storeys S. The gross ensemble surface A is equal to the net neighbourhood surface (see h in *Fig. 921*). So, neigbourhood infrastructure and ~facilities are excluded, and there is only one basis for density: F/A (FSI). The coverage of the total surface A by buildings B/A (GSI) is a primary variable.
B multiplied by the average number of storeys S (if façades are vertical) produces the floor surface F.

Spacemate

If F = S · B, then F/A = S · B/A. To compare ensembles with different A, Permeta draws a diagram[a] called Spacemate, plotting F/A against B/A. In *Fig. 926* both are given as percentage of B and F from

[a] PERMETA architecten (2002) Spacemate. FSI-GSI-OSR als instrument voor verdichting en verdunning (Amsterdam) Bureau Parkstad / TU-Delft, Faculteit Bouwkunde: 79, preceded by the graduation work of Meertens, R. (2000) Density? (Delft) DUT Faculty of Architecture.
Haupt Per and Meta Berghauser Pont (2005) Spacemate©the spacial logic of urban density (Delft) Imprint: DUP Science ISBN 90-407-2530-6

the total area A. Moreover, the diagram is extended from 0 into 100%. So, B on the horizontal axis includes also unusual, mostly theoretical high densities.
In that diagram the %floor surface as a function of %built-up area appears as a straight line starting in the origin with a slope according to the average number of storeys. Any ensemble appears as a spot according to %F and %B (*Fig. 926*).

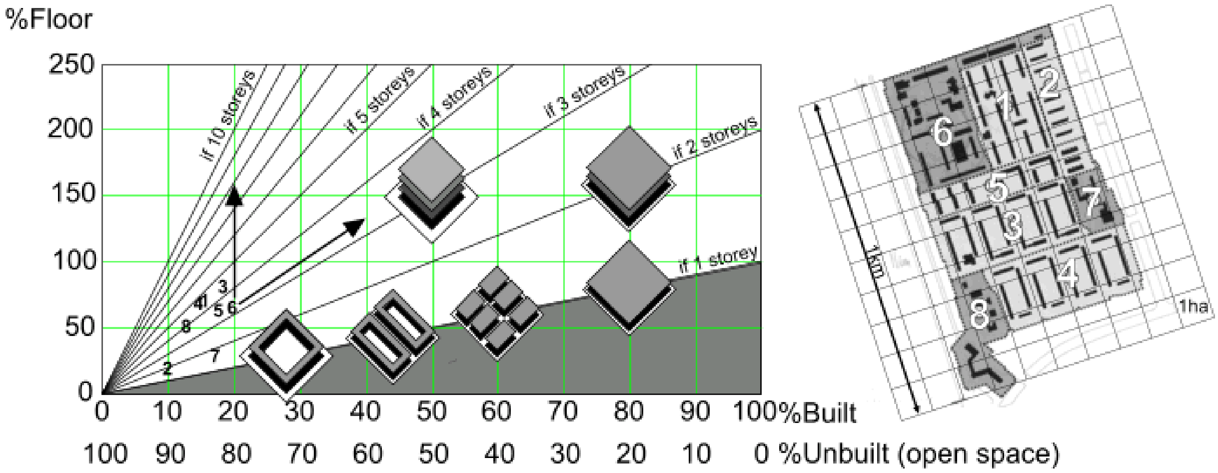


Fig. 926 Spacemate: floor surface as a function of built-up surface according to Permeta

In *Fig. 926*, 6 theoretical parcellations are drawn on 1 hectare (approximately 1 quarter of a nominal ensemble R=100m). The 8 actual ensembles in Osdorp, Amsterdam West as measured by Permeta are given as numbers. They have all less than 20% built area, and the theoretical parcellations have more. For example, ensemble 6 has the highest %built surface, but not the highest %floor surface.

Intensifying floor surface

Making plans to increase density in existing areas, political targets are often expressed in increasing FSI (%floor surface/100). The Spacemate is primarily made to visualise the qualitative effect of such operations. Permeta calculated many examples, real or made by students, on different spots in the diagram to show the effect. A computer programme shows different photographs of ensembles categorising them in clickable surfaces of the Spacemate.

To intensify the floor density you have to increase the building height or the average number of storeys (arrow crossing lines of floor density with the same number of storeys in *Fig. 926*) or without increasing the number of storeys you have to increase the %built surface (arrow parallel to lines of floor density with the same number of storeys in *Fig. 926*). By increasing the %built-up surface (decreasing open surface A - B) more, one can cross the lines of floor density with average 3 storeys in horizontal direction even decreasing the number of storeys to 2 (draw it yourself).

Urban quality

Most design alternatives will appear on 50% built-up area (see *Fig. 904*). Then the potential of urban-architectural quality and the length of façades, where building and open space are connected is highest (structural quality). However, lower levels increase the potential of open space, afforded views and green space (form quality), higher levels increase the support for schools, shops and other population-dependend facilties (functional quality). So, there are at least three components of urban quality direcly related to the %built-up surface.

More than 50% built-up area

Parcellations with more than 50% built area have seldom courts or streets larger than 10m width.

Novelli (1989)

Fig. 927 Ensemble in Venice 1: 5000; 200x200m

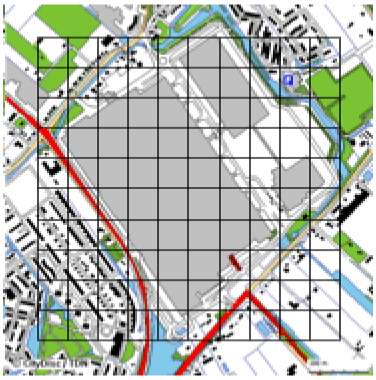


Fig. 928 Auction Aalsmeer 1:25000, ha grid of 1kmx1km, one building nearly covering a district

Such urban areas have no cars like Venice (*Fig. 927*) or they have internal traffic in buildings like the flower auction in Aalsmeer (*Fig. 928*).

The use of open space

The elegantly simple and useful diagram by Permeta is complicated without necessity by introducing %unbuilt/%floor (OSR), or in formula: (A-B)/F. It is supposed that factor determines the use of open space: little unbuilt area compared to a large available floor space would give a pressure of floor-space users on the unbuilt area and for example a shortage of space for cars.
However, the intensity of use of public space (part of the open space) is not very dependend on use by local inhabitants. The traffic intensity of residential streets usually is 1% of its capacity (see *Fig. 530*) The expectation of urban liveliness (intensity) by design is overestimated in districts other than for example the city of New York. In student plans, that overestimate is frequently represented by drawing too much people in suburban public space. A global calculation[a] proves that you must be economical with the crowd pullers to get *some* lively places in the city. And to feed that, you need still a lot of quiet suburbs in the conurbation.

Empty streets

That calculation goes approximately this way. According to the ground usage statistics of CBS[b], in The Netherlands we have approximately 1 billion m^2 circulation area, whereas our population of about 16 millions (including home-bound children and elderly) is on the street at the most half an hour per person per day. This means that, on $100m^2$ public area through the daytime, at average you will see someone driving or walking approximately one minute within a quarter of an hour. Assume that you call a public space as 'urban' in contrast with 'suburban' if you come across someone on $100m^2$ for one minute long each minute ('urban intensity'). How much public space can be then 'urban'?

Stealing liveliness from the suburbs

You must make almost $2000m^2$ street elsewhere quieter for $100m^2$ urban intensity, but not too quiet, otherwise people cannot come to the urban space you want to make 'urban'. That ends up then on 5% of the paved area. If you divide 3% of it concerning the districts, you keep still 2% for the concentration of urban crowd pullers. You should not subdivide urban crowd pullers too much; because you lure more people out of their house with bigger free choice-serving centres. You can at most try to make the public space so attractive, that people exchange the street to their television for a little bit longer than a half hour per day. Can a master plan contribute to that, or should you trust the architectural development?

---

a Jong, Taeke M. de (2004) Grenzen van Stedelijkheid (Zoetermeer) http://team.bk.tudelft.Netherlands/ > Publications 2004
b CBS is the Dutch national bureau of statistics.

Building height, number of storeys

Multipying the Built-up surface by the number of Storeys produces the Floor surface B x S = F (if all façades are vertical). So, the number of storeys S = F/B. If we make F = 100% of the Area A (FSR=1), then the Area is fully covered with one storey, half covered with two storeys, but doubling the number of storeys again reduces the profit of open space (see *Fig. 929*). So, piling up storeys is subject of diminishing returns in terms of open space, while the visual impact of the high rise on open space increases.

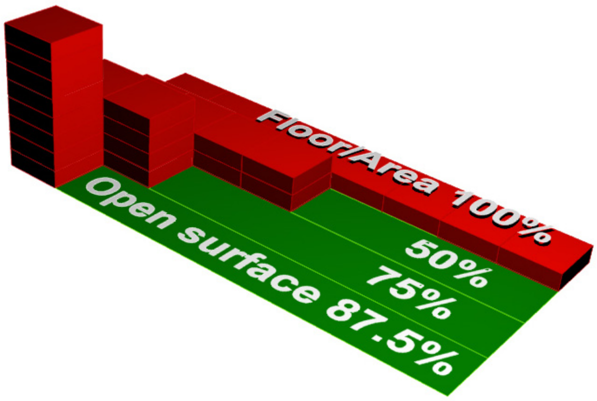
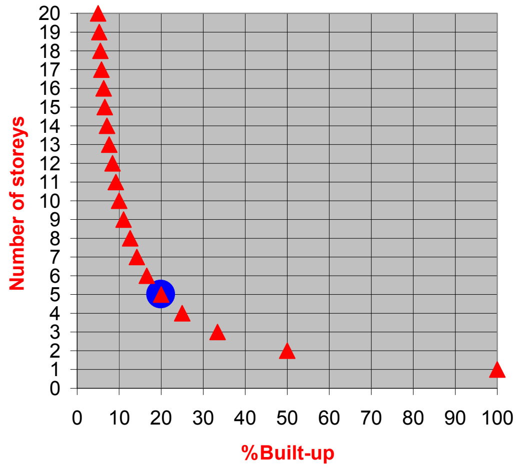


Fig. 929 Diminshing returns of open surface by increasing high rise building



http://team.bk.tudelft.nl/ > Publications 2006 > %Built-up.xls

Fig. 930 Progressively increasing Built-up surface by decreasing number of storeys on 100% F/A

The Built-up surface B is the complement of open surface. The %Built-up (of A) is dependend on the number of Storeys S if we keep FSR or %Floor surface (of A) constant. You can try different %Floor values yourself to change *Fig. 930*.[a] The profit of open space does not increase much above 5 storeys (blue spot in *Fig. 930*).

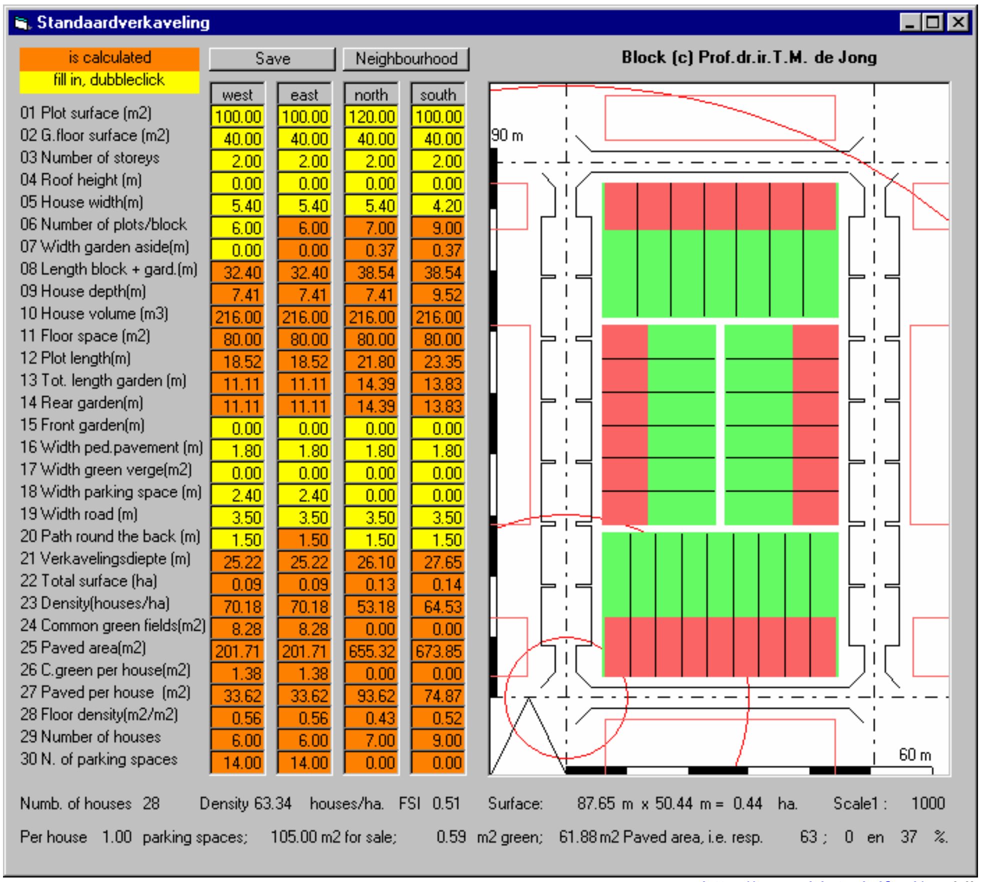
Non-vertical façades

The Built-up area B is recognisable on the topographical map as the vertical projection of the building on the ground-level. However, for example a pyramid will have less floor space than a cube. So, F < S x B. The same applies for buildings with different heights, extended parts, internal voids and non-vertical façades.

[a] http://team.bk.tudelft.nl/ > Publications 2006 > %Built-up.xls

6.3.14 Urban island density$_{30m}$

The urban island is the best level to avoid coincidental differences that could disturb a reliable density comparison. An urban island is bordered by the axis of public infrastructure that opens up or encloses private properties in closest surrounding not intersected by other infrastructure. So it encloses no other public infrastructure than dead-end streets, opening up backyards and garages, water and green area only functional to the smallest publicly opened-up urban area.



	west	east	north	south
01 Plot surface (m2)	100.00	100.00	120.00	100.00
02 G.floor surface (m2)	40.00	40.00	40.00	40.00
03 Number of storeys	2.00	2.00	2.00	2.00
04 Roof height (m)	0.00	0.00	0.00	0.00
05 House width(m)	5.40	5.40	5.40	4.20
06 Number of plots/block	6.00	6.00	7.00	9.00
07 Width garden aside(m)	0.00	0.00	0.37	0.37
08 Length block + gard.(m)	32.40	32.40	38.54	38.54
09 House depth(m)	7.41	7.41	7.41	9.52
10 House volume (m3)	216.00	216.00	216.00	216.00
11 Floor space (m2)	80.00	80.00	80.00	80.00
12 Plot length(m)	18.52	18.52	21.80	23.35
13 Tot. length garden (m)	11.11	11.11	14.39	13.83
14 Rear garden(m)	11.11	11.11	14.39	13.83
15 Front garden(m)	0.00	0.00	0.00	0.00
16 Width ped.pavement (m)	1.80	1.80	1.80	1.80
17 Width green verge(m2)	0.00	0.00	0.00	0.00
18 Width parking space (m)	2.40	2.40	0.00	0.00
19 Width road (m)	3.50	3.50	3.50	3.50
20 Path round the back (m)	1.50	1.50	1.50	1.50
21 Verkavelingsdiepte (m)	25.22	25.22	26.10	27.65
22 Total surface (ha)	0.09	0.09	0.13	0.14
23 Density(houses/ha)	70.18	70.18	53.18	64.53
24 Common green fields(m2)	8.28	8.28	0.00	0.00
25 Paved area(m2)	201.71	201.71	655.32	673.85
26 C.green per house(m2)	1.38	1.38	0.00	0.00
27 Paved per house (m2)	33.62	33.62	93.62	74.87
28 Floor density(m2/m2)	0.56	0.56	0.43	0.52
29 Number of houses	6.00	6.00	7.00	9.00
30 N. of parking spaces	14.00	14.00	0.00	0.00

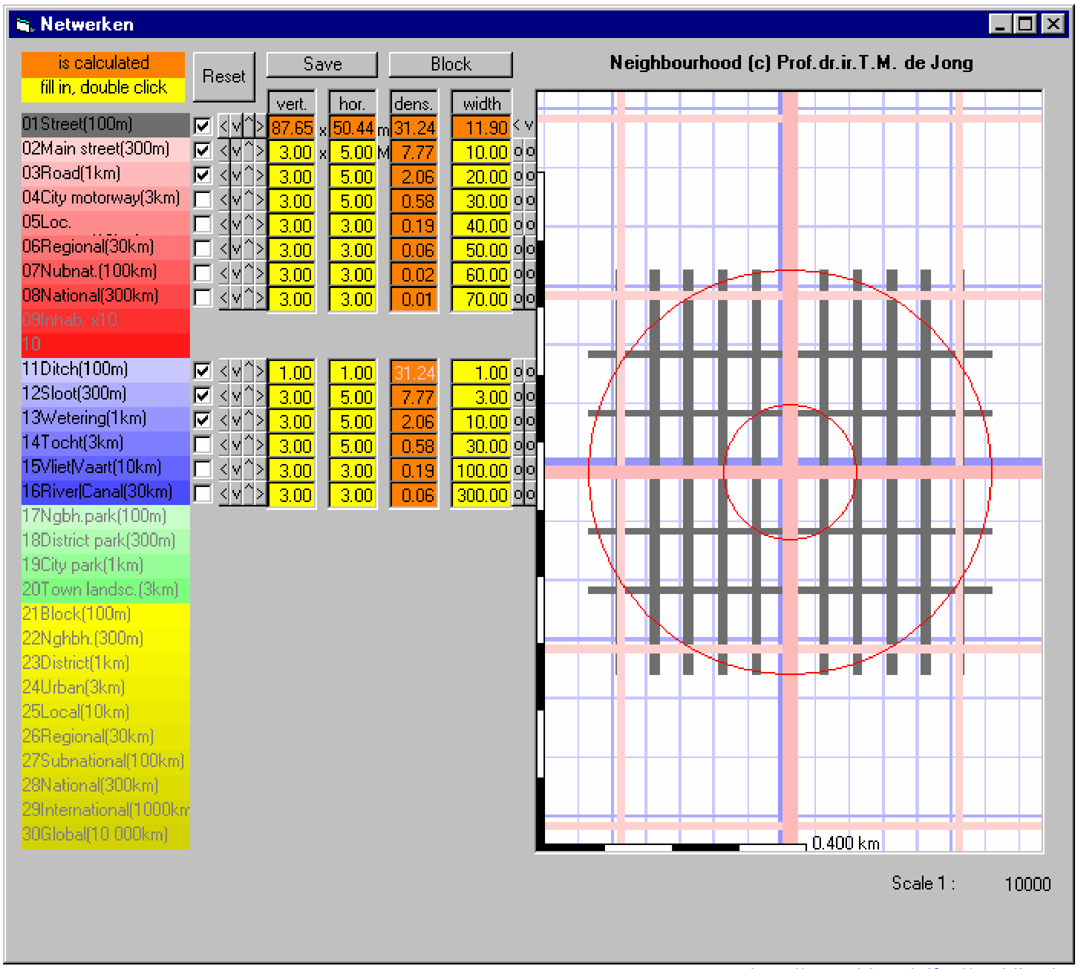
http://team.bk.tudelft.nl/ publications 2003

Fig. 931 The urban island

An ensemble encloses several urban islands + ensemble infrastructure, a neighbourhood encloses several ensembles + neighbourhood infrastructure and so on. The %floor surface per area of an urban island is equal or higher than any other useful density measure by lack of urban tare, except the %floor surface of a particular plot (FAR). Jong (2001) made an interactive computerprogramme showing the behaviour of an orthogonal island changing any of the determining design measures (*Fig. 931*).

Multiplying urban islands into a neighbourhood

Any higher level of scale adds its own tare decreasing the density. The programme shows in a next window the considerable surface occupied by dry and wet infrastructure on every higher level (*Fig. 931*).



http://team.bk.tudelft.nl/ publications 2003

Fig. 932 Adding dry and wet infrastructure

Green surfaces and surfaces for amenities are not yet shown in this window. It should be clear that such infrastructure of higher order should not be counted in the density of the lower order when they lack in other locations to compare. On this level of scale these surfaces are *location factors* by which the external *context* of the urban island differs, but not its *density*. They become comparable by density measures on a higher level of scale.

6.3.15 Urban details$_{10m}$ influencing density

Many questions[a] about the influence of urban details of a closed buiding block on density like built width and length, the building depth, the width and length of court, the width of streets, the width and length of island, the built-up surface, the %built-up, the average height of storeys, the number of storeys, the date and hour of sunlight[b], solar angle limits, the outer wall ratio limit and the surface of outer wall are answered quickly by experimenting with all these measures in a downloadable spreadsheet (see *Fig. 933*)[c]. These parameters can be changed easily to find their influence on density. By experimenting with this spreadsheet you are warned for dark buildings, courts or streets changing them.

[a] Uytenhaak (2005)
[b] see http://www.jgiesen.de/sunshadow/
[c] http://team.bk.tudelft.nl/ > Publications 2006

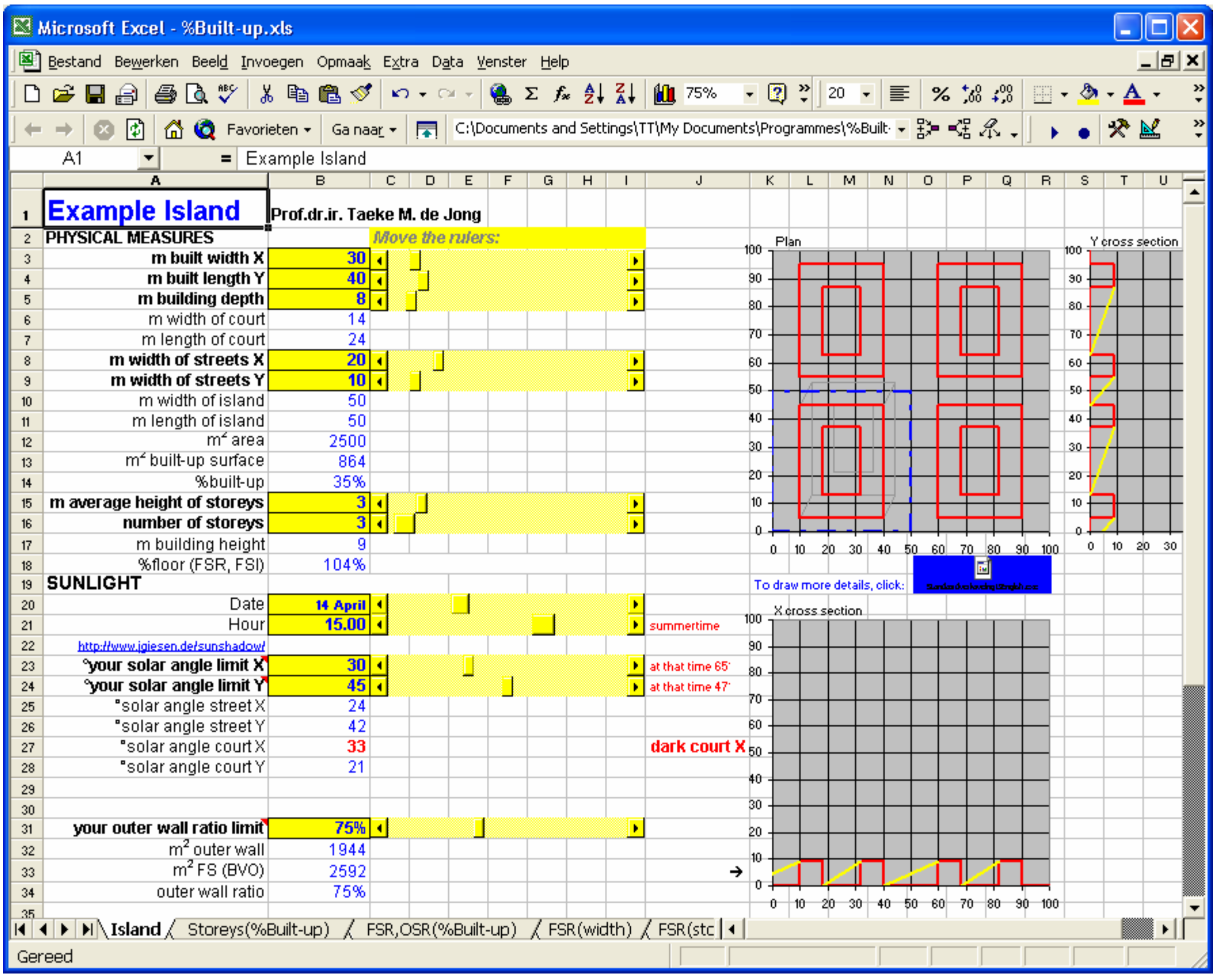
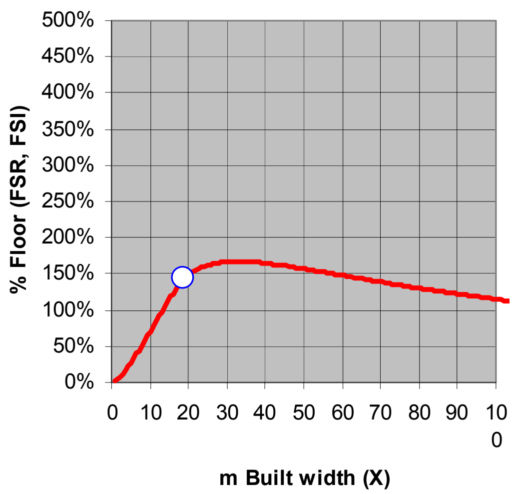


Fig. 933 The %built-up spreadsheet



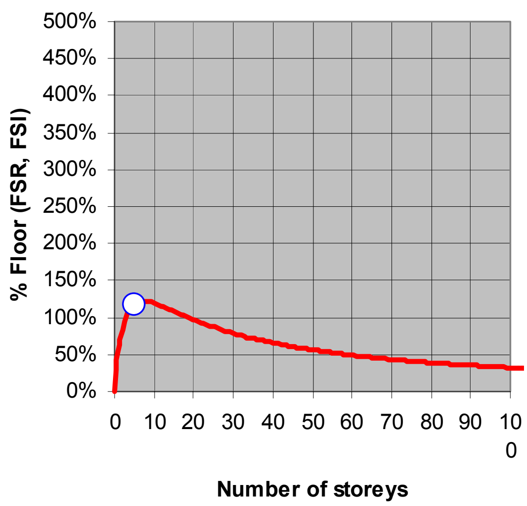


Fig. 934 FSR(Built with) *Fig. 935 FSR(Number of storeys)*

Many graphs like *Fig. 934* and *Fig. 935* can be constucted according to their hidden supositions about these parameters.

6.3.16 References to Densities

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6.4 Economy

6.4.1 Dutch statistics

Every year, as far as I can remember, the the national bureau of statistics CBS has produced the Statistisch Jaarboek (earlier a more extensive Statistisch Zakboekje). Since 2006 it is also available in English (Statistical Year Book). This inexpensive publication gives an overview and a popular extract of CBS statistics (currently, with much more data, to be found on http://www.cbs.nl/).

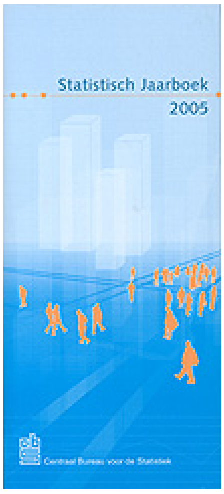


Fig. 936 The Statistical year book

An example for direct use in urban design

There, for example, you can find characteristics of 240 urban facilities. Dividing their number by total population of The Netherlands you can calculate how many people you need to support each facility at average (see page 730). How many schools, restaurants, petrol stations has a Dutch district of 10 000 inhabitants at average? The deviation from this average determines the functional profile or identity of a region, conurbation, town, district or neighbourhood.

Intellectual substance

Those who are familiar with this pocket book are mostly of the opinion that one is not an intellectual unless one has a subscription to it. I support this view. At some point early in the year, as soon as my new copy falls through the letter-box, I settle down in a comfortable chair to look through it. Then, I am unavailable for a few hours, as, with the help of this impressive statistical material, I see numerous popular myths collapse before my eyes.

Manipulating figures in Excel

It appears in the bookshops at the same time as the inexpensive CD-ROM. Like the website http://www.cbs.nl/ this is a great blessing, because now all the tables can be transported to Excel and then the feast of selecting and working with this material can begin. A number of establishments are listed for every organization and branch. To give an impression of the kind of data you can find and manipulate, I have taken my CD-ROM *Statistisch Jaarboek 2001* with figures from 2000 and put the relevant urban architectural tables from the following chapters, in Excel[a]:

1 Population
1.1 Population
1.2 Health and well-being
1.3 Education
1.4 Culture, recreation and other uses of time
1.5 Legal protection and safety
1.6 Residence

2 Employment, incomes and social security
2.1 Employment and wages
2.2 Incomes, property and expenditures
2.3 Social security

3 Businesses
3.1 Demography of businesses
3.2 Business book-year accounts
3.3 Automation and research and development (R&D)
3.4 Agriculture and fisheries
3.5 Energy and minerals
3.6 Industry
3.7 Building industry
3.8 National trade and service industry
3.9 International trade
3.10 Traffic, transport and communication

4 Government, politics and management
4.1 Government finances
4.2 Politics and management

5 Macro-economy and the money and capital market
5.1 National accounts
5.2 Money and capital market
5.3 Producer and consumer prices

6 Geography and environment
6.1 Geography
6.2 Environment

Fig. 937 The content of the Statistisch Jaarboek 2001
(See page 737 for a specification relating to the tables used)

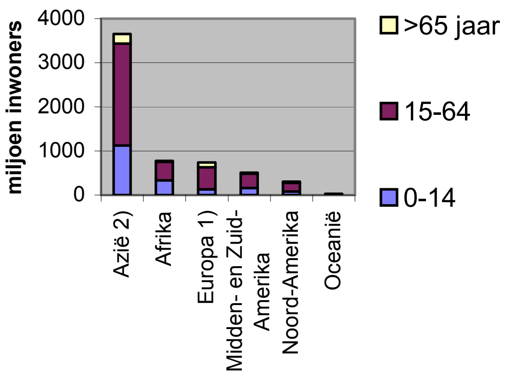
It is up to you to make the same graphs with more recent figures and to compare them with those of 2000.

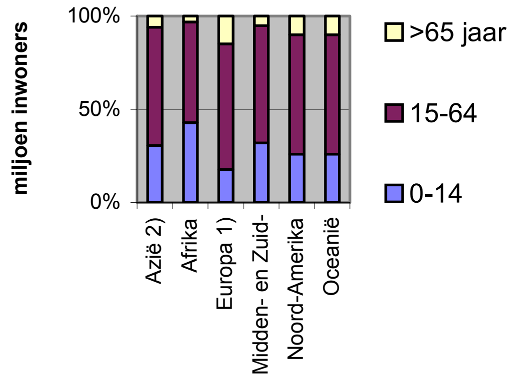
[a] http://team.bk.tudelft.nl/ > databases

6.4.2 Population

Compared with other continents

Compared with Asia, Europe is not only small, but, in contrast to all other continents, its population is much older (*Fig. 938* en *Fig. 939*).





(1) Including Russia, excluding Turkey. (2) Including Turkey. Source: U.S. Bureau of the Census International Database

Fig. 938 Number of residents per continent *Fig. 939 Age range per continent*

Population development in the Netherlands

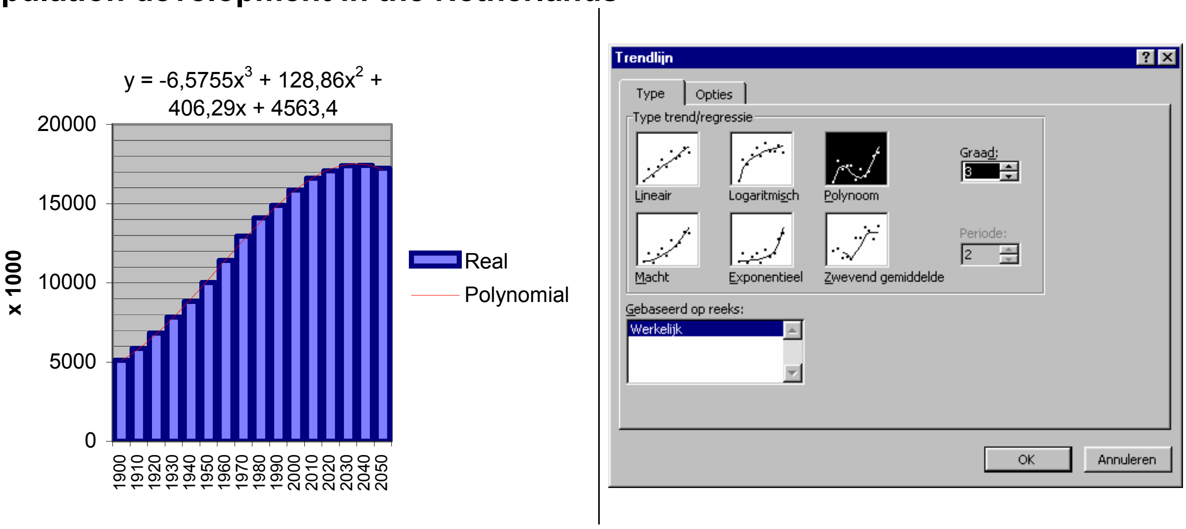


Fig. 940 How the Dutch population has developed (see also Fig. 831), using a polynomal trendline from Excel

When you make a chart in Excel to show how the Dutch population has developed (omitting the years between the 10s), you discover that, for a century, every 10 years, the population has increased roughly by a million. Select a chart and click on the toolbar ‘chart/add trendline’ and you will find the above menu (see also *Fig. 414*). If you choose a third-degree polynomial and, from ‘options’, click on ‘show equation in chart’, then you get the above result. A polynomial appears to fit in well here, and allows interpolation between the available years, but it has no rational linkage at all with reality. To find that kind of formulas is the task of demography (see page 532). So, it should not be used for extrapolation.

Population characteristics

After World War 2, the number of people per household (which almost equates with 'occupance per dwelling') decreased from 5 to 2.3 and the expectation is that it will decrease even further. From an urban point of view, this is an important figure because this halving of occupancy meant that, for the same population, twice as many dwellings had to be built (*Fig. 941*). Family dilution has mainly come about due to the increasing number of single-family households (*Fig. 942*).

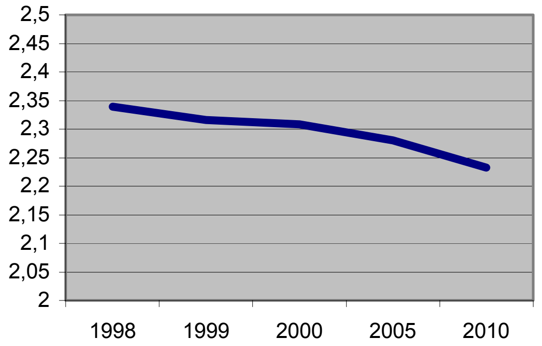


Fig. 941 Average number of people per household

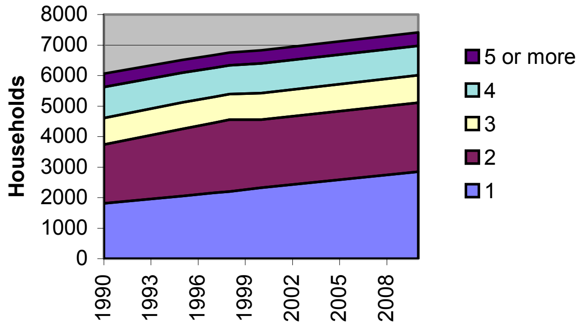


Fig. 942 Number of people per household

Ageing

The population continues to age, but the question is whether, under the new politics, the number of immigrants will continue to grow as was forecast in 2001.

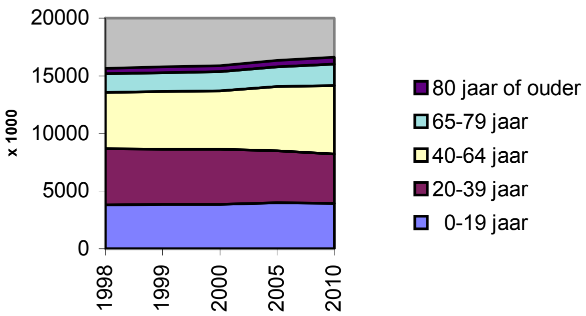


Fig. 943 Changes in age range

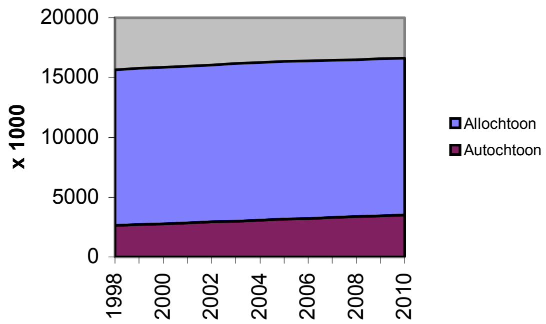


Fig. 944 Proportion of first and second generation immigrants

6.4.3 Time and movement

Time utilisation

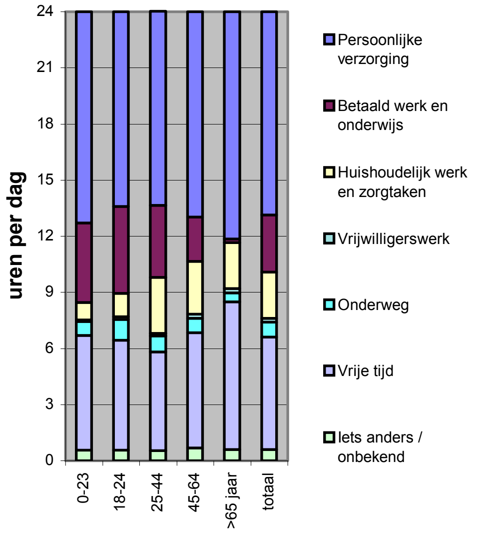


Fig. 945 Time utilisation in 1997

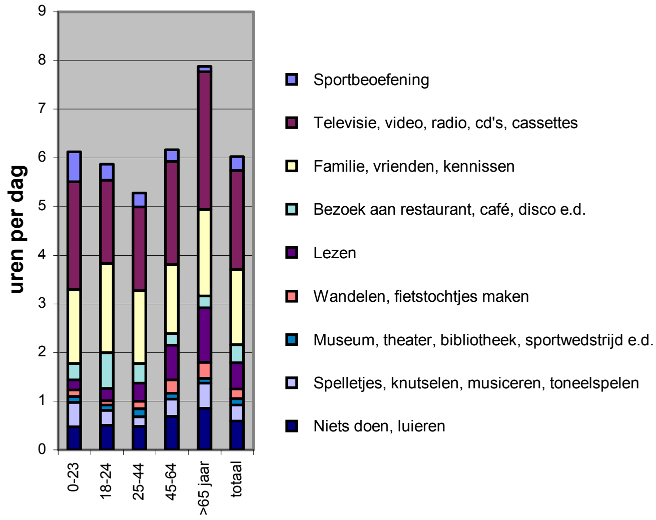


Fig. 946 Use of free time in 1997

Daily population movements

The average total distances travelled, mainly by car, per person per day is fairly constant at 35 km (*Fig. 947*). Commuting accounts for almost 10 km of this distance (*Fig. 948*).

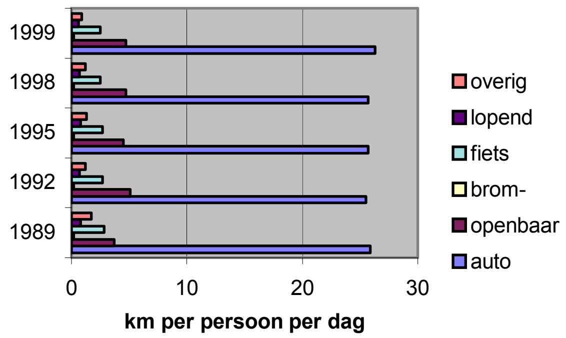


Fig. 947 Total distance travelled per means of transport

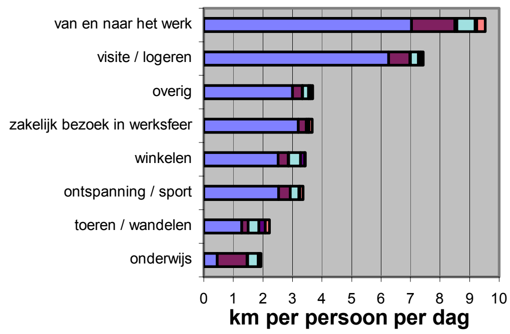
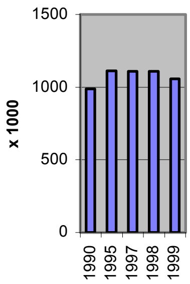


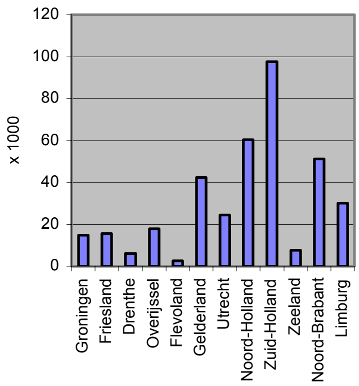
Fig. 948 Distance travelled per motive and means of transport

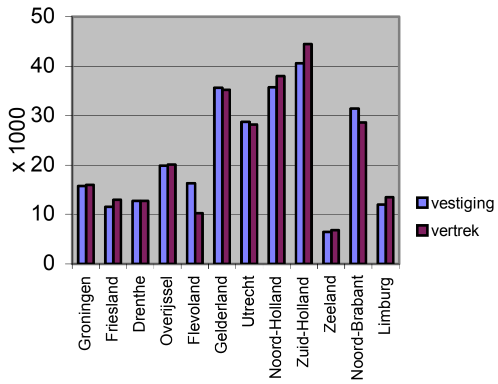
Removals

In 1999, 1,696,000 Dutch people moved to another place of residence in the Netherlands. More than a million of these changes of address were within the same municipality (3 km radius), more than a quarter of a million within the same province (30 km radius) and almost 0.4 million from one province to another (300 km radius).

Removals in 1999 within	3km	30km	300km	total
	1058000	267000	371000	1696000
	See *Fig. 949*	See *Fig. 950*	See *Fig. 951*	







Number of removals

Fig. 949 Municipal *Fig. 950 Provincial* *Fig. 951 National*

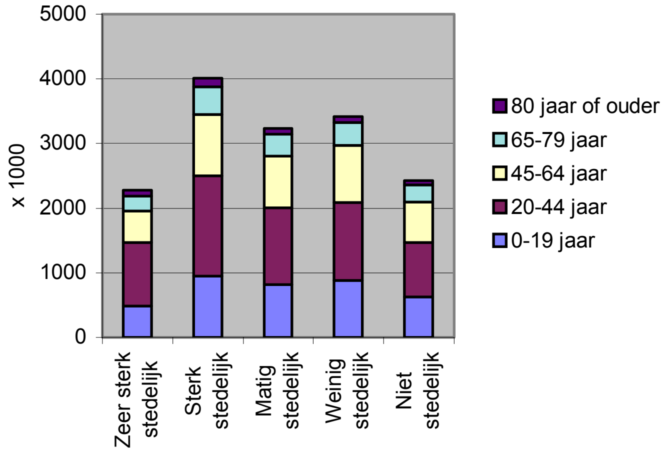
The largest number of removals took place within and between the provinces South and North Holland.

6.4.4 Urbanity

For the classification of urbanity the numerical values for the neighbourhood address densities of the different municipalities are categorised into five groups or classes. The boundaries of the classes have been chosen in such a way that all the classes contain about the same number of residents. In this way, the following categories can be distinguished:

- very strongly urban municipalities with a neighbourhood address density of 2,500 addresses or more per km^2 ;
- strongly urban municipalities with a neighbourhood address density of 1,500 to 2,500 addresses per km^2 ;
- moderately urban municipalities with a neighbourhood address density of 1,000 to 1,500 addresses per km^2 ;
- hardly urban municipalities with a neighbourhood address density of 500 to 1,000 addresses per km^2;
- non-urban municipalities with a neighbourhood address density of less than 500 addresses per km^2.

The number of residents who live in these environments is therefore divided rather similarly, with small variations in age (*Fig. 952*).



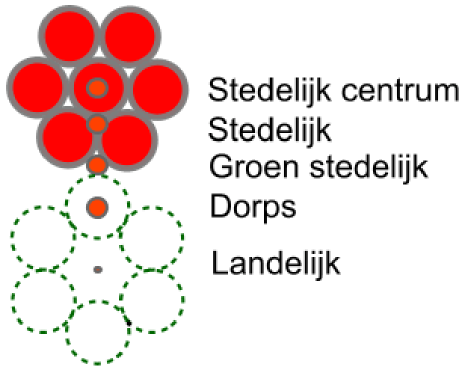


Fig. 952 *Inhabitants by urban environment category, according to the CBS*

Fig. 953 *On the map*

In NRO5, the RPD used a similarly grouped classification to that of a stipple chart, for reading off a location (*Fig. 953*).

Order of municipality by size

On 1st January 2000, this population was resident in 537 municipalities. When one lists these municipalities according to size, one gets the ‘ordering’ of municipalities (rank size). In *Fig. 954*, using the ordering in this list, 1 in 40 of the municipalities is named. This does not produce a straight line, because the size of municipalities from the largest, downwards, diminishes rapidly, at first, before slowing down.

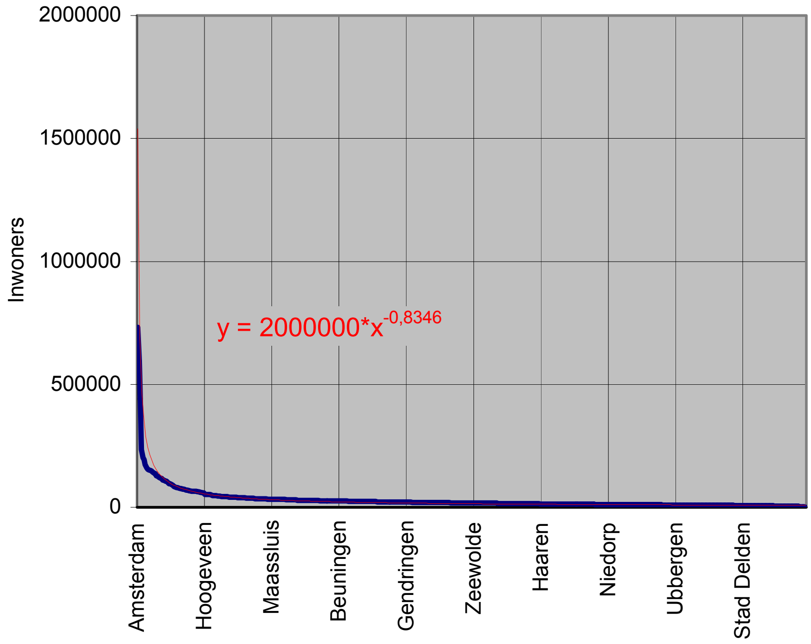


Fig. 954 *Ordering municipalities using a power trendline in Excel*

When the *y* axis is made logarithmic, the graph becomes clearer:

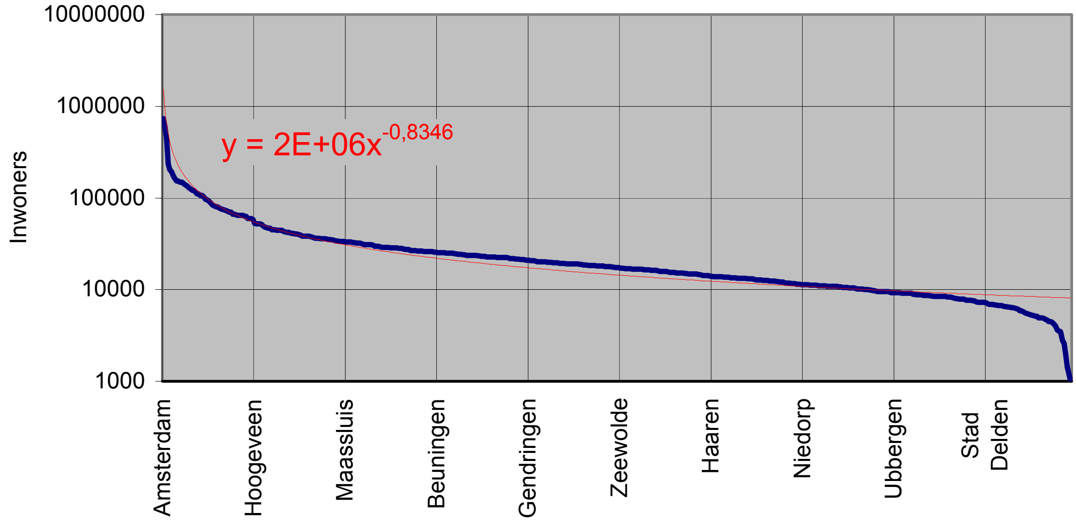


Fig. 955 *Ordering municipalities, expressed logarithmically, using a trendline in Excel*

Then it also becomes clear that, for the smallest municipalities, the trendline is no longer accurate: reality decreases faster for populations from below 10,000 to the smallest municipality (Schiermonnikoog), probably due to the geographical restrictions of the island boundary.

Order of conurbations

The historical boundaries of municipalities cut through the reality of amalgamated built-up areas (urban conurbations), so that these graphs give an incorrect picture of the Ordering of urban areas. However, the *Yearbook* also gives a table of urban conurbations of over 100,000 inhabitants. The somewhat out-of-date definition of this type of conurbation is given in the *Yearbook* as follows:

A central town with surrounding municipalities that (on 31st May 1960) fulfilled the following conditions:

- more than 50% of the commuters resident there must be employed in the central town;
- in addition, the above-mentioned commuters must comprise at least 15% of the working population of the central town.

This table is shown next to the upper section of the municipality table (*Fig. 956*) in *Fig. 957*.
In general, municipal density is much higher than conurbation density.

	inhabitants	km² land	no. inhabitants /ha.
Amsterdam	731288	165,13	44
Rotterdam	592673	208,61	28
DenHaag	441094	67,92	65
Utrecht	233667	61,42	38
Eindhoven	201728	87,31	23
Tilburg	193116	117,42	16
Groningen	173139	80,15	22
Breda	160615	127,00	13
Apeldoorn	153261	340,30	5
Nijmegen	152200	53,70	28
Enschede	149505	140,04	11
Haarlem	148484	29,45	50
Almere	142765	131,62	11
Arnhem	138154	98,57	14
Zaanstad	135762	74,50	18
DenBosch	129034	85,00	15
Amersfoort	126143	62,88	20
Maastricht	122070	57,01	21
Dordrecht	119821	80,58	15
Leiden	117191	22,16	53
Haarlemmermeer	111155	180,01	6
Zoetermeer	109941	35,59	31
Emmen	105972	340,56	3
Zwolle	105801	95,35	11
Ede	101700	318,29	3

Fig. 956 *Municipalities > 100,000 inhabitants*

	inhabitants	km² land	no. inhabitants /ha.
Amsterdam	1E+06	365,12	27
Rotterdam	989956	355,50	28
DenHaag	610245	187,50	33
Utrecht	366186	140,93	26
Eindhoven	302274	181,27	17
Leiden	250302	87,26	29
Dordrecht	241218	153,42	16
Heerlen	218078	109,22	20
Tilburg	215419	159,47	14
Groningen	191722	126,09	15
Haarlem	191079	76,67	25
Breda	160615	127,00	13
Amersfoort	154890	121,50	13
DenBosch	154368	118,55	13
Apeldoorn	153261	340,30	5
Nijmegen	152200	53,70	28
Enschede	149505	140,04	11
Arnhem	139576	126,50	11
GeleenSittard	127322	98,13	13
Maastricht	122070	57,01	21
Zwolle	105801	95,35	11

Fig. 957 *Conurbations > 100,000 inhabitants*

From these tables, it appears that some conurbations (Heerlen and Geleen–Sittard) are composed of municipalities smaller than 100,000 inhabitants, while a number of municipalities (Almere, Zaanstad, Haarlemmermeer, Zoetermeer, Emmen and Ede) with more than 100,000 inhabitants are missing, partly because, due to commuting, they have been included in the conurbation of a larger municipality nearby. *Fig. 958* shows the Ordering of the agglomerates in *Fig. 957*.

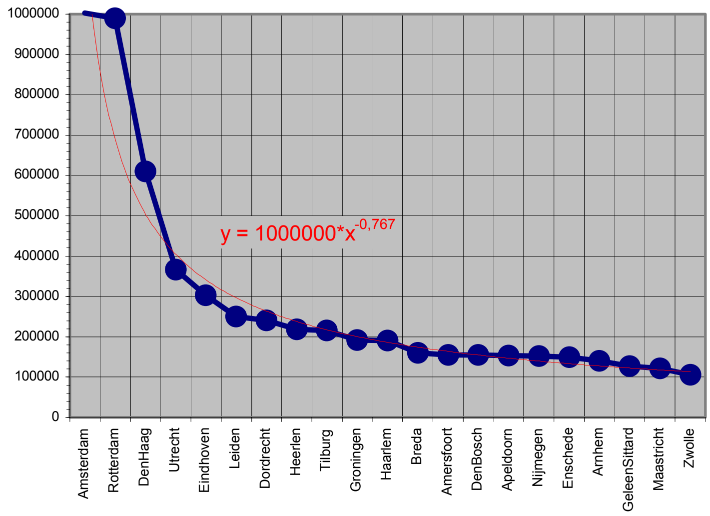


Fig. 958 *Ordering of conurbations*

Going beyond The national order

In the Netherlands, two large conurbations dominate the ordering. If Amsterdam had 2 million inhabitants, the ordering would fit better into the formula. When we map the deviations from the formula (*Fig. 959*), then Amsterdam or Rotterdam, and, to a lesser extent, The Hague, are incongruous. This can indicate an international position, which has its own order. Following this line of thought, then, Utrecht falls within the national ordering.

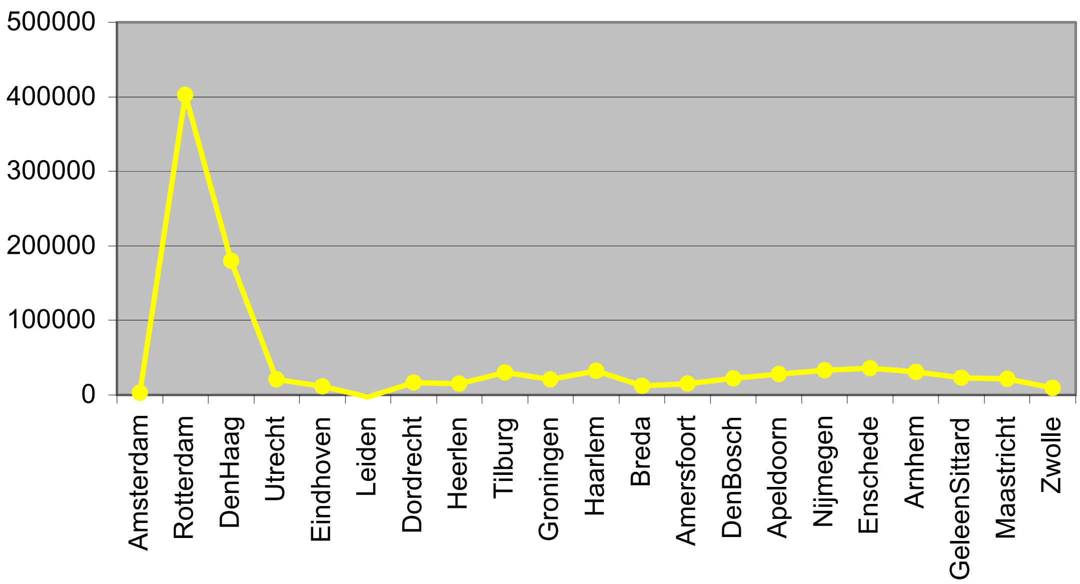


Fig. 959 *Deviations from the ordering y = 1000000·x-0.767 in the higher regions*

6.4.5 Facilities

Order of facilities

amenitiesThroughout the Yearbook 2001, numerous tables are included that mention the number of established faclities for every organization and branch. I have been able to find those statistics for 256 types of establishment, but many are still missing, such as prisons, police stations, ministeries, embassies, surrogate family homes, boarding schools, monasteries and convents. The figures are taken from different years. For each year, I divided the population of the Netherlands by this statistic, to calculate the average support base needed for each type of facility. The size and importance of these facilities (see Appendix 2, page 730) equates with the size of the urban area (*Fig. 960*).

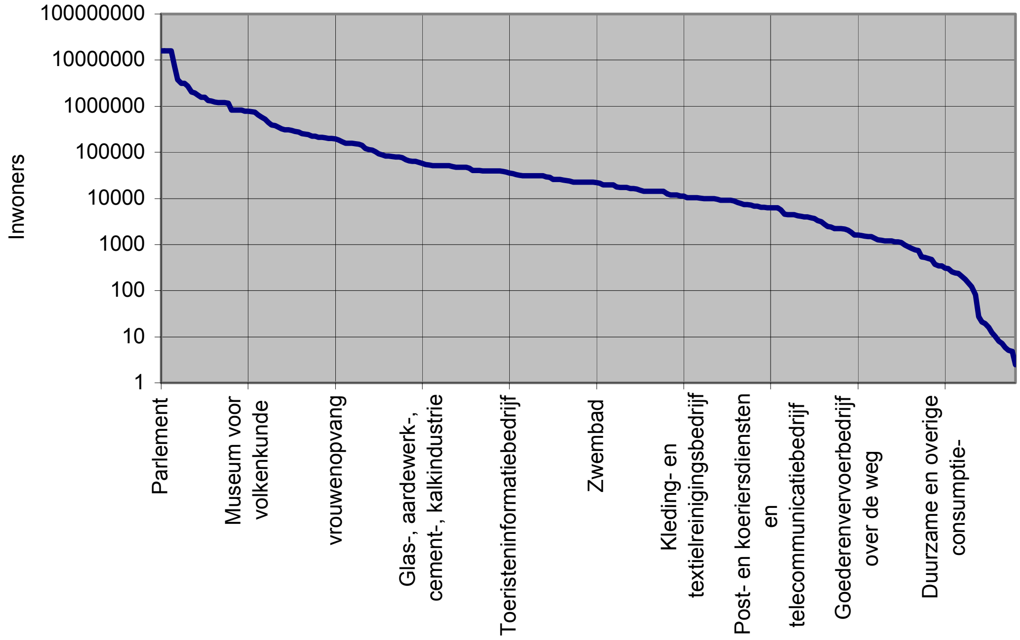


Fig. 960 *Ordering of 244 types of establishment, shown logarithmically*

From this, one can see that, for a population of 100,000 inhabitants, a 'town', that most facilities can find a sufficient support base. Local deviations from this Dutch average also contribute to (part of) the functional identity of the town (or urban district). For those who would like to know more about these urban facilities on the level of a town, *Fig. 961* gives a good picture.

Facilities on town level

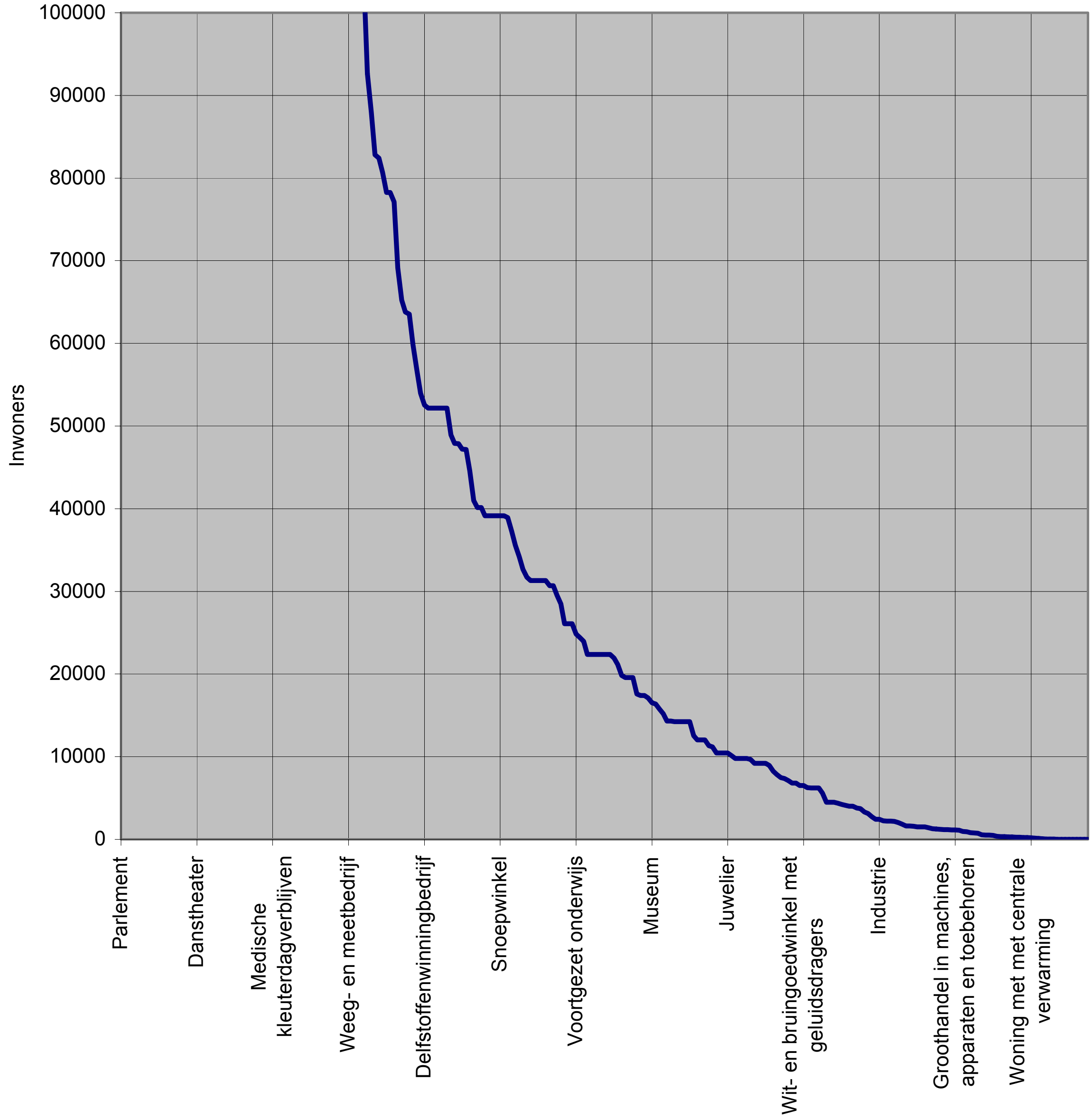


Fig. 961 *Ordering of facilities for 100,000 inhabitants*

This graph has a certain multi-staged characteristic. In the steep vertical parts, urban growth apparently allows little growth in the level of facilities that it can offer. For populations between 55,000 and 100,000 inhabitants, the number of types of facility hardly increases at all. In the horizontal parts, a little growth can deliver much more facilities. With 25,000 inhabitants (large village, district) one already has a base that is large enough to support half the number of known facilities. To examine the lowest part from 10 000 inhabitants in more detail, *Fig. 962* gives a good picture.

District or village facilities

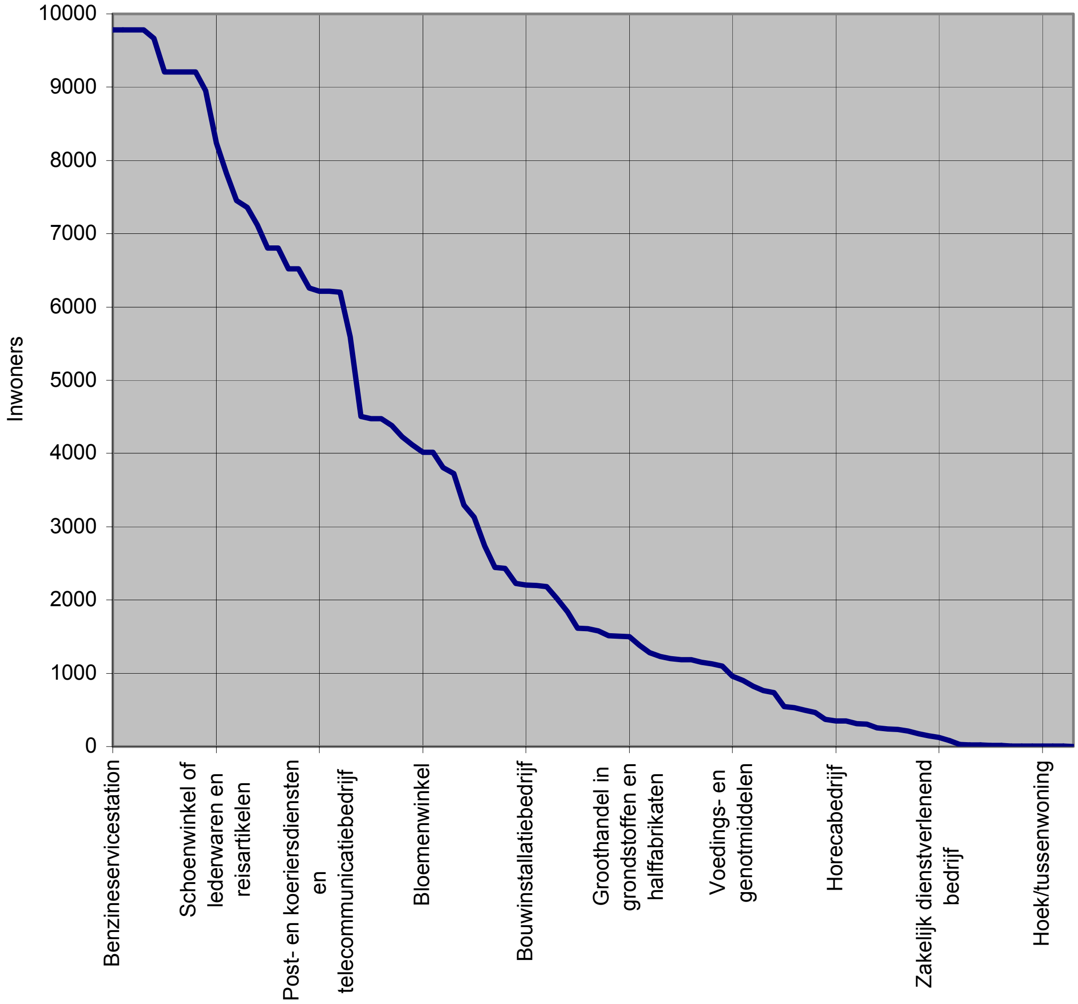


Fig. 962 *Ordering of facilities for 10,000 inhabitants.*

A 1000 inhabitants (neigbourhood) give support to 1/3 of the district facilities.

6.4.6 Dwellings

How many of each kind

On 1st January 2000, in the Netherlands, there were approximately 6,588,000 homes, the value of which totalled € 575,945,000,000, divided into categories, as shown in *Fig. 963*

	year	population x 1000	number of dwellings	support base in persons
Home	1999	15760	6390100	2.47
Own home	1999	15760	3303700	4.77
Rented home	1999	15760	3086400	5.11
Home with central heating	1999	15760	89700	176
Flat/appartment, etc.	1999	15760	1965000	8.02
End of terrace-/terraced house	1999	15760	2689900	5.86
Home with a garden or grounds	1999	15760	75600	208
Home with a garage and/or a carport	1999	15760	33600	469
A detached house	1999	15760	979400	16
A semi-detached house	1999	15760	755800	21
A 1 or 2-roomed home	1999	15760	580500	27
A 3-roomed home	1999	15760	1273800	12
A 4-roomed home	1999	15760	2164100	7.28
A 5-roomed home	1999	15760	1556300	10
A home with 6 or more rooms	1999	15760	815400	19

Fig. 963 *Housing categories and their number in relation to the total population of the Netherlands*

So, on every 19 inhabitants there was a dwelling with 6 or more rooms.

Price and age

From *Fig. 964* and *Fig. 965* it is possible to determine the average age and price of homes in the Netherlands.

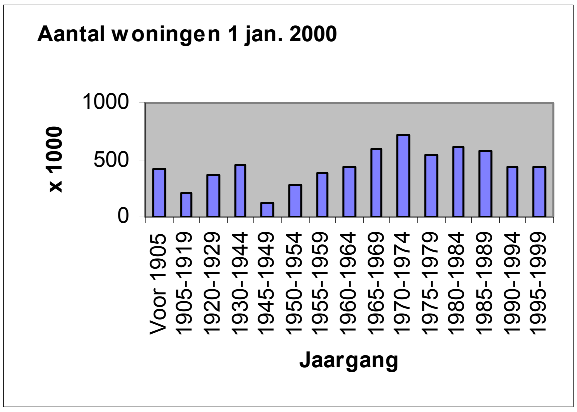


Fig. 964 *Number of homes per year of construction*

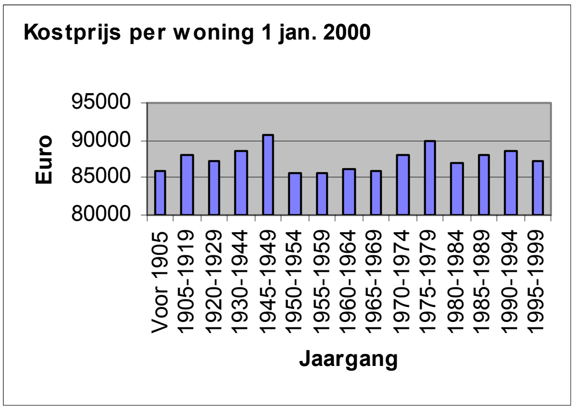


Fig. 965 *Value of home per year of construction*

Most of people live in houses constructed after 1960, singles rent, families buy

The majority of people in the Netherlands live in accommodation that was built after World War II, between 1960 and 1990 (*Fig. 966*). Single-person households are mainly accommodated in rented homes. Couples usually buy their own living accommodation (*Fig. 967*).

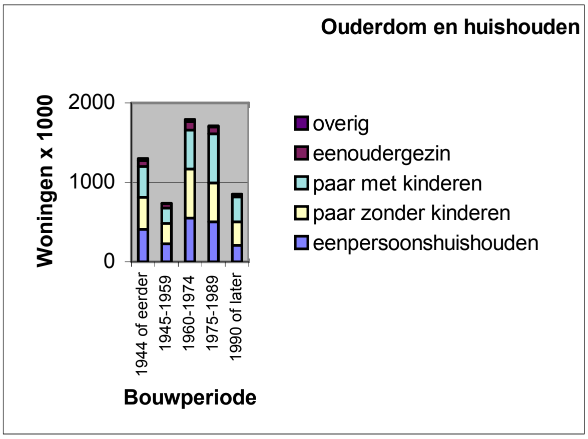


Fig. 966 *Occupancy per year of construction*

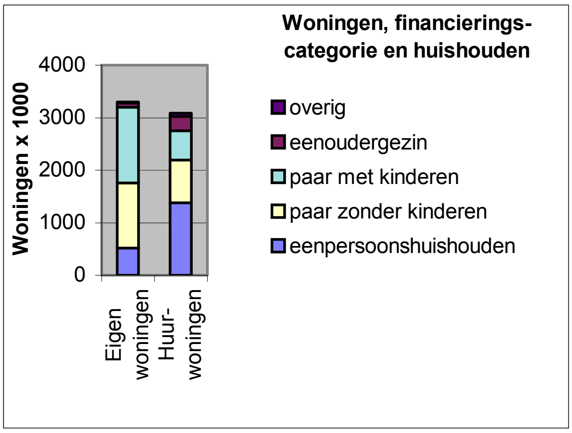


Fig. 967 *Occupancy in own or rented houses*

6.4.7 Public space

National territory

In 1996, the Netherlands occupied a territory of 41,526 km^2, divided over various provinces and land-use categories, as shown in *Fig. 968*. Of these categories, forest, nature and water can be seen as public facilities, to a greater or lesser extent. Built-up areas occupy a relatively small area.

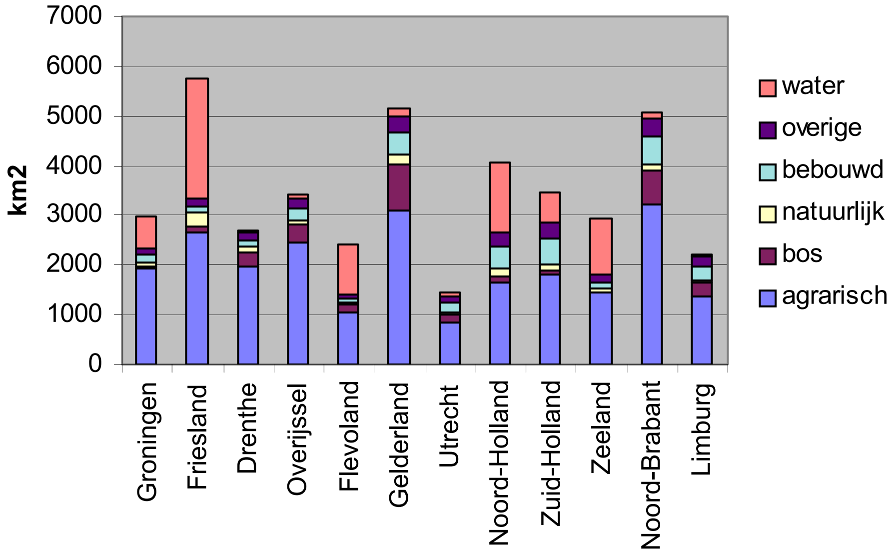


Fig. 968 *Land use in different provinces (from below: agriculture, forest, nature, built-up, otherwise, water) in the Netherlands*

The lengths of roads

In 1999, the Netherlands had 117,430 km of surfaced roads (if one was to include unsurfaced roads, this would be approximately 95% of the total road network). The growth of this road network is shown in *Fig. 969*. Although not all means of transport are public facilities, they form, together with the surfaced roads, a transport system (*Fig. 970*).

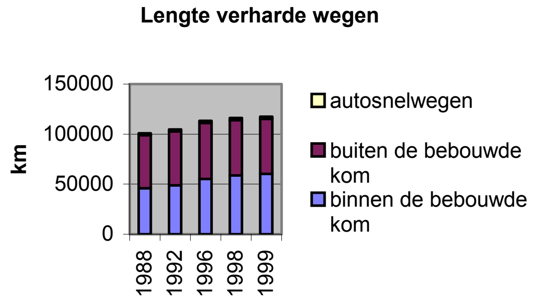


Fig. 969 *Extent of surfaced roads*

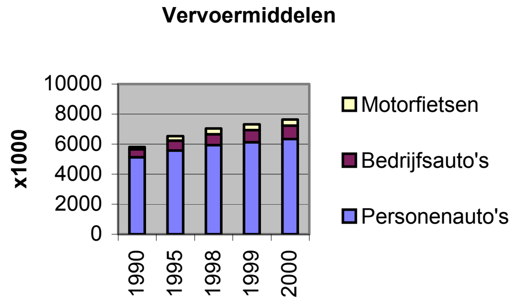


Fig. 970 *Means of transport*

The density of roads

Outside the built-up areas, the prevailing road network has an average mesh width of approx. 1 x 1 km (density 2 km per km^2). Within built-up areas, the mesh width is almost 100 x 100 m (20 km per km^2). Motorways have an average mesh width of approx. 30 x 30 km (0.07 km per km^2).

	length	surface area	density	average mesh width in km
motorways	2256	29261	0.077	30
outside the built-up areas	54820	26060	2.104	1
inside the built-up areas	60354	3201	18.85	0.1
total extent of surfaced roads	117430	29261	4.013	
railways	2808	33873	0.083	30

Fig. 971 *The density of the road network*

The density of the railway network can be compared with that of the motorways.
Approximately 135 people are needed as a support base for a kilometre of road.

6.4.8 Public utilities

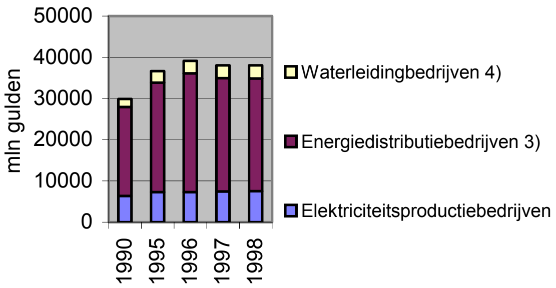
Energy and water companies

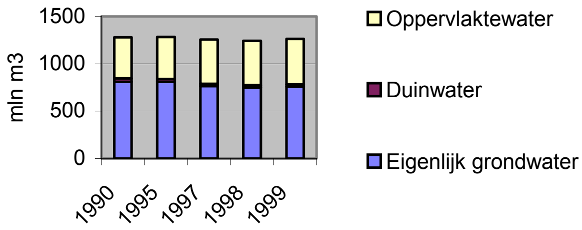
The number of water boards has decreased from 32 in 1990 to 20 in 1998. However, the number of employees or cubic metres of water produced remained the same (*Fig. 974*). As with agrarian firms, this indicates concentration.

Establishments for:	**year**	**population**	**number**	**growth per year**	**support base**
Electricity producing company	1998	15654	5	0%	3130838
Energy distribution company	1998	15654	70	-1%	223631
Water Board	1998	15654	20	-9%	782710

Fig. 972 *Number of utility facilities compared with the size of the Dutch population*

Energy and water production





Note 3: Including power installations(>50 GWh per year), in the context of joint ventures, exploited by energy distribution companies and industrial companies.
Note 4: Excluding multi-utility companies.

Fig. 973 *Production value of utility companies*

Fig. 974 *Water production*

Facilities for health and welfare

Fig. 975 is a table showing 20 different types of public health facilities. By dividing the population by the number of facilities, a potential support base emerges that indicates the number of inhabitants that would be needed to support this type of facility. Due to an irregular, historically determined distribution of the facilities and the factors determining their establishment at a specific location, their distribution is, of course, unevenly concentrated, which, in turn, means that the actual support base, locally, can also vary.

Establishments for:	**year**	**population**	**number**	**growth per year**	**support base**
after-school care centres	1998	15654	992	18%	15780
hostels caring for vagrants and homeless people	1999	15760	228	5%	69124
host-family care centres	1998	15654	189	1%	82826
half-day crèches/nurseries	1998	15654	169	9%	92628
full-day crèches/nurseries	1998	15654	1749	16%	8950
family doctors'/ general practitioners' (gps') practises	2000	15864	4809	0%	3299
established general practitioners (gp)	2000	15864	7217	1%	2198
childrens' independently homes	1998	15654	789	4%	19841
homes for the mentally handicapped	1999	15760	151	2%	104372
homes for the those with sensory handicaps	1999	15760	12	-1%	1313352
community care centres	1999	15760	75	3%	210136
childrens' hospitals and hospices	1999	15760	13	1%	1212325
medical day centres for infants	1999	15760	56	8%	281433
psychiatric hospitals	1999	15760	76	-1%	207371
dentists	1998	15654	7030	-1%	2227
nursing homes	1999	15760	334	0%	47186
care homes for the elderly	1998	15654	1380	-1%	11344
crisis centres for women	1999	15760	80	25%	197003
independent dispensing chemists	1998	15654	1547		10119
hospitals	1999	15760	136	-2%	115884

Fig. 975 Number of health facilities compared with the size of the Dutch population

The growth figures for the latest available year, compared with the year prior to that, give an indication of the figures for the years to come, but, in the longer term, they must be calculated more closely in the light of rational expectations of their expected use.

Facilities for children and elderly

Fig. 976 and *Fig. 977* show the growth of facilities for children and elderly not reflecting the number of *users* (dependent on growing Dutch population), but rather the number of establishments.

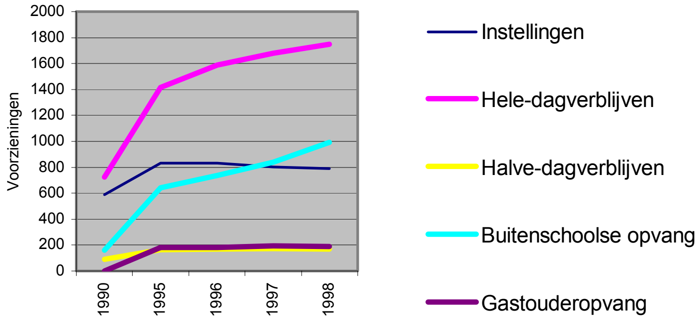


Fig. 976 *Development of facilities for children*

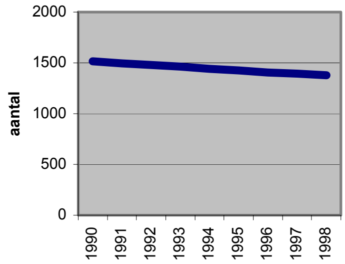


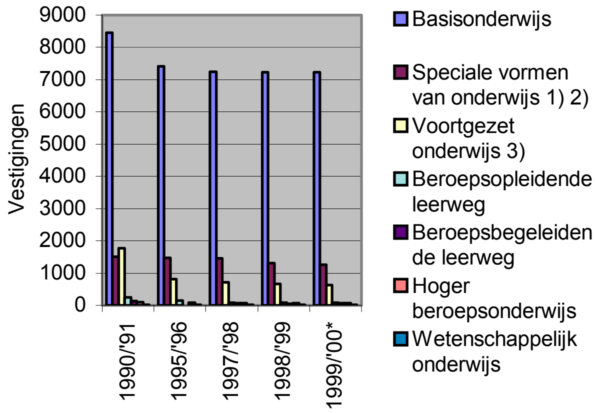
Fig. 977 *Facilities for the elderly (care homes for the elderly)*

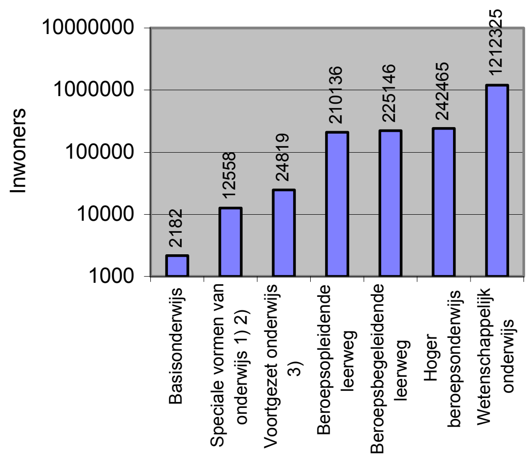
Schools

Establishments for:	year	population	number	growth per year	support base
primary education	1999	15760	7224	-1%	2182
day-release learning path	1999	15760	70	-4%	225146
vocational learning path	1999	15760	75	-7%	210136
higher vocational education	1999	15760	65	-3%	242465
special forms of education	1999	15760	1255	-2%	12558
secondary education	1999	15760	635	-6%	24819
scientific education	1999	15760	13	1%	1212325

Fig. 978 *Number of educational facilities compared with the size of the Dutch population*

Decreasing number of schools





Note 1: Number of departments.
Note 2: Including practical education.

Legend top down: primary, special, secondary, technical and vocational training, technical and vocational guidance, higher technical and vocational, scientific.

Fig. 979 *Development in the number of schools*

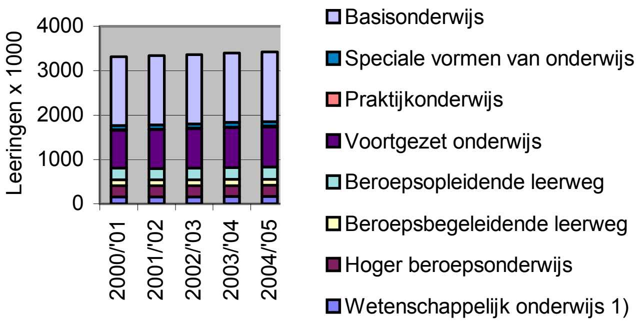
Note 3: University Preparatory Education (vwo), Senior General Secondary Education (havo), Junior General Secondary Education (mavo), Preparatory Vocational Education (vbo) and Learning Path Supporting Education (*lwoo*)

CBS-publication: Education Year Book.

Fig. 980 *The average support base of* Fig. 978

From Fig. 980 you can learn you need a conurbation of more than 1 000 000 inhabitants for a university, a town of >100 000 inhabitants for technical and vocational schools, a district of >10 000 inhabitants for secondary and special schools and a neigbourhood of more than 1 000 inhabitants for a primary school.

Equal number of pupils



Note 1: Including part-time education.

Fig. 981 *Expected number of pupils*

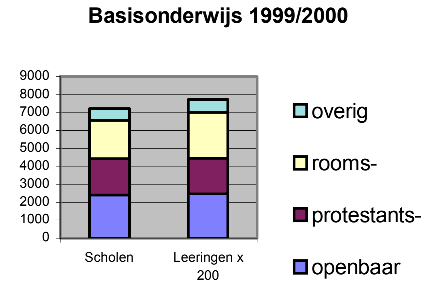
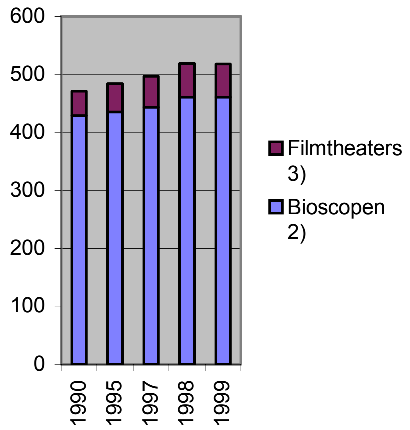


Fig. 982 *Establishments and users of primary schools*

An equal number of pupils combined with the decreasing number of schools shown in Fig. 979, means a development into larger schools.

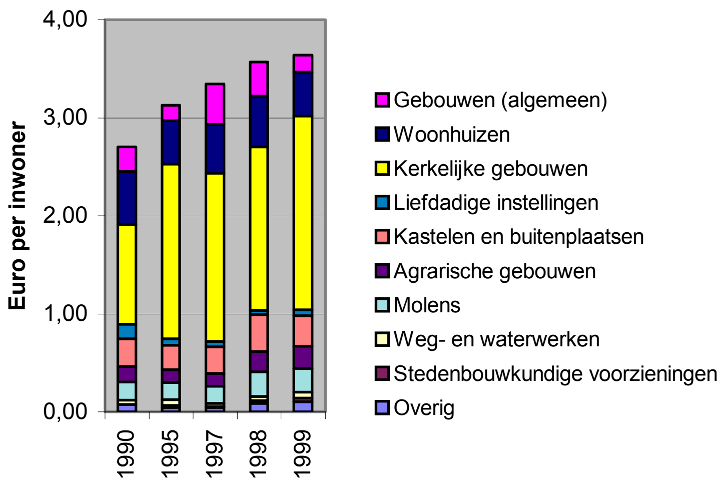
Cinemas and film theatres, preservation of monuments and historic buildings



Note 2: Including two drive-in cinemas
Note 3: Excluding non-specifically equipped performance rooms

Source: (Cinemas) Dutch Federation for Cinematography; (film theatres) Dutch Film Theatre Association

Fig. 983 *Cinemas and film theatres*



Legend top-down: general buildings, dwellings, churches, charity buildings, castles and estates, agricultural buildings, mills, civil engineering works, urban facilities, remaining.

Fig. 984 *Expenditures on historic building projects*

Cinemas are just one category of facilities for culture and recreation summarised in Fig. 985. There you can conclude their number did not increase in 2000.

Facilities for culture and recreation

Establishments for:	year	population	number	growth per year	support base
amusement hall I	1998	15654	420		37272
amenity park	1998	15654	35		447263
ballet theatre	1997	15567	2	-6%	7532471
cinema	1999	15760	461	0%	34187
cabaret theatre	1997	15567	20	2%	761849
casino or lottery	1998	15654	40		391355
creativity centre	1997	15567	63		247097
dance theatre	1997	15567	8	6%	2048304
dance theatre	1997	15567	13	-2%	1173400
zoo	1999	15760	27		583712
film theatre	1999	15760	57	-2%	276495
music and creative arts centre	1997	15567	52		299367
hotel with 1000 over-night stays per year	1999	15760	29053	4%	542
academy of fine arts	1997	15567	244		63800
yacht harbour	1997	15567	400	3%	38918
camping grounds, holiday chalet complexes, youth and group accommodations	1999	15760	3595	-3%	4384
museum	1997	15567	942	1%	16526
mixed museum	1997	15567	19		819321
industrial and technical museum	1997	15567	260		59873
fine arts museum	1997	15567	102		152619
historical museum	1997	15567	491		31705
natural history museum	1997	15567	50		311342
museum of ethnology and folk history	1997	15567	20		778355
musicians' performance stage	1997	15567	50	1%	310514
music school	1997	15567	129		120675
muziektheater	1997	15567	44	4%	355413
theatre for operettas, musicals and revues	1997	15567	8	1%	1954030
horticultural gardens, show gardens and arboretums	1999	15760	104		151541
different types of performing platforms	1997	15567	4	-2%	3736106
place of performance for ensembles	1997	15567	9	0%	1729679
place of performance for improvised music	1997	15567	13	5%	1219356
place of performance for large orchestras	1997	15567	6	1%	2731071
place of performance catering for 300 concerts per year	1997	15567	189	1%	82409
puppet theatre	1997	15567	13	2%	1203642
open-air sports facility	1997	15567	4090		3806
indoor sports facility	1997	15567	2115		7360
theatre	1997	15567	78	0%	200780
playhouse	1997	15567	48	-2%	321413
watersportclub	1997	15567	950	0%	16386
zeil- en surfschool	1997	15567	90		172968
swimming bath	1997	15567	710	0%	21926
swimming bath complex	1997	15567	140	3%	111194
open-air swimming bath	1997	15567	245	-2%	63539
indoor swimming bath	1997	15567	325	1%	47899

Fig. 985 *Number of cultural facilities compared with the size of the Dutch population*

6.4.9 Businesses

On 1st January 1999, there were 752,825 active businesses in the Netherlands, divided into the main categories as shown in *Fig. 986*. A number of these are more finely subdivided in the paragraphs below.

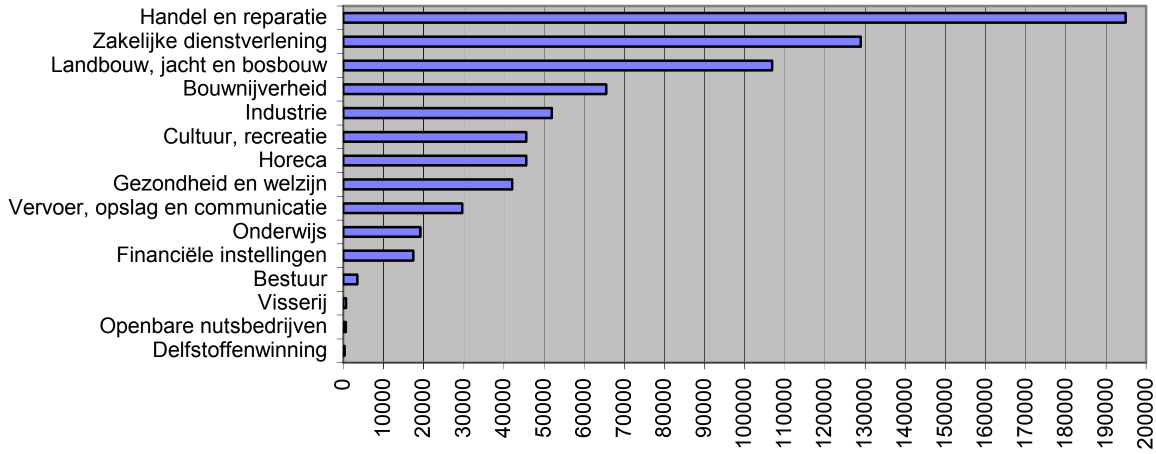


Fig. 986 *Business establishments in 1999*

Agriculture and Fisheries

In 1999 there were still more than 1 million active agrarian firms in the Netherlands (see *Fig. 987*).

Establishments for	year	population	number	growth per year	support base
agricultural, hunting and forestry firm	1999	15760	106815		148
fishery firm	1999	15760	745		21155

Fig. 987 *Number of agrarian firms compared with the size of the Dutch population*

Larger farms

The increase in the scale of these firms can be seen in *Fig. 988*.

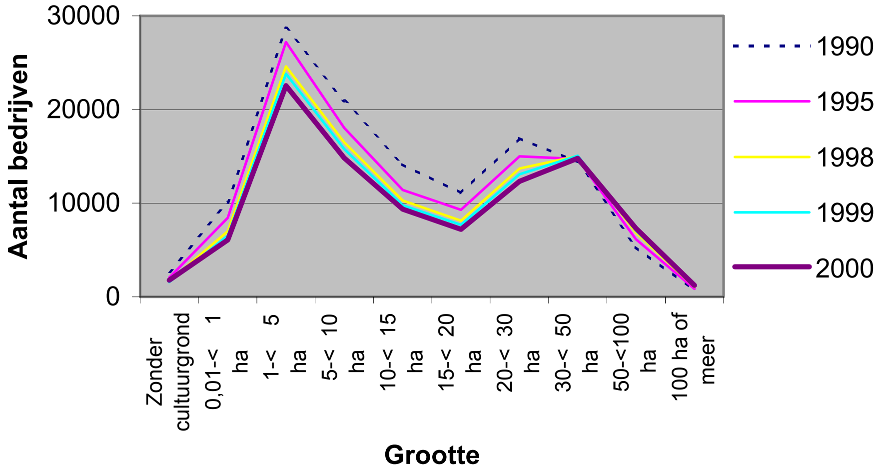


Fig. 988 *The increase in the scale of agrarian firms*

The scaling-up of individual farms while the surface remains equal implies decrease of the number of farms (*Fig. 989*), but increase of the number of large farms (*Fig. 990*).

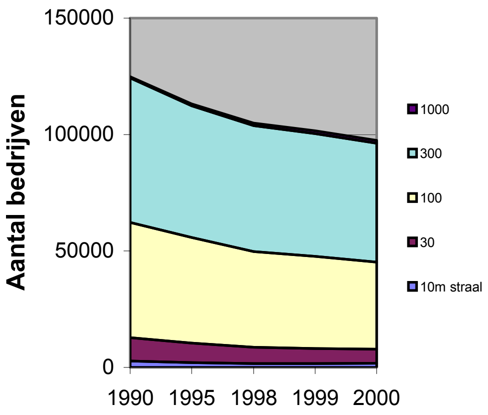


Fig. 989 *The development in the order of size of agrarian firms*

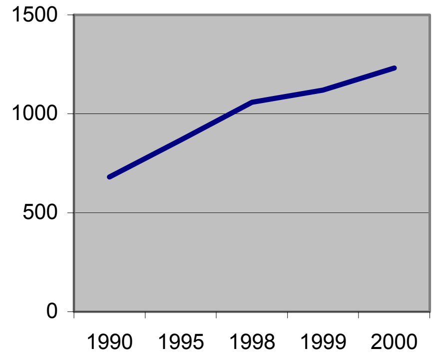


Fig. 990 *The growth of agrarian firms larger than 100 ha. (with a radius of 1 km)*

The surface farms need

The surface areas in hectares in these charts have been recalculated into radii used in urban architecture (*Fig. 991*).

-	from m^2	To m^2	Radius in m	Number of firms 1990	1995	1998	1999	2000
Without arable land			10	2714	2061	1691	1585	1769
0,01-< 1 ha	100	9999	30	10046	8453	7010	6515	6086
1-< 10 ha	10000	99999	100	49556	45253	41076	39613	37355
10-<100 ha	100000	999999	300	61906	56568	54038	52712	51042
100 ha of meer	1000000	9999999	1000	681	867	1058	1120	1231

Fig. 991 *Areas in hectares recalculated into radii used in urban architecture*

Industry

Establishments for:	year	population	number	growth per year	support base
chemical industry	1998	15654	327	1%	47872
clothing and fur industry	1998	15654	77	8%	203301
electrical apparatus industry	1998	15654	390	0%	40139
food-processing and drinks industry, tobacco processing industry	1998	15654	891	1%	17569
furniture and related industries	1998	15654	382	-3%	40980
glass, earthenware, cement and chalk industry	1998	15654	276	3%	56718
industry	1998	15654	6433	1%	2433
leather, leather goods and footwear industry	1998	15654	41	-7%	381810
machine and apparatus industry	1998	15654	915	3%	17108
metal products industry	1998	15654	1093	4%	14322
office-equipment and computer industry	1998	15654	24	-8%	652258
paper (goods) and carton (goods) industry	1998	15654	203	15%	77114
publishers, printers, reproduction	1998	15654	654	-1%	23936
rubber and synthetic-material processing industry	1998	15654	351	1%	44599
textile industry	1998	15654	178	-5%	87945
transport vehicles industry	1998	15654	332	-3%	47151
wooden, cork, and cane goods industry (excluding furniture)	1998	15654	194	5%	80692

Fig. 992 *Number of industrial branches compared with the size of the Dutch population*

Building Industry

Establishments for:	**year**	**population**	**number**	**growth per year**	**support base**
building company	1998	15654	31459	1%	498
building company specialised in finishing off buildings	1998	15654	8514	4%	1839
building company specialised in *b&u, gww*, excluding excavation	1998	15654	14268	0%	1097
building company specialised in preparing building sites	1998	15654	1095	3%	14296
building company specialised in hiring out building machinery and personnel	1998	15654	479	-1%	32681
building company specialised in installation	1998	15654	7103	-1%	2204

Fig. 993 *Number of companies in the building industry compared with the size of the Dutch population*

Retail and inland Trading

Establishments for:	**year**	**population**	**number**	**growth per year**	**support base**
florists	1998	15654	3900		4014
bookshops	1998	15654	1100		14231
building material retailers	1998	15654	1300		12042
computer retailers	1998	15654	500		31308
pet shop	1998	15654	1500		10436
diy retailers	1998	15654	3900		4014
chemists	1998	15654	1700		9208
chemists selling medical goods, perfumes and cosmetics	1998	15654	2100		7454
durable consumer goods and other forms of consumption -	1998	15654	50500		310
cycle shops	1998	15654	2300		6806
audio and amplification equipment retailers	1998	15654	700		22363
glass, porcelain and earthenware retailers	1998	15654	700		22363
greengrocers	1998	15654	2200		7116
wholesalers	1998	15654	61496		255
wholesale suppliers of business requisites and packaging	1998	15654	2524		6202
wholesale suppliers of raw materials and semi-fabricated goods	1998	15654	10420		1502
wholesale suppliers of wood, building materials, iron and metal goods	1998	15654	5727		2733
wholesale suppliers of machinery, apparatus, accessories and parts	1998	15654	13899		1126
wholesale suppliers of non-food consumer goods	1998	15654	21193		739
wholesale suppliers of food, spices and energisers	1998	15654	7733		2024
(textile) handicrafts shop	1998	15654	600		26090
household goods retailers	1998	15654	900		17394
household linnen retailers	1998	15654	100		156542
ironmongery (hardware) and tool shop	1998	15654	700		22363
jewellers	1998	15654	1500		10436
jewellers selling costume jewellery	1998	15654	300		52181
cheese shop	1998	15654	600		26090
stationers	1998	15654	2000		7827
kitchen equipment retailers	1998	15654	500		31308
dress fabric retailers	1998	15654	400		39135
lamp and lighting retailers	1998	15654	400		39135
retailers of leatherware and travel goods	1998	15654	300		52181
lingerie retailers	1998	15654	700		22363
furniture shop	1998	15654	1700		9208
furniture shop with home textiles, lighting goods and floor coverings	1998	15654	5000		3131
musical instrument retailer	1998	15654	400		39135
sewing and knitting machine shop	1998	15654	200		78271
opticians	1998	15654	1100		14231
perfumery	1998	15654	300		52181
poulterers	1998	15654	300		52181
health-food shop	1998	15654	300		52181
shoe shop	1998	15654	1600		9784
shoe shop with leatherware and travel goods	1998	15654	1900		8239
butchers	1998	15654	3700		4231
off-licence	1998	15654	1100		14231
sweet shop	1998	15654	400		39135
toy shop	1998	15654	700		22363
sports and camping-gear retailers	1998	15654	1600		9784

Establishments for:	year	population	number	growth per year	support base
supermarket, grocers	1998	15654	3500		4473
tobacconists	1998	15654	1700		9208
textile supermarket	1998	15654	400		39135
textile retailers	1998	15654	9900		1581
garden centre	1998	15654	600		26090
paint and wallpaper shop	1998	15654	700		22363
fishmongers	1998	15654	700		22363
carpet shop	1998	15654	500		31308
foods, spices and energisers	1998	15654	16300		960
shop	1998	15654	66800		234
shop selling glass, porcelain and earthenware; household articles or toys	1998	15654	2300		6806
shop selling durable household goods	1998	15654	3800		4120
photographic shop	1998	15654	800		19568
retailers of medical and orthopedic goods	1998	15654	100		156542
retailers of kitchen apparatus, other electrical goods and audio equipment	1998	15654	2400		6523
interior decorators, general assortment	1998	15654	1300		12042
home furnishing retailers	1998	15654	1100		14231

Fig. 994 *Number of trading companies compared with the size of the Dutch population*

Inland Services

Establishments for:	year	population	number	growth per year	support base
job centres/employment bureaus for assessing, attracting and selecting personnel	1998	15654	1300		12042
architectural and technical design and drawing consultancy	1998	15654	13200		1186
suppliers of spare-parts and accessories for cars	1998	15654	400		39135
car servicing company	1998	15654	3500		4473
tyre servicing company	1998	15654	200		78271
job pools (job-opportunity projects)	1998	15654	100		156542
garage for industrial vehicles, trailers	1998	15654	800		19568
petrol station	1998	15654	1600		9784
bookkeepers, accountants	1998	15654	13200		1186
cafe	1998	15654	12700		1233
cafeteria, snack bar	1998	15654	10400		1505
bodywork repair firms	1998	15654	1500		10436
catering (w.o. party-catering)	1998	15654	1600		9784
car tyre wholesalers and trade intermediaries (middle men)	1998	15654	300		52181
wholesalers and trade intermediaries in spare-parts and accessories for cars	1998	15654	1500		10436
hotel, b&b (bed & breakfast), conference centre	1998	15654	2500		6262
camping ground	1998	15654	1700		9208
camping ground or holiday chalet park, bungalow park	1998	15654	2800		5591
cantine (incl. contract catering)	1998	15654	800		19568
cantine and catering	1998	15654	2400		6523
hairdressers	1998	15654	11300		1385
testing or checking office	1998	15654	500		31308
dry cleaners	1998	15654	1400		11182
motor cycle retailers	1998	15654	500		31308
private car garages	1998	15654	13000		1204
advertising agency	1998	15654	12200		1283
restaurant	1998	15654	9700		1614
restaurant, cafeteria, snack bar	1998	15654	20400		767
beauty salon, pedicure or manicure	1998	15654	13600		1151
cleaners for buildings and transport vehicals	1998	15654	6400		2446
temporary employment agency	1998	15654	900		17393.55
holiday chalets or bungalow park	1998	15654	1100		14231

Fig. 995 *Number of service-providing firms compared with the size of the Dutch population*

Traffic, Transport and Communication

Establishments for:	year	population	number	growth per year	support base
inland shipping company	1998	15654	4200	-1%	3727
forwarders, ship-brokers or chartering brokers	1998	15654	1620	-5%	9663
road freight haulage companies	1998	15654	9750	5%	1606
loading, unloading and trans-shipment companies	1998	15654	320	7%	48919
airports and other air transport services	1998	15654	30	0%	521806
air transport companies	1998	15654	10	0%	1565419
storage/warehousing companies	1998	15654	510	2%	30694
pipeline transporting companies	1998	15654	10	0%	1565419
post, courier services and telecommunications companies	1998	15654	2520	11%	6212
travel agencies	1998	15654	1030	-5%	15198
travel organisations (tour operators)	1998	15654	550	0%	28462
taxi firms	1998	15654	2520	-7%	6212
tourist information offices	1998	15654	440	19%	35578
tram and bus/coach companies	1998	15654	290	-6%	53980
land transport service companies	1998	15654	390	8%	40139
water transport service companies	1998	15654	240	9%	65226
weighing and measuring companies	1998	15654	110	-15%	142311
ocean-going shipping companies	1998	15654	510	-9%	30694

Fig. 996 *Number of transport companies compared with the size of the Dutch population*

6.4.10 References to Economy

See page 730
CBS, C. B. v. d. S. (2001) Statistisch Jaarboek 2001 (Voorburg/Heerlen) CBS.
Jong, T. M. d. and H. Priemus (2002) Forecasting and Problem Spotting in: T. M. d. Jong and D. J. H. v. d. Voordt Ways to research and study urban, architectural and technical design (Delft) DUP

6.5 Environment

Definition

We define environment as *'the set of conditions for life'* (Hendriks 1993). In this definition, both 'conditions' and 'life' can be more closely specified. By means of substitution, more precise concepts of the environment arise, such as 'the set of physical conditions required for plant life' or 'the set of managerial conditions required for animal life'.

conditions	**life**
managerial	human
cultural	
economic	animal
technical	
ecological	plant
mass/time/spatial	

Fig. 997 *Substitution possibilities in defining environment*

One can presume a sequence of conditionality in both columns (one cannot imagine management without a culture to carry it; one cannot imagine animal life without plant life, etc.). That becomes an issue as soon as one attempts to weigh the importance of different environments against each other.

Different environments

However, also *without* the above presumption, these substitution possibilities allow 18 more precise environmental definitions to be made. We can summarise managerial, cultural and economic conditions as 'societal conditions' and the remaining ones as 'physical conditions'. In this way, the number of environmental definitions is reduced to 6. Plant and animal life-forms can be summarised as 'non-human life-forms' (12 environmental definitions), but they can also be more precisely distinguished in the five 'kingdoms'[a] currently recognised in biology, with *homo sapiens* as the sixth category, bringing the number of environmental definitions up to 42. This figure increases further, if we define a species-specific environment for every species.

Physical conditions for human life

The current environmental definition of 'physical conditions for human life' (more or less according to Udo de Haes in Boersema, Peereboom et al. (1991)) is just one of the environmental definitions identified above. Udo de Haes' formulation[89] can be expressed as a technical definition, by reducing it to 'the collection of physical conditions for societal life'. However, by doing this, the physical surroundings become less optional than those postulated as a *condition* for societal life.
In other words, an asymmetry is assumed in the 'relations' between society and the physical environment.

[a] Vroeger werd alleen planten- en dierenrijk onderscheiden. Tegenwoordig worden naast deze rijken monera (bacterieën zonder celkern), protocristen (eencelligen met celkern) en fungi (schimmels) onderscheiden, see Margulis, L., K. Schwartz, et al. (1994) The illustrated Five Kingdoms; A guide to the diversity of life on earth (New York) Harper Collins College Publishers ISBN 0-06-500843-X..

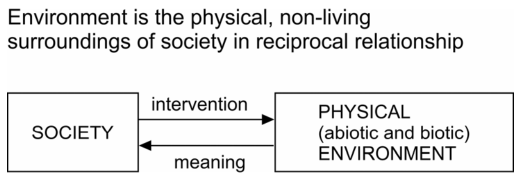


Fig. 998 *Environment according to Udo de Haes*

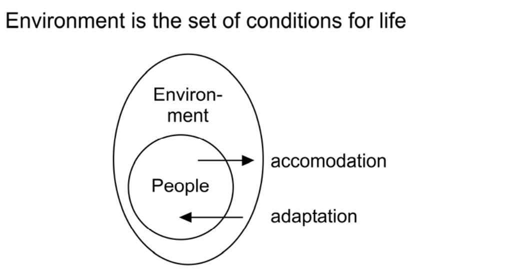


Fig. 999 *Environment in technical sense*

After all, one cannot imagine people, let alone a society, without physical surroundings, but one can imagine physical surroundings without people. A physical environment is thus a technical *condition* for human and societal life.[36] Because of this, a specific physical environment is not the cause of one or other *form* of human life[90], such as physical determinism at the end of the last century would have led one to believe[a]. After all, human beings are able to create new physical conditions for themselves (accommodation) and are thereby the cause of their own conditions. However, they are also able to adapt themselves to existing conditions (adaptation), and only in that case do they partly allow the causality of their lives to be determined by the physical environment[91].

6.5.1 Conditions

Conditions determine what is possible

Technical conditions are related to what is possible, while causal relations have a bearing on what is probable within that possibility. After all, what is probable is, by definition, also possible, but not everything that is possible is also probable.There are, therefore, improbable possibilities. One cannot *predict* these, so one has to *design* them.[92]

The analogue of this is that every cause is a condition for something happening, but not every condition is also a cause. The foundations of a house can be a condition for building that house, but, that does not mean that they are a reason why that house was built. A house can be a condition for a household; it can create the possibilities for a certain kind of household, but, nevertheless, it is still not the cause of that household.

Design makes possible, not probable

The above argumentation gives an exact indication of what the responsibility of the designer is, in contrast to that of the researcher. If (s)he designs a home, (s)he must not do it in a way that presumes its occupancy by a specific type of household - that would be an encroachment on the freedom of choice of the future occupants - his design must keep possibilities open for its occupancy by different sorts of households.

The same sort of dilemma exists in ecology. It is not always possible to forecast where a certain ecosystem will come into existence, but we can create the conditions under which certain ecosystems *can* exist, while others can not.[93]

Environmental problems

With this conditional environmental definition, *environmental problems* are simply '*missing conditions for life'*, that have to be specified further (see Fig. 997), by substituting for 'conditions' (physical, social) and 'life' (human or other). For the other forms of life, human beings have, by now, become a plague, and, in this sense, are the cause of environmental problems. Physical conditions are becoming increasingly unavailable to non-human life forms.

[a] De op- en neergang van het determinisme in de ruimtelijke wetenschappen omstreeks de eeuwwisseling is onder meer duidelijk beschreven in Claval (1976) De geschiedenis van de aardrijkskunde (Utrecht) Het Spectrum.

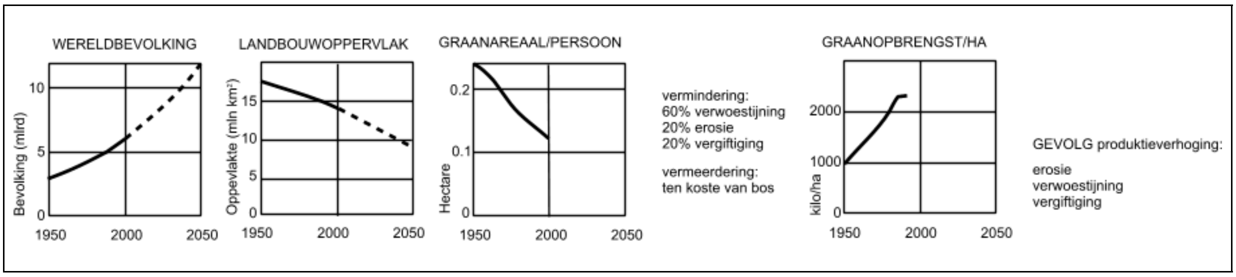


Fig. 1000 *Doom scenario*

Using the technical definition chosen here, environmental problems are easily definable as life-sustaining conditions that are missing, and environmental regulations as actions designed to provide for them.

Creating new conditions instead of restoring old ones

For a technical definition, therefore, environmental regulations do not need to be directed only on restoring an earlier situation (that is often an illusion by the actual human population), they can also create new life-sustaining conditions (see Environmental , page 646). This perception of environmental problems distinguishes designers from researchers. The relations between organisms and their surroundings (including that of the human society and its physical environment) can, for the time being, still be only very partially understood. However, they do not need to be completely understood to restore lost life-sustaining conditions, or to create new ones.

Taking away the causes is not enough

In addition, many environmental problems cannot be solved any more by removing the cause[94].
We cannot return any more to the situation of 10,000 years ago. At that time, there were an estimated 3 million people on earth and at least 50,000 species more than there are now.
And, because we cannot go back, we have to do more than just maintain the old environmental conditions; we have to create new ones.

Diversity of conditions

What is meant by ‘conditions’ and ‘life’, can turn out to be different when put into practice. One can define abiotic, biotic, technical, economic, cultural and managerial conditions for different forms of plant, animal and human life (see Fig. 997). General technical environmental definitions of these different substitutions form just as many environmental concepts, in which apparently conflicting opinions about environmental problems and regulations are brought to the fore.[95]

For example, the abiotic conditions for plant life are contained in an environmental concept that is different from those for animal life. In particular, the construction of ecological linkages creates new abiotic conditions for certain forms of animal life. Viewed from their predominantly botanical understanding of the environment, the authoritative plant ecologists, Westhoff and Van Leeuwen (see page 463), and rightly so, more value in isolation, than in the construction of linked ‘ecological infrastructure’.

Conditional conflicts

It is thus impossible to talk about ‘the environment’ in general, and to put a general stamp of ‘environmentally friendly’ on one or other regulation. Every interference with the surface of the earth increases the possibilities of the one species, to the detriment of other ones.

In agriculture, for instance, we create optimal conditions over enormous areas of land (by fertilisation, hydraulics, etc) for a few plant species, with the result that, with such strong competition, every other species is eliminated. In urban architecture, we optimalise in favour of the human species and, within that, for each location, according to certain societal categories.

Thus, for each intervention, we must specify which environment we are talking about.[96]

Urban design providing human conditions

In that perspective, we can now define urban design and architecture as supplying, research- and design-based conditions for *human* life by constructing buildings and organising space (whether or not on a larger scale than that of a single building). *Urban and architectural problems* consist of the (future) absence of those conditions. The aim of *urban and architectural research* is to draw attention to, anticipate or formulate in a programme these (missing) conditions. Therefore, it includes not only anticipatory, explanatory and problem-indicative research, but also design research and effect analysis *beforehand* (ex ante) and evaluating research *after* completing the construction (ex post). The aim of *urban and architectural design* is to present these conditions in a realisable spatial relationship.[97]

Probable, possible and desirable conditions

Environment is the collection of conditions for life in general. *Ecology* is the research into the *probability* of these conditions, and *technical ecology* is the (design)research into their *possibility*. *Environmental planning* is the provision of conditions for life in general by means of research, design and policy (of course, as far as these can be appreciated by human beings), viewed from the higher scale levels to the lower ones (*an inward-directed approach*). In a similar way, *environmental technical design* is viewed from the lower scale levels to the higher ones (*an outward-directed approach*)[98]

Anthropocentric and ecocentric viewpoints

With respect to the environment, two standpoints, one of them *anthropocentric* and the other *ecocentric*, can be discerned. The first standpoint should view every aspect from the point of view of human beings (nature as part of culture, see *Fig. 1001*), and the second one, from the point of view of 'nature' (culture being part of it). As 'nature' is a human concept, the debate between anthropocentrists and ecocentrists, that flares up once in ten years or so, invariably veers in favour of the anthropocentrists. Thus, an '*ecocentric standpoint*' includes only that part of the anthropocentric standpoint that attempts to distance itself from human biases (*έποχη*, epochè) in depicting and organising the environment (the conditions for life). Due to this, the concept 'anthropocentric' has, in fact, become useless, because as long as animals and plants are unable to speak an understandable and convincing language, every standpoint is, by definition, anthropocentric.[99]

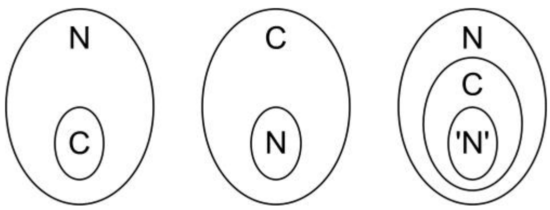


Fig. 1001 Culture (C) and nature (N)

Fig. 1002 Conditional or operational approach

Operational and conditional action

There are *direct* requirements for human life which, if missing, cause loss of comfort or even the death of people, and *indirect* requirements (such as the existence of plants and animals) that, should they be missing, would adversely affect these direct requirements. The existence of direct requirements for life is thus linked to indirect requirements and, in turn, these are linked to requirements that lie even further away (*conditional links*).[a] For example, for many organisms, the necessary existence of oxygen in the air is, itself, indirectly dependent on the existence of photosythesis by plants. It is these indirect requirements that are often either easier to influence by *conditional* design or (if they have been irretrievably lost) by providing a new form, than to 'tackle' the missing direct requirement *operationally* as being the 'cause' of the problem (see *Fig. 1002*).

[a] The theory of conditionality is elaborated in Jong, T. M. d. (1992) Kleine methodologie voor ontwerpend onderzoek (Meppel) Boom, translated and extended in English in Jong, Taeke M. de (2006) Suppositions of imagination, boundaries of design (Zoetermeer) http://team.bk.tudelft.nl/ Publications 2006.

A quiet study room can be a requirement for studying. Noise from neighbours leads to the problem that this direct requirement for studying is destroyed. Indirect conditions that can restore this direct requirement can, in this case, be: adopting a complementary living rhythm (so that the noise occurs at times when no one is studying), thick walls or quiet neighbours. Noise from neighbours can thus be solved in more ways than just by ‘removing the cause’.

Interference of conditions

By providing missing direct requirements (to solve environmental problems) one can, in addition, adversely affect other (mostly indirect) conditions. In building a house, one provides, in a direct way, requirements (an ‘environment’) for human life, but, by so doing, one adversely affects the environment for other life forms and thereby perhaps the indirect conditions for human life. Thus, not only living requirements, but also environmental measures (the provision of certain conditions), are conditionally linked with each other.

For example, to save energy, there is no sense in letting sun enter the house if that house does not stand in the sun, but, in reverse, there is. If the last-mentioned condition is not met, then it would be senseless to provide the first-mentioned requirement. Environmental measures can become each others’ conditions or restrictions, without, however, also being each others’ direct cause.

Conditional sequence

Environmental problems (missing conditions)[100] have a conditional link with each other in this way. After all, one environmental problem can facilitate another one, without directly causing it. Eliminating the direct causes (operationally) without analysing the condiotions, followed by creating (conditionally) all related requirements for success has often be shown to be ecologically counterproductive.[101]

For example, one cannot bring a manure-polluted drainage ditch back to its original state by stopping the manure pollution as Nienhuis (1993) and Hekstra, Strien et al. (1993) show. In the short term, manure pollution is irreversible. The same sort of problem occurs in medical science: a complaint appears to have a direct cause, but the true cause may lie in shortages elsewhere in the body, so that, unexpectedly, one of the conditions of the body that would otherwise ensure that this sort of complaint does not manifest itself, is not met.

Environmental strategies are combinations of environmental regulations, such that they enable and even strengthen each other, both in the time taken and in the sequence of requirements, without creating new problems. *Environmental tactics* is one of the locally or temporarily (politically, culturally, economic, technically) adapted effects of the strategy to the various situations.[102]

6.5.2 Emission

In this section, a number of technical aspects of environmental hygiene are brought to the fore that are important for making short reports on environmental effects and environmental policy plans. There is much literature about this subject primarily summarised in Boersema, Copius Peereboom et al. (1991) to be completed with recent figures from RIVM (2001).

Environmental hygiene, spatial planning and nature conservancy are policy sectors concerned with the unwanted side-effects of human activities. In spatial planning and nature conservancy, in the first place, this has to do with the mechanical effects such as management, disruption, and small and large interventions in nature and space. Environmental hygiene is mainly concerned with material and energetic effects, among others, on materials, people, other organisms, systems and entire geographical areas, including nature reserves.

A chain of impacts

In order to be able to estimate the unwanted side-effects of all sorts of activities in a given location, beforehand, it is best to divide these activities into living, traffic, nature and agriculture, businesses and incidental activities. These categories can be subdivided into a multiplicity of activities for which, for each activity, emission factors are known. By multiplying these factors by the number of inhabitants, jobs, or km^2 , one can gain an impression of the emissions. This emission is dispersed by air, water,

the ground or other dispersion agents, and eventually has a negative effect on materials, people or other organisms.
These can be summarised in the following diagram:[103]

economic activity---->	direct effect of emission ---->	indirect effect of transmission ---->	end-effect of emission and exposure
SOURCES (page 626) 1. Homes 2. Traffic 3. Agriculture 4. Businesses 5. Incidents	EMISSIONS (page 629) 1. Inorganic 2. Energetic 3. Mechanical 4. Information 5. Potential emissions	DISPERSED BY (page 633) 1. Air 2. Water 3. The ground 4. Food chains 5. Transport	OBJECTS (page 637) 1. Materials 2. People 3. Other organisms 4. Systems 5. Locations

Fig. 1003 *The chain of environmental effects*

In this table, no account is taken of unwanted socio-economic side-effects,. All that is given is a checklist to assess the environmental effects. The nature of sources, emissions, dispersing agents and objects is dealt with in more detail, respectively, in pages 626 - 637.
By estimating the expected emission, transmission, immission and exposure, one can make a report of the environmental effect for an activity or for an entire area. However, in such a report, no policy will still have been formulated to restrict these effects.

A policy to restrict environmental effects

A policy of that kind must weigh-up the unwanted side-effects against the useful effect of the intended activity, or of the situation that has come into being, which can then be expressed in an environmental policy plan. A similar consideration occurs due to standardisation. Standards to reduce the damage that many objects suffer due to different human activities, originate in these objects. Initially, it can be established where the limits of damaging influences need to be set, in order to prevent that particular object from suffering an adverse effect.

Standards

This can lead to quality standards being set for the ground, water and air, that, in turn, lead to the setting of limits for emissions from a wide range of activities. Finally, one can bring about changes in the harmful activities themselves by linking the processing, the product, or the particular establishment as a whole, to standards and regulations. These are summarised in Fig. 1004[104].

STANDARDS, applied to: the source	the emission <----	the dispersing agent <----	the object <----
product standards processing standards regulations	emission standards - emission ceilings	quality standards	exposure and immission standards
EXAMPLES OF NON-NUMERICAL STANDARDS ('Policy starting-points')			
'Avoiding at the source' (of the emission)	'Combating at the source' (of the emission) 'best technical means' 'Most practical means'	'standstill' principle	'no effect' 'no adverse effect'
EXAMPLES OF NUMERICAL STANDARDS			
Lead content petrol	max. of 500 mln sulphur dioxide per year in the Netherlands	average % of oxygen in the water	EPEL value

Fig. 1004 *Standardising to reduce adverse effects*

All standards contain a policy-based consideration of the useful effect of various activities compared with their unwanted side-effects. This is an economic consideration, which is examined further in Section 6.5.5, page 641.

Sanctions

This standardisation, intended as a feed-back system on human activities in order to prevent negative side-effects, must, of course, be achieved by sanction possibilities.
The Environmental Management Law offers the integral legal framework to accommodate these standards. The international, national, provincial and municipal environmental policy plan can play an important role in this. Whether the standards in the environmental policy plan must be adapted beforehand (by a licencing system), or afterwards (by environmental accountancy) is not yet of importance for the technical aspects of environmental hygiene. In both cases, these remain the same.

Sources of environmental stress

For the registration of emissions in an area, more facts about the sources are necessary.They can be gained according to Fig. 1005(a further elaboration of Fig. 1003)

Sources	**Subdivision**
1. housing, temporary-stay recreation	1.1 households 1.2 encroachment onto public space 1.3 public green areas
2. traffic, infrastructure	2.1 cars and other petrol-powered vehicals 2.2 routes used for transporting dangerous substances 2.3 railways and other electrically powered routes 2.4 shipping 2.5 airways 2.6 cables and pipelines 2.7 beam transmissions (e.g. for radio and tv)
3. nature agriculture, forestry, nature recreation	3.1 natural areas 3.2 forestry 3.3 arable farming 3.4 glasshouse cultivation (incl. mushrooms) 3.5 open-air horticulture and fruit growing 3.6 animal husbandry, fisheries
4. business, day recreation	4.1 mineral exploitation 4.2 historical manual skills 4.3 industry 4.4 public utility companies 4.5 building industry 4.6 services
5. incidental activities	

Fig. 1005 *Overview of the sources*

In1977, the total emissions for all provinces in the Netherlands were estimated by means of collective registration, supplemented by individual registration. For example, for Gelderland, the emission registration for the four most important emissions gave the picture of Fig. 1006[105].

gram per day	Carbon monoxide CO	Sulphur dioxide SO_2	Nitrogen oxides NO_x	Hydrocarbons C_xH_y	per:
Housing	12	4	6	13	inhabitant
Traffic	200	8	54	48	inhabitant
Nature		869	32	690	km2
Glastuinbouw	362	1346	317	43	job
Glasshouse cultivation	107	5	5	35	other agrarian job
Firms	180	588	266	393	job

calculated from the Emission Registration for Gelderland (1997) and LEI statistics (1977)
Fig. 1006 *Four important emissions per source category (Gelderland 1977)*

For the benefit of an initial global reference, for emission factors for a particular area, one should be able to use a more recent version of such figures (http://arch.rivm.nl/environmentaldata/).The figures given above are clearly out-of-date, but are useful, as such, because they provide interesting comparative material for assessing policy directed towards emission sources.

Combustion emissions and other types of emission

Emissions occur due to the processing of fuels or raw materials. This causes combustion emissions and process emissions, respectively. Energy saving could lead to a significant reduction in combustion emissions. The following table gives some insight into the relation between both types of emission during the 1970s.

1Tg = 1000 000 000 kg = 1 mln ton		Combustion emissions	Process emissions	total
		g/inhabitant/day	g/inhabitant/day	Tg/year*
carbon dioxide	CO_2	8920	90	46.04
carbon monoxide	CO	286	49	1.71
nitrogen oxide	NO_x	108	6	0.58
sulphur dioxide	SO_2	70	8	0.40
hydrocarbons	C_xH_y	33	25	0.30
aerosols, dust, soot		20	0.13	
hydrated calcium sulphate (gypsum)	$CaSO_4$		427	
salt	NaCL		67	0.34
sulphuric acid	H_2SO_4		22	0.11

(CBS statistics 1978; Emission registration 1974/1981; Hermans and Hoff 1982)

Fig. 1007 *Relation between combustion emissions and other types of emission*

Types of emission and environmental stress

To estimate the nature of the end effect and the manner of dispersal, the emissions need to be distinguished from each other, either by source or by groups of source, as in Fig. 1008 (an elaboration of Fig. 1003).

Types of emission	Subdivision	Examples
1. inorganic emissions	1.1 metallic 1.2 other inorganic	copper, lead, mercury CO, SO_2, NO_x
2. organic emissions	2.1 pure 2.2 halogenic 2.3 oxygenic 2.4 nitrogenic 2.5 sulphuric 2.6 metallic 2.7 other inorganic	methane, toluene, benzene vinyl chloride alcohols, esters amino acids thiols organic mercury organic phosphorus
3. mixtures	3.1 complex mixtures 3.2 aerosols 3.3 solid waste 3.4 microbic	BZV (biological oxygen consumption), CZV (chemical oxygen consumption), kjeldahl (method for measuring nitrogen) fly ash, industrial waste tetanus, botulism
4. energetic emissions	4.1 heat 4.2 sound 4.3 radiation, magnetic 4.4 radiation, radioactive 4.5 magnetic field	cooling-water traffic, industry light, infra-red, ultra-violet, radar, ether waves alpha-, beta-, gamma- high-voltage transmission lines
5. mechanical emissions	5.1 disturbance 5.2 small interruptions 5.3 substantial interruptions	treading on the ground, mowing, vibrations, up-rooting, digging ploughing, vandalism, clearing ground, building explosions
6. information emissions	6.1 visual 6.2 olfactory 6.3 others	horizon pollution bad smells misleading sounds
7. potential emissions	7.1 emission reduction 7.2 risk 7.3 variation in emissions	cloth filter, sedimentation plant, lpg (liquid propagaz) tank, (waste) storage day–night variations

Fig. 1008 *Types of emission*

Further information is given briefly below about a few of these types of emission.

Material emissions

Metallic inorganic compounds can produce accumulating pollution that is heavily poisoned. For water pollution, mercury and cadmium, in particular, and compounds of these substances, are on the black list. The black list is a European list of the most dangerous substances for the environment that may not be released in any quantity at all.

The other inorganic compounds include: *carbon monoxide, sulphur dioxide, nitrogen oxides, halogen compounds, phosphates and arsenic*. These include, therefore, the quantitatively most important emissions and the majority of the combustion emissions. Special attention is given to a few of these below.

Carbon monoxide (CO) is formed when combustion is incomplete. It is a poisonous, colourless and odourless gas. The total amount of CO throughout the world remains surprisingly constant, despite increasing (industrial) production. In addition, CO occurs naturally in the atmosphere, due to the oxidation of hydrocarbons. However, CO is effectively oxidised to CO_2, so CO only remains in the atmosphere for 0.1 of a year.

Sulphur dioxide (SO_2) is a colourless gas with a suffocating smell. It irritates the mucous membranes and the lungs, but, apart from this, it is not so damaging. It occurs naturally in the atmosphere, among other things as a result of volcanic eruptions. A high concentration of SO_2 is indicative of pollution by tiny particles (aerosols).
Sulphur dioxide is extracted from the atmosphere by oxidation to SO_3 , which reacts with water to form sulphuric acid (H_2SO_4). Together with other substances, this is the cause of acid rain.
This is the reason why more and more lakes in Canada, Scandinavia and the Netherlands have become sterile, why forests have lost their vitality or have been declared as dead, why heather has been taken over by grass, why wood and agricultural yields have declined and why our cultural heritage has been irreversibly harmed. A small part of the SO_2 is immediately washed out and absorbed by vegetation and water. The time that SO_2 stays in the lowest part of the atmosphere is in the order of a number of days, and, under certain conditions, a number of hours.

Hydrogen sulphide (H_2S) is a smelly, poisonous, inflamable gas, that irritates the eyes and the respiratory tissues. It is released into the air by natural bacterial decomposition processes, but also by many industrial processes. It disappears from the atmosphere via oxidation to SO_2 or due to the activities of certain bacteria. It remains in the lowest part of the atmosphere from a few hours to a number of days.

The nitrogen oxides (NO_x, i.e. NO, NO_2 and NO_3) originate from nitrogen and oxygen in the air at temperatures higher than 800°C. NO occurs in the first instance, but as it cools, it is partly transformed in the atmosphere to NO_2. NO is a colourless gas that, in itself, is not harmful.
The reddish-brown NO_2, on the other hand, is much more harmful due to its irritating effect on the muscous membranes. NO_x is finally oxidised to nitrate and stays for about five days in the atmosphere. NO_x, in combination with hydrocarbons, can form all manner of new compounds in the atmosphere that can contribute to ‘photo-chemical smog’. This results, among other things in *‘PAN’(peroxide-acyl-nitrate) and formaldehyde (HCHO).*

Of the inorganic halogen compounds, it is mainly the compounds with fluorine (F) and chlorine (Cl) that are important.
Hydrofluoride (HF) is a very corrosive, poisonous fluid, that, due to its low boiling point (19.4°C), is easily emitted as a gas (of importance as a potential emission from storage sites). It is a cumulative poison, i.e. it builds up inside organisms.
Chloride gases enter the atmosphere mainly as a result of industrial accidents and leakages, as an insecticide, or due to burning plastics.
The phosphates are mainly important in water pollution. They can cause such an enormous richness of food in the water that it becomes devoid of oxygen.

Organic emissions

Organic ammonia (NH_3) occurs especially in the bio-industry. It stays for about seven days in the atmosphere.

Of the *hydrocarbons* in the atmosphere, only about 15% originate from human activities. However, this amount has another composition, and is concentrated in a relatively small area. The natural hydrocarbons come from the decomposition of organic material and emissions from plants, especially certain trees. Above pine forests and citrus cultivations a haze can often be seen due to photo-chemical smog formation. The majority of hydrocarbons disappear from the atmosphere due to photo-chemical smog formation. They remain for quite a long time in the atmosphere; methane (CH_4), for example, remains there for about four years.

However, the length of time that these substances remain in the atmosphere is dependent on reactivity. A total of 150 different hydrocarbons have been identified in car exhaust gasses. They are released mainly due to incomplete combustion and by evaporation. From the many different hydrocarbon compounds, a number of examples are given below.

The group of *halogenic hydrocarbons* contains a large number of black-listed substances, such as alpha-, beta-, gamma- *hexachloro-cyclohexane*, the PCBs (polychloro-biphenyles) and *PCTs* (polychloro-therphenyles), hexachloro-benzene, hexachloro-butadiene, pentachloro-phenol and trichloro-phenol.

The chlorofluoro-hydrocarbons (CFKs, such as freon) belong to the halogenic hydrocarbons. They are used in cooling systems, as a propellant in spray cans, and are not poisonous in themselves. However, they can harm the ozone layer of our atmosphere, so that there would be no resistance any more to ultra-violet rays. [106]

The **other material emissions** include complex mixtures, aerosols, dust or particulate matter in the air, solid waste and free-coming bacteria, viruses (sick buildings!) or genetic material.

Mixtures

The complex mixtures include a large number of emissions from mostly organic material that can be largely biologically decomposed, and therefore their exact chemical composition does not need to be known. For these complex mixtures, standards are used such as BZV (biological oxygen consumption), CZV (chemical oxygen consumption) or the Kjehldahl method for measuring nitrogen.[107]

Areosols

The aerosols are tiny solid and/or fluid air-borne particles that have such a slow rate of fall that they can be considered to float or drift. They originate naturally, enter the atmosphere through combustion processes, or are formed in the atmosphere by chemical reactions (e.g. by photo-chemical smog). Rain or snow is formed by condensation and sublimation, respectively, on the aerosols. Compared with the air over oceans, the average pollution of the air over rural areas by aerosols is ten times higher. Above small towns, air pollution by aerosols is 35 times higher, and above large cities 50 times higher than over the oceans. In unfavourable situations, this figure can increase to 4000 times or more.

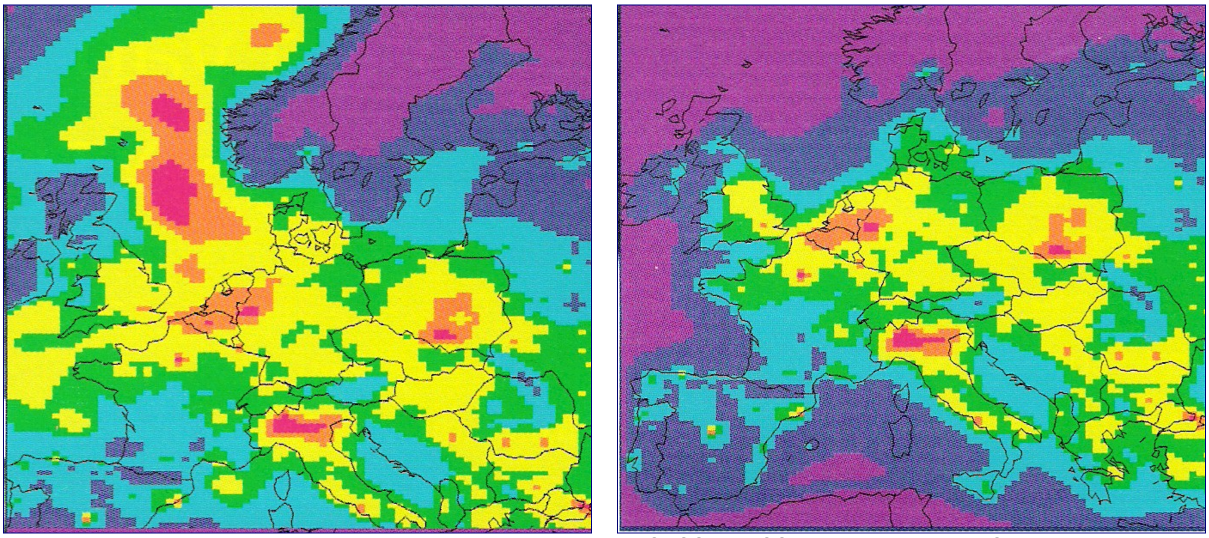
Fine dust or particulate matter (PM)

Fine dust or particulate matter in the air (particles <10μm notated by PM_{10}) of different substances could be dangerous for human health. That is why the European standard from 1st of January 2005 is maximally 40 μg/m^3 average *per year*, with maximally 35 times per year a *24-hour average* exceeding 50 μg/m^3. Enduring exposition seems to be more dangerous than short exposition, but in 2005/2006 many Dutch building projects were rejected by jurisdiction based on measurements and prognoses of exceeding the short 24-hour average exposition standard. However, a distinction should be made in more dangerous fine (0.1 - 2.5 μm, deeply penetrating the lungs) and less dangerous coarse mode (2.5 - 10 μm) particulate matter and their composition concerning health-effects varying over Europe.

> [a]‘Inorganic ions nitrate, sulphate and ammonium sum to 34% of PM mass and the measured organics from combustion processes up to 2%. Rough estimates of the traffic contributions of these two fractions vary from 30% to 60%. In the framework of the project 'Health effects of particles from motor engine exhaust and ambient pollution - HEPMEAP', a unique European collaboration between toxicologists and epidemiologists, ambient particulate matter (PM) was collected at various sites across Europe during the periods November 2001 and March 2003. The HEPMEAP project studies the relation between the composition of particulate matter, and the toxicity and health effects. Besides strong similarities, PM samples from these various locations/sources show substantial differences in chemical composition. For example, samples from the rural location in Northern Sweden were highly dominated by organic matter, most likely originating from wood combustion.’

In The Netherlands natural salt spray particles from the sea vary around 7 μg/m^3 along the West Coast until 3 μg/m^3 in the Eastern part of the country. So, since August 2005, dependent on the location from West to East a municipality may subtract 7 to 3 μg/m^3 from the measurements to reach the maximally 35 days exceeding the 50 μg/m^3 24-hour average.[b]
If you subtract this harmless part of particulate matter, the European picture becomes less threatening (see *Fig. 1009*).[c]

[a] http://www.rivm.nl/bibliotheek/rapporten/863001002.html
[b] http://www.vrom.nl/get.asp?file=Docs/milieu/200508_meetvoorschriftluchtkwaliteit2005.pdf.
[c] http://www.tno.nl/tno/actueel/magazine/bouw_en_ondergrond/2006/juni_2006/beno_2_2006_16.pdf?__lang=nl
http://www.tno.nl/tno/actueel/magazine/2006/june_2006/em_2_2006_18.pdf?__lang=nl



LOTOS-EUROS computer model, TNO magazine, june 2006

Fig. 1009 Calculated PM10 concentrations with and without salt spray particles in Europe.

In 2006 more recent measurements changed the expectation of PM10 values in 2010 dramatically (see *Fig. 1010*).

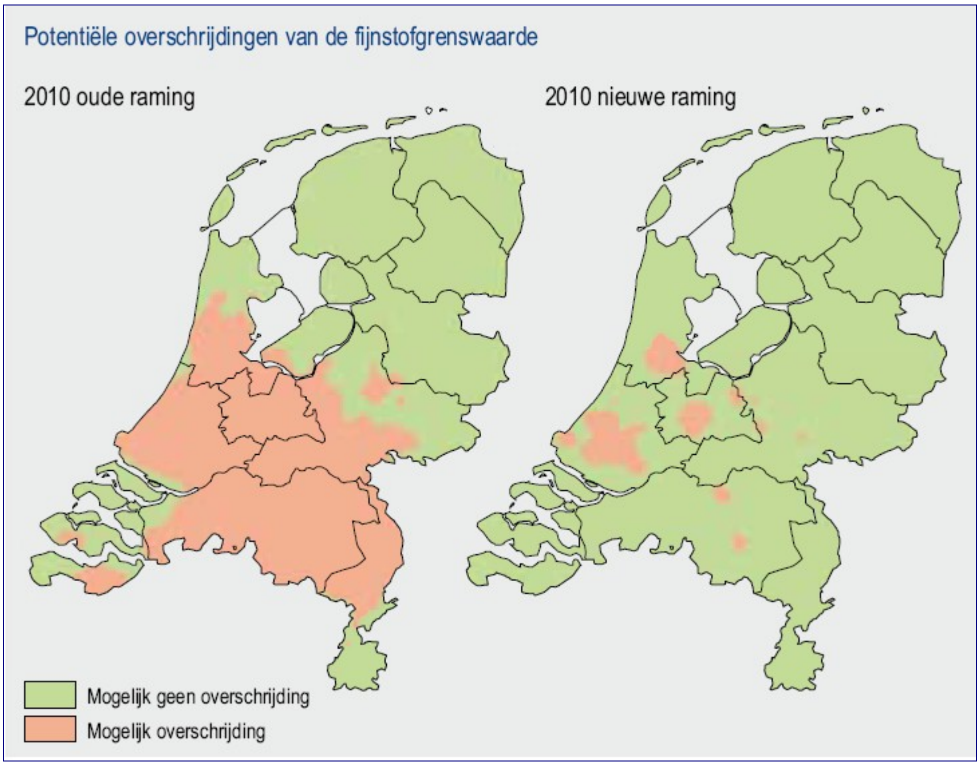


Fig. 1010 2005 (left) and 2006 (right) prognoses of exceeding European standards for particulate matter in 2010[a]

A more precise evaluation of health effects of different PM components may change the imminent social and economic effects of these standards up to now even more.
Kuypers (2006)[b] claims plantation can clean the urban air. A tree could take the equivalent NO_2 and PM_{10} of a car driving 10 000 km.

[a] http://www.rivm.nl/bibliotheek/rapporten/500093003.pdf
[b] Woestenburg (2006) Naar een zelfreinigende groene stad in: Het kwartaaltijdschrift van Wageningen Universiteit en Researchcentrum Nummer 2, Juni 2006

Energetic emissions

Energetic emissions include warmth, sound, electromagnetic and radioactive radiation, and changes in the magnetic field. With the exception of radioactive radiation, in so far as it originates from radioactive substances that are dispersing, this is a form of emission, the spread of which is very predictable. If these emissions occur, it is known that almost all objects in the vicinity will be subjected to immediate exposure. Because of that, in measuring emissions (as in the case of sound), certain aspects of the exposure can already be included. The unwanted side-effects of energy-in-motion emissions can, on the basis of a named characteristic, best be controlled within the framework of spatial planning.[108]

Mechanical emissions

Mechanical emissions, such as disturbances, small and substantial interruptions, are, within the framework of environmental hygiene, not generally considered to be ‘emissions’. They are a part of the working field of spatial planning, ‘urban management’ and nature conservancy. However, logically and systematically, they fit in with an overview of types of emission and environmental stress, such as that shown in Fig. 1008. These emissions can also be largely controlled using spatial planning regulations.

Information emissions

Information emissions include all influences that disturb the functioning of our ability to form images by sight, smell, taste, touch, balance, and voluntary movements. They are subjective, difficult to measure, and traditionally belong partly to the working field of spatial planning. However, a lot of research still needs to be carried out in this area. For example, if symptoms of psychiatric illness could be linked to urban living conditions (e.g. in the form of sensoric or motoric overloading or deprivation), then interesting new requirements could be placed on urban surroundings.

Potential emissions

Potential emissions include emission-reducing regulations, risks[a] and variations in emissions. Emission-reducing regulations and risk management are part of the continuing responsibility of all engineers.[b] The variation in emissions makes it somewhat more complicated to set standards than to fix an average. Local and temporary periods of peak stress are, after all, the most dangerous. Variations in stress can be cyclical, subject to trends, and/or can increase abruptly, in leaps.

6.5.3 Transmission

Transmission is especially important for material emissions. It contains the propagation of energetic, mechanical, informational (noise) and potential influences (risk) and of material by air, water, the ground or via food-chains, mainly the territory of specialists and extensive computer programs. Transmission includes the transport, dilution, dispersion, conversion and removal of material in and out of the air, water, ground, food-chains and other relocating systems.[109]

Air pollution

We will go into the spreading of air pollution the most thoroughly below. In addition, ground and water pollution is partly a result of pollution in the air, so that, also from this view point, priority must be given to gaining a better understanding of air pollution. In this respect, it is important that a distinction is made between vertical and horizontal air movements.

Where there are no vertical air movements in a stable atmosphere, pollution stays at low levels and can become highly concentrated locally. Horizontal air movements are important in predicting where air pollution will occur. For water pollution, especially important are the horizontal displacements, and only in the case of deep lakes or seas do vertical displacements also play a role. The displacement of ground pollution is largely dependent on ground water currents, and possibly on human transport.

[a] De kans op effecten wordt risico (populair geformuleerd als kans x effect) genoemd. De risico-benadering is uitgangspunt voor de normering en komt uitgebreid aan de orde in het parallel-college veiligheidsbeleid (Hale).
[b] Notitie "Omgaan met risico's", gelijktijdig gepubliceerd met het Nationaal Milieubeleidsplan.

Vertical air movements

The sun's rays act as the motor for almost all air movements. They are partly intercepted by the atmosphere and, especially in the higher layers, warms it up. The lowest layers of air receive their heat mainly from the surface of the earth, which is warmed up during the day, releasing its heat again by radiation at night. Because of this, the lowest layer of air (to about a height of 10 km), the troposphere, has, in principle, an upwards-decreasing temperature. However, the stratosphere, that lies above it, becomes warmer in its higher levels. If rising air comes into contact with warmer layers of air, it stops rising. There is thus little exchange between the troposphere and the stratosphere, also with respect to air pollution. The troposphere is approximately 10 km high and contains about 80% of the total mass of the atmosphere. This is where almost all weather phenomena occur; this is where the largest warming up and cooling down takes place, and where the air pollution increases and decreases due, respectively, to emissions being released and washed away.[110]

Polluted air remaining low

Warm air rises until the surroundings become warmer, but, in retaining its own heat content, rising air also cools off due to expansion. This cooling off process amounts to about 1°C for every 100 m that the air rises. An air bubble warmed up by the surface of the earth that is 2 degrees warmer than its surroundings will thus rise 200m if the surroundings of the air bubble stay the same, and it will rise more than 200m if the surroundings become colder.
It is clear that if the lowest part of the troposphere has become relatively warm because of a number of hot days, there will be very little rising air, so that the air pollution will stay below. One can talk then of a stable atmosphere. Especially after the night time cooling off of the lowest layers of air due to radiation from the earth's surface, temperatures, that rise with height, can occur the following morning.

Inversion

If a chimney doesn't rise above the point where the temperature starts to go down again, as is normal in the troposphere, then the smoke stays held in the lowest layer of air, because the surroundings are too warm to allow the air to rise. Such a situation is called *inversion* (an inverse temperature gradient).

In the course of the day, a rise in temperature in the lowest layer of air can cause the inversion to disappear. However, that does not happen if there are clouds in the sky, or if the rise in temperature is insufficient to make the lowest layer of air much warmer than the layers above it. Because of this, an inversion can last for several days.[111]

Moisture

The amount of moisture in the air is just as important for the development of vertical air movements. Moist warm air, rising from the surface of the earth, cools down by expansion and, above a certain height, loses its moisture by condensation. This condensation produces heat that causes the air to rise further and then to cool down further, thereby producing more condensation. The height at which condensation begins forms the flat underside of the cloud layer.[112] Thus, because of the heat development that then occurs, a loss of moisture can cause the air to rise even more.

Horizontal air movements

At ground level, the air is warmed up the most in the tropics and the least at the poles. Because the air in the tropics is continually rising, warm air moves northwards in the higher layers, partly due to it cooling down over the subtropics, and then it sinks to the lower layers of air in our latitude (see Fig. 207). The continually sinking air at the poles produces a cold northerly wind, that meets the warm humid air masses from the south in our latitude. This results in a lot of condensation and precipitation in our latitude, in cold polar air wedging its way under rising warm air until this too is heated up by the earth's surface. Because of this, the polar front in our latitude produces a much more turbulent weather pattern than elsewhere.[113] On the one hand, this is good for the mixing and dispersion of air pollution, but it also makes air pollution less predictable than in tropical or polar climates.

Southwestern winds

The sun rises in the east because the earth rotates eastwards. The atmosphere rotates with the earth. Therefore, in contrast to polar air masses, tropical air masses have a strong eastward impulse. As they move towards the north, this eastward tendency persists, so that tropical air in our latitude comes mainly from the southwest. As relatively stationary polar air masses move southwards, they become increasingly confronted with the earth's rotation and thus have a tendency to move westwards in relation to the earth's surface. Because of this, in our latitude, cold polar air masses come mainly from the northeast.[114]

Polar front
The eastward tendency of the tropical air and the westward tendency of the polar air, when they meet in our latitude (the 'polar front'), cause air movements that circulate in an anticlockwise direction.[115] In low pressure areas (depressions), into which the winds always blow, this is usual. That means, for example, that the winds are southerly if a depression lies to the west of the Netherlands, and northerly if the depression lies to the east. Based on this, a number of frequently occurring circulation patterns can be identified for Europe, and their frequency over the years can be established statistically.
From this, statistical indicators have been formulated of expected weather types, and these can be applied to dispersion models for air pollution.

Coastal circulations
A very frequently occurring type of circulation, on a smaller scale, occurs systematically in coastal regions. Because of the alternation between day and night, there is also an alternation here between sea and land winds. A sea wind occurs along the coast when the sun shines strongly and, due to this, the land warms up faster than the water, causing a difference in air pressure. At night, the land cools off faster than the sea, causing a wind to blow from the land, seawards.[116]

Turbulence
Based on climatological factors, regularity in wind direction, as mentioned above, applies to flat, open spaces, but not to built-up urban areas. Very many smaller circulations occur there that are summarised by the concept 'turbulence'. Where there are eddies behind buildings, the only way of predicting turbulent air movements in these urban areas to any extent, is to place maquettes in wind tunnels, on a revolvable platform. To carry out very exact tests on them, such maquettes must be built by specialists, because it is very important to simulate the roughness of the material and it is impossible to position gauge points on a normal maquette.[117]

Mathematical models of wind circulation
For sources in relatively open areas, mathematical models can be applied. One can distinguish pollution-point sources, such as chimneys, line sources, such as main roads, and surface sources, such as an industrial sites. The most frequently used dispersion model is the Gaussic Plume model, of which there are a number of variations. In addition, there are 'grid models' and 'trajectory models' as described in KNMI KNMI De Bilt (1979). In the Gaussic Plume model, it is assumed that air pollution is dispersed perpendicular to the direction of the air movement, according to a statistical distribution.
Grid models divide the space into box-shaped units, by means of a co-ordinate system whereby the input and output is calculated per box.
Trajectory models are based on forward-moving box-shaped units of air, each unit of which has input and output values.[118]

Concentration of air pollution
The concentration of air pollution substances can be shown in three different ways:[119]

- volume/volume (unit ppm)
- weight/weight (unit ppmm)
- weight/volume ($\mu g/m^3$)[a]

RIVMs national gauging network for air pollution was drastically modernised in 1985 and now comprises 68 gauge points. In addition, TNO manages ten more points, and the provinces and municipalities 80 and 20, respectively.

Deposition
Apart from the dispersion of air pollution, the fall-out (deposition) of particles and the washing out of air polluting substances in rainwater, chemical changes in the air pollution itself also play a role in the total transmission of air. However, not much is yet known about these processes. Most of what is

[a] Het begrip µg/m3 staat voor 1 miljoenste gram (microgram) per m3.

known concerns photo-chemical smog, in which mainly the chemical composition of combustion emissions changes under the influence of light.

Smog

Photo-chemical smog mostly occurs as a result of ‘ground inversions’ caused when the lowest layers of air cool down faster than the layers of air above. Because of this, condensation occurs in the lowest layers of air (fog), and, as there is an inversion, the pollution also stays trapped in these layers. Aerosols serve as nuclei for condensation and the drifting drops of water catch the remaining pollution, whereby all manner of reactions occur. The formation of ozone (O_3) under the influence of sunlight can play an important role in these reactions.
However, with respect to water pollution, chemical and biological reactions in air pollution do not play such a large role.

Water pollution

Pollutants enter water by deposition from the air, by draining out of polluted ground and by direct discharge. Thus, in the pattern of currents in a river, one can find pollution-surface sources on the surface of the water, line sources along the banks and point sources at the location of the discharge. Apart from these sources of pollution, the following means of ‘removal’ also play a role:

- extractions, removal to groundwater, to tributaries;
- reactions of a physical, chemical or biological nature.

Based on this input and output, a balance can be drawn up for each stretch of river. As one can talk here of a one-dimensional current movement, the concentrations can be calculated using rather simple models. However, after 1965, models were developed that could also handle two-dimensional situations (as in shallow lakes, bays and harbours).

Mathematical models of water pollution

Insight into bio-chemical processes also became more advanced. Before 1965, already, the models took into consideration the deterioration of dissolved oxygen and the decomposition of organic material from waste water. Between 1965 and 1970, the oxidation of reduced nitrogen compounds was also included in the models. Between 1970 and 1975, three-dimensional situations, such as deep lakes and seas, were included in the models. The water masses were thereby divided up into layers (stratification). In addition, the growth and death of algae, and the physiological reaction of organisms to temperature, sunlight and the availability of food materials were described. After 1975, the behaviour of toxic substances in biological processes (among others, their accumulation in the food chain) was researched, as well as their transport on floating particles and sediment.[120]
Because of the increasing complexity of the models, it has to be recognised that their reliability is decreasing. For this reason, one-dimensional models are still being used.[121]

Ground pollution

In chapter 4.6 Soil pollution, page 370 and further you can find a more comprehensive treatment. Here we restrict to some fundamentals. Ground pollutants can be transported in the ground water. They can held and removed by absorption into soil particles, precipitated by chemical processes and dissolved again, and (partly) decomposed by micro-biological processes, especially in the thin zone that is not completely saturated with water.
The speed, direction and depth of a groundwater current depends very much on the type of soil and the variation in subsoils. In principle, three-dimensional current models are available for this, but these need to be fed with an extremely large amount of detailed information about the subsoils. This information is largely unavailable, so one has to make do with simpler current models. For regional studies, in particular, taking the relatively limited depth of the water transporting systems into account in relation to the extent of the region, a calculation in two dimensions is usually sufficient.[122]

Absorbtion

The speed and direction of groundwater currents are, of course, initially dependent on the type of ground. For removing pollution by absorbing it onto the surface of soil particles, the specific surface area of a solid soil particle is important. For clay, for example, this is larger than for sand. The more acid the environment, the more difficult it is for pollutants to attach themselves to the soil particles. Acidity, therefore, leads to some pollution of the groundwater. In addition, of course, as time goes on, the whole surface area can become saturated, so that larger amounts of pollution come to be transported in the groundwater currents. In that case, certain substances can still be precipitated out of the water or dissolved into it again. The solubility of chemical substances is also dependent on the acidity (pH) and on the ‘redox potential’ (Eh).

Conversion
Micro-biological decomposition and conversion processes are generally the most effective in the thin zone that is not completely saturated with water. Especially in the transition zone, where the presence of oxygen may or may not still play a role, can anaerobic decomposition processes (without oxygen) be of great significance. Among the well-known micro-biological conversion processes are nitrification, denitrification and sulphate reduction.

Data
For a quick orientation regarding the possible risks of extending pollution that has appeared on or in the (water) bed, reference can be made to archive information (van Duijvenbooden 1982). Among other sources of information, reference can be made to:

- geological maps
- ground maps
- topographical maps
- hydrographic charts
- geo-hydrological mapping (surface contour charts, seepage/infiltration charts, quality charts)
- geo-electrical mapping
- individual reports and data.

By studying the information listed above, a preliminary insight can be gained of the local direction and speed of the groundwater currents. If information on substances is available, then it is also possible to estimate their transport.

Points of interest
Attention should be given, among other aspects, to: [123]

- the structure and composition of the soils (clay/peat with low *k** and high CEC; sand with large *k* and low CEC, pH, redox; and the mud and organic-material content);[a] [124]
- the geological structure (presence of pockets of sand in contrast to layers of clay, heterogeneities, holes, stratification);
- the hydrological situation (seepage/infiltration, current direction and speed, location of the watershed, drainage or infiltration channels);
- topography (on the basis of height characteristics, gives a first impression of the probable current direction).
- If necessary, extra information can be collected in the field (van Duijvenbooden 1982).

6.5.4 Immission and exposition

Exposed objects
Determining the end effect (see Fig. 1003) is the final and most difficult part of every environmental-impact statement. The first thing that has to be established is which objects situated in the neighbourhood of the environment-damaging activity are the ones on which the effects have to be determined. In this section, the types of object distinguished are materials, people, plants and animals, (eco)systems, or entire areas. When there is no clear prior agreement regarding on which objects the effect has to be reported, there will always be criticism afterwards on the effect report that is delivered. If one already has a list of objects on which one has to report, then the question still remains of which effects have to be reported.

[a] k en CEC zijn maten voor het adsorptievermogen van de bodemsoort. Voor k geldt: lage waarde betekent hoge adsorbtie. Voor CEC geldt hoge waarde betekent lage adsorbtie.

Damage
If the object is people, then one can still distinguish absolute effects (such as the mortality rate) from gradual effects (such as the illness rate). To be able to view the effects against each other and against the useful effect of an environment-damaging activity, it is desirable, though usually impossible, to quantify it to a common denominator. Of course, especially in the United States, frequent attempts have already been made to express the damage caused by environment-damaging activities in terms of money. The table below pictures this for the Netherlands (1978).

Damage to	mln.guilders	no. guilders per inhabitant
materials	110	8
health	1000	71
commercial crops and livestock	85	6
lost residential value	1400	100
total estimative damage	2600	185

Jansen en Olsthoorn (1982), Jansen et al (1974)

Fig. 1011 *Damage due to air pollution in the Netherlands in 1978*

Costs of damage
The most reliable datum in this table is 'damage to materials'. The way in which 'damage to health' is calculated is already indicative of the dubious assumptions that have to be made when expressing this damage in terms of money. The costs of early death were estimated as the (discounted) income that the deceased would have earned had there been no air pollution. The amounts used to arrive at the costs of illness were 'loss of production' and 'the costs of curative care'.

There are, though, three methods of approach for damage due to death:

1. The 'human capital' approach;
2. The 'costs of risks' approach;
3. The comparison with costs made to prevent unnecessary death.

The method used in Fig. 1011 is the 'human capital' approach. For the second approach, wage differences – that can be interpreted as 'risk surcharge' – are used as the point of departure. To determine the value of a life, the extra wage paid for a 1% higher death risk is, for instance, multiplied by 100. The third approach ought to be based on the amount that the Dutch society is prepared to spend on 'the most expensive patient in the Netherlands'.
For example, a vaccine should not cost more than € 18 000,- per life year gained (NRC Handelsblad 2003-07-06).

Distinguishing the environmental part of damage
It must be clear that, even if the nature of the effect can be described clearly and unambiguously, it is usually difficult to quantify[125]. In addition, it is difficult to separate the effects of environment-damaging activities from other influences. In this way, the 'lost residential value' in Fig. 1011 is estimated on the basis of differences in house prices observed in transactions in Rijnmond. However, the house-price differences are also dependent on house characteristics (type of home, house size, year of construction, with garden, etc.) and the characteristics of the district in which the house is located (green facilities, nearby shops, noise levels, accessibility, etc.)

To be able to determine the effect of a home located in a foul-smell zone from these fixed variables, complicated regression analyses and daring assumptions are necessary. Instead of 1.4 billion guilders, a few changes in the assumptions would have given 1.7, 2.4 or 3.3 billion guilders as the lost residential value in the Netherlands. [126]

Dose-response of living objects
The effect of environmental pollution on living organisms can be shown in the form of a dose-response diagram (Fig. 1012).

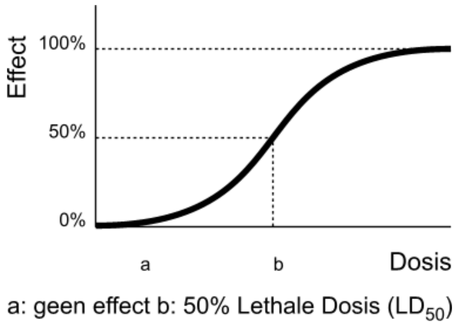


Fig. 1012 Dose-response relation

A similar diagram can be drawn for poisoning a large number of individuals with different doses. The dose that causes death in 50% of the cases, within a given time, is called 'the lethal dose at 50%' (LD50).[127]

It is clear that dose-effect relations are only known for a small number of substances on a small number of organisms. It is, of course, difficult to establish the dose-effect relations for human beings empirically, so there are still many knowledge gaps in this area.

Material damage

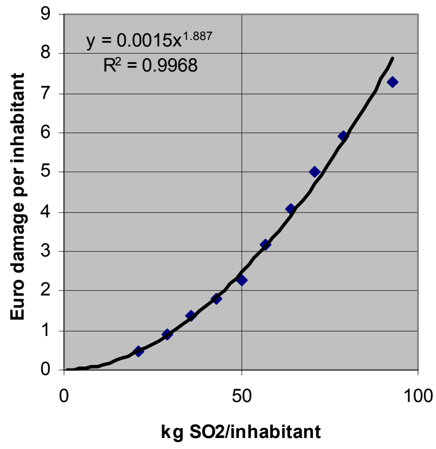
Research has established that the worst damage to materials is brought about by the action of SO_2 on painted steel, galvanized steel and on zinc foil. Research (*Fig. 1013*) was set up by Jansen and Olsthoorn (1982) consisting of:

- Measuring the concentration of SO_2;
- Determining the exposed quantity of materials;
- Establishing the dose-effect relations;
- Making an economic evaluation of the effects.

In this research, only maintenance costs, the costs resulting from reduced economic lifespan and substitution costs were taken into account. Indirect costs (for example, those resulting from the failure of affected parts) were not taken into account.

The costs listed above were estimated using a number of formulas by which, if the concentration of SO_2 in the air is known, the reduction of the galvanized layer, the length of protection of the paint layer, or the lifespan of the construction part were derived. These sorts of formula, in fact, represent dose-effect relations. Recalculated as costs and added up, it is possible to give a dose-effect relation for the whole of the Netherlands.

Doses in mln.kg SO2	Effect of damage in mln. guilders.	Dose per inhabitant kg SO_2	Effect per inhabitant Damage in guilders.
1300	225	93	16
1200	177	79	13
1000	151	71	11
900	123	64	9
800	92	57	7
700	74	50	5
600	56	43	4
500	40	36	3
400	25	29	2
300	18	21	1



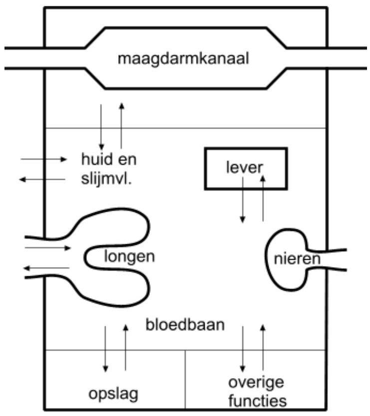
Figures per year, calculated according to Jansen and Olsthoorn (1982)

Fig. 1013 Dose-effect relation of SO_2 on a range of metal constructions in the Netherlands (1978).

This dose-effect relation is thus composed of different dose-effect relations that are only related to a certain material part of the damage not including health effects.[128]

Toxicology of people

For people, the lethal doses of a lot of poisons are known, as well as many of their clinical characteristics and side-effects (the absolute and gradual effects). The branch of medical science that concerns itself with poisonings is ‘toxicology’ see: Sangster (1987).[129] The process by which humans take up, re-absorb, transform, apportion, store and excrete poisons can be summarised in the following diagram.[130]



Verberk and Zielhuis (1980)
Fig. 1014 Toxicological access routes into the human body

Contrary to materials, human beings, animals and plants can develop resistance to repeated exposure to poisons. However, a slow build-up of toxins is equally likely to have sudden, serious consequences. In addition, the effects of different types of pollution can be increased by their interaction. One example of this is evidenced by smokers’ increased susceptibility to the adverse effects of air pollution. As a rule of thumb, one can say that if air pollution increases by 10%, the mortality will increase by approximately 1%.[131]

Historical disasters

As the literature on toxicology is fairly easy to access, we will restrict ourselves here to human exposure to a few historical cases of severe air pollution (*Source*: KNMI 1979)

In December 1930, the narrow and heavily industrialised Meuse valley, in the neighbourhood of Leige, experienced weather conditions, which – for almost a week – hindered the spread of the pollution produced there. The result was that a large number of people became ill due to respiratory problems, and, before the end of that week, 60 people had died. It is not clear whether very high concentrations of sulphur or florides were the cause of the disaster, because no pollution measurements were taken at that time.

A disaster that *has been* extensively researched is the one that hit the small town of Donorain in the valley of the River Monongahela in the State of Pennsylvania in the United States in 1948. Also here, unfavourable meteorological conditions, together with the hills that encircle this industrial town, hindered the dispersal of air pollution. The result was that thousands of people became ill, mainly with respiratory complaints and problems with the eyes, nose and throat. During this 7-day period, 20 people died.

Even worse was what happened in London from 5-9 December 1952. The majority of Great Britain was covered in fog at that time. Elderly people in particular became ill, suffering from heart problems or respiratory difficulties, and had to be taken to hospital. Even after the worst period of pollution had subsided, more deaths occurred than was usual for December. The total number of deaths rose to between 3,500 and 4,000 above the usual number of deaths in December. The extremely high concentrations of soot and sulphur dioxide were probably the cause of this disaster

In the Netherlands, air pollution has not led to a *demonstrable* number of deaths (that is something else tnan calculated decrease of lifetime-expectenace or brain performance), but there were obvious increases in the numbers of both illnesses reported and hospital admissions, such as in the period 26-30 January 1959 and 4-6 December 1962. In Rotterdam, in 1959, the amount of smoke in the open air, and, in 1962, the sulphur dioxide concentrations, reached extremely high levels. In both these cases, too, it was long periods with no wind and bad vertical exchange that caused increasing concentrations of toxins in the air.

Plants and animals

Hardly anything is known about the extent to which material pollution has caused the disappearance of plant and animal species. For a number of species, such as lichens, a clear link can be made with air pollution. The extinction of plants and animals is largely due to the loss of their biotope. This is mostly caused by light and heavy mechanical interferences, such as agriculture, urbanisation and road building. For instance, lowering the water level of ditches can cause a significant reduction in the diversity of vegetation.

However, a correlation does not always have to be a causal relation. The distance to a farm and the related reduction in agrarian activities can also offer a better explanation for local diversity, even if there is already a correlation with the water levels in drainage ditches. Water levels in themselves can correlate with the distance to the farm, if that farm is situated on higher ground so that the water level in the nearby drainage ditches is deeper than in those further away.[132]

Systems and areas

The effect of various forms of environmental stress on eco-systems and related geographical areas or utility zones is largely unknown. The effect of the ‘mechanical emissions’ named in Fig. 1008, such as treading on the ground, mowing, up-rooting, digging, ploughing, clearing the ground, and building, is the easiest is to determine.

The vulnerability of different geographical units to light or heavy interferences is recorded on environmental charts. Vulnerability charts are compiled to show the vulnerability for each environmental theme. More will be said about this in the following section. The old objections to environmental charts are, that these divert attention away from the interferences, their alternatives and effects, so that only alternative locations are discussed. These are less of an issue now that the instrument of environmental impact assessment (MER) is available. Although by far not everything is known about the environmental effects on plants, animals and ecosystems, an interesting part of the MER series has been published, entitled: Effect prognoses. Part V: ‘Plants, animals and ecosystems’.VROM/LNV (1987)

6.5.5 Creating standards

Effect-directed norms

In the previous sections, the unwanted side-effects of the activities summarised in Fig. 1005 are described. Effect reports can be compiled along these lines.
However, in this section, the focus is no longer on ascertaining the effects, but on the policy-wise reduction of those effects

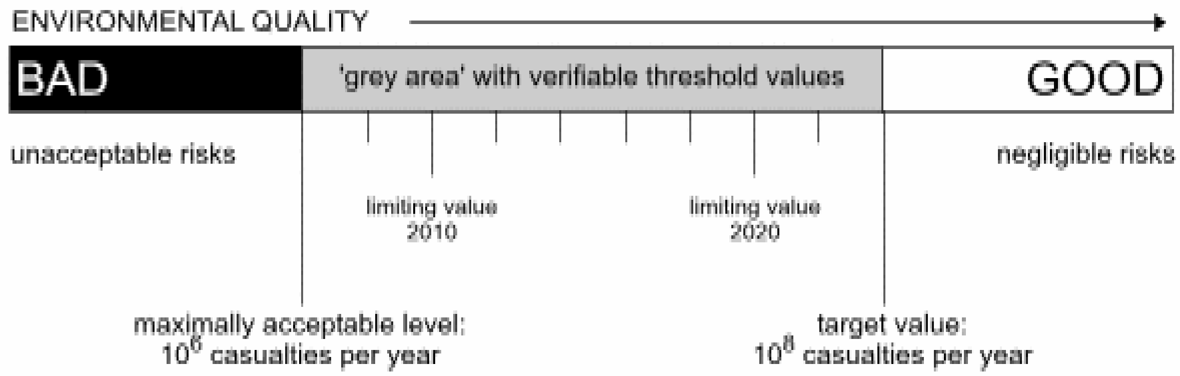


Fig. 1015 *Threshold, limiting and target values*

Accepted risks

The starting point is the end effect on people, ecosystems and economic functions, as shown in the previous diagram. In the totality of risks, to human beings an individual chance of dying of 10^{-5} per annum is accepted by government; the *maximal acceptable level of risks*. For each single activity or substance, the maximal acceptable level is 10^{-6} per annum. For illness (effects with a threshold value) comparable levels are given, as well as for disturbance resulting from noise or foul smells. For ecosystems, a similar sort of approach is developed. The maximal acceptable level is achieved when the concentration of a substance is the same as the calculated concentration, whereby protection is offered to 95% of the species in an ecosystem. However, in many cases these norms appeared to be unattainable (RIVM 2003).

Negligible effects

It is assumed that below 1% of this maximal acceptable level the effects are negligible. This marks the target value of all emissions and environmental effects: the value that should be eventually achieved. Between both levels there is a so-called 'grey area' within which targets for a certain period can be formulated using verifiable threshold values.
As soon as these threshold values have gained the legal status that they may not be exceeded, they are referred to as 'limiting values'. If such values may only be exceeded when reasons are given, then they are referred to as 'guide values'. Before these values are fixed, one can refer to them as environmental quality targets, and after that, as environmental quality requirements.

Target values

As a target value can only be reached in the longer term, for the shorter term, one can fix lower limiting values for what must be achieved during a certain year as an interim step towards the year in which the target value has to be achieved. An example of environmental quality targets is the table of target and limiting values of priority substances from the first National Environmental Policy Plan (see Fig. 1016).

substance	target value	limiting value	average	concentration around the sources	% reduction for the benefit of the target value	% reduction for the benefit of the limiting value	reference
trichloro-ethene	50	50	0.65	80	35-40	35-40	IMP
surface water	0,1		2,0		95		1987
tetrachloro-ethene	25	2000	1,0	30	20		IMP
surface water	0,1		3,5		98		1987
benzene	1	10	2	40	97,5	75	base
				(185)			doc
phenol	1	100	0,008	2	50		MP
etc							

VROM (National Environmental Policy Plan) (1989) page 141

Fig. 1016 *Target and limiting values of priority substances and the percentages of necessary reductions in emissions that result from this. Amounts in ?g/m^3 for air (or ?g/l for water).*

Time to reach target values

Regarding the priority substances, after thoroughly studying the effects of each substance, target values will be prepared in a 'basic document' for the general environmental quality of water, ground and air. In the grey area, for phasing the policy, limiting values must be fixed that indicate how far the protection will extend during the period agreed. This takes place on the basis of an economic consideration.[133]

Weighting costs and environmental quality

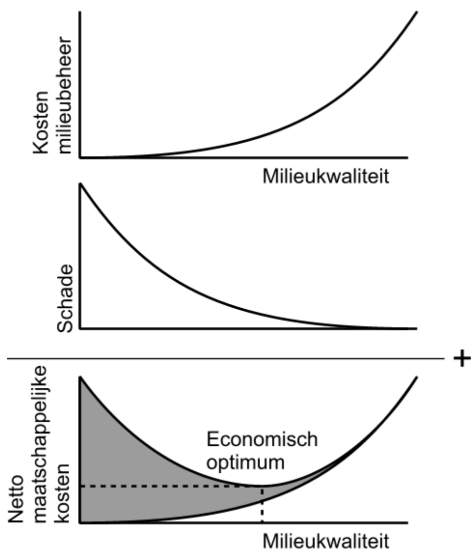


Fig. 1017 *Net societal costs after deducting environmental damage*

The costs of this protection increase progressively with the quality of the environment that we want to achieve in this way. It is not always possible to achieve an immediate recovery of environmental quality to the target value. One only has to think of the amounts of money involved in soil decontamination to understand that complete recovery of environmental quality not only financially, but also technically, takes time to achieve.

Limiting values include a consideration whereby the damage to exposed objects is weighed against the economic interests associated with the activities involved.[134]

In so far as this damage can be expressed in terms of money, this consideration is rather simple. After all, the costs of the damage can be added to the costs of protecting the environmental quality for every protection level imaginable. From this, for a certain threshold value, an economic optimum is obtained.[135]

Threshold values

However, in section 6.5.4, it became clear how open to interpretation the concept 'damage' is, and how dependent this is on the value we place on the protected objects. In addition, the graph does not run as continuously as in Fig. 1017. Locally, a small additional protection effort can suddenly save a species of fish. These sorts of quality aspect are therefore expressed as verifiable threshold values. For example, a threshold value can be established for the oxygen content of water, above which a species of fish will certainly survive.

A legally established limiting value will go further than the economic optimum, as other values are also taken into consideration than those that can be expressed in terms of money.
The limiting value can be established regionally; it can also be differentiated according to different functions (special environmental quality). Special environmental quality is the opposite of 'general environmental quality'. Based on separate general protection levels for drinking water, inland fisheries and shellfish, norms were established in, for instance, the Indicative Long-term Water Programme (IMP Water). Each of these protection levels is based on different criteria.

Different supposed uses of damaged objects

The criterium for fishing water can thus be a dose-effect relation for a certain species of fish and a certain form of pollution. Also the consumability of the fish that will be caught can be used as a criterium for the quality of the water in which the fish will have to be caught. It is clear that the criterium for drinking water will be different again from that needed for fish.

Levels of standards

Setting norms takes place on different managerial levels, beginning with the European level. The higher the managerial level and the larger the area over which the norm must apply, the more flexible the norm has to be to encompass all eventualities and to maintain a certain feasibility.[136]

The length and frequency of exposure

The length and frequency of exposure are essential considerations when setting norms. Certain norms may be exceeded for a short while, but not too often. In addition, it can be established that excesses, if they take place at all, may not follow each other within a certain interval of time. Human beings or organisms need time to recover from a certain excess. From this it appears that, in many cases, setting norms demands a statistical approach. This approach, whereby norms can be given an average value, must not lead, though, to ignoring periods of peak stress. Exact values remain necessary, therefore, not only as a means of evaluation, but also especially because of their role as an indicator and as a maximum value for incidents ('98 percentile, and similar).

An example of these sorts of peak sensitive exposure norms are the so-called EPEL and MAC values [a]. The MAC values are hygienic values for companies, fixed by the national MAC commission under the terms of the Working Conditions Law (ARBO). The MAC values are the Dutch version of the American Threshold Limit Values (TLV).[137]

Spatial zoning

The association of Dutch municipalities (Vereniging van Nederlandse Gemeenten VNG) made a list of approximately 600 business categories and the reach in metres (zone) of their environmental impacts intolerable for quiet residential areas Peters (2001). The businesses are categorised in column 1 of Fig. 1018 (for complete Dutch list see page 655) according to the SBI classification of CBS (1993), comparable with BIK-codes (Bedrijfsindeling Kamers van Koophandel), NACE-codes (Nomenclature générale des Activités économiques dans les Communeautés Européennes) from European Community and ISIC-codes from the United Nations.

Critical effects to keep distance

In its columns the list distinguishes zones for smell (4), dust (5), noise (6), danger (9), traffic (10), and visual impacts (11). The largest of them is critical and repeated in column 12. Column 13 gives a category of impact based on the largest zone (category 1 has a largest distance of 0 or 10m, category 2 a largest distance of 30m and so on). These categories are used in zoning plans.
Column 7 shows whether the impacts are expected to be present continuously (C) or not. Column 8 shows whether they were subject of earlier regulations (Z) or not. In the last columns 14-16 is indicated whether you can expect soil (B) and air (L) pollution and whether the impact is very diverse (D) in different cases depending on the business size and technology used. Anyway, the list has to be adapted to local conditions by municipalities using it in their zoning plans.

[a] MAC betekent Maximaal Aanvaardbare Concentratie.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SBI-code	Serial number	Description	Smell	Dust	Noise	C	Z	Danger	Traffic	Visual impact	Critical distance	Category	B	D	L
01	-	AGRICULTURE AND AGRICULTURAL SERVICES													
0111, 0113		Arable farming and fruit culture (industrial buildings)	10	30	30	C		10	1	1	30	2	B		L
0112	0	Horticulture:													
0112	1	- industrial buildings	10	30	30	C		10	1	1	30	2	B		L
0112	2	- greenhouses without heating	10	10	30	C		10	1	1	30	2	B		L
0112	3	- greenhouses with gas heating	10	10	30	C		10	1	1	30	2	B		L

Peters (2001)

Fig. 1018 *Zones of impacts around businesses intolerable for quiet residential areas (see page 655)*

Sensitive spatial functions

Some spatial functions are more sensitive (!), others less (-) than quiet residential areas (Fig. 1019).

	Indicative sensitivity by environmental aspect						
	smell	dust	noise	danger	traffic	visual	soil
Environment							
A quiet residential area							
B busy residential area			-	!	-		
C mixed area			-		-	-	
D rural area without dwellings	-	-	-	-	-	!	
E rural area without dwellings	-	-	!	-	-	!	
D business	!	-	-	-	-	-	
G protected soil or groundwater area							!
H noise protected area			!		!	!	
I Natural reserve	-	-	!	-	!	!	
J Reside area				-		!	

Fig. 1019 *Sharpening or moderating environmental claims according to sensitivity of affected functions*

In case of less sensitive functions a municipality can choose a lower zoning category.
When a business deviates from the average of the classification by special storage or installations (Fig. 1020) larger zones can be necessary.

Description	Smell	Dust	Noise	C	Z	Danger	Traffic	Visual impact	Critical distance	Category	B	D	L
STORAGES OF DANGEROUS MATERIALS													
butane, propane, LPG:													
- aboveground, < 2 m3	-	-	-			30	-	-	30				
- aboveground, 2 - 8 m3	-	-	-			50	-	-	50				
- aboveground, 8 - 80 m3	-	-	-			100	-	2	100				
- aboveground., 80 - 250 m3	-	-	-			300	-	3	300				
- ondergronds, < 80 m3	-	-	-			50	-	-	50				
- underground, 80 - 250 m3	-	-	-			200	-	-	200				
Non reactive gasses (incl. oxygen), cooled	-	-	-			50	-	2	50				
gas cylinders (acetylene, butane, propane and suchlike):													
- < 10.000 l	-	-	-				30	-	-	30	D		
- 10.000 - 50.000 l	-	-	-			100	-	-	100				
- >= 50.000 l	-	-	-			200	-	-	200				
inflammable liquids:													

Peters (2001)

Fig. 1020 *Zones of impacts around installations intolerable for quiet residential areas (see page 737)*

From effect- into source-directed standards

The development of environmental quality requirements originates from the exposed objects (risk criteria, dose-effect relations). From this end effect, limits can be set on the indirect and direct effects of activities and on the activities themselves (see Fig. 1003 and Fig. 1004).

Non-accepted exposure effects result in limiting values for the media air, water and the ground, from which environmental quality norms can be derived.
Emission limiting values and emission ceilings follow from this, as well as requirements and norms for products and processes towards which the activities lead.

The advantages and disadvantages of norms on the source and emission side compared with norms on the exposure and environmental quality side lie, on the one hand, in the area of the practical applicability of issuing licences and, on the other hand, in the possibility of objective under-pinning and the mutual consideration of different environmental stresses.

Process and product standards

Applying quality and imission norms can, after all, in principle, prevent the sum of all sorts of different activities (e.g. industry, traffic and home heating, as sources of air pollution), even though reasonably clean in themselves, from causing, nevertheless, an unwanted or unacceptable situation. On the other hand, they do not help to grasp the specific possibilities that can exist in an individual pollution-reducing source. Process and product norms have the advantage that they tackle pollution at source. However, they make an approach based on regional conditions impossible. Emission norms and ceilings have a sort of intermediary position between both.

6.5.6 Environmental policy

International principles: sustainable development and biodiversity

The ‘Brundtland Committee’ (World commission on environment and development, 1987) declared the principle of ‘sustainable development’ (to leave at least as many possibilities for future generations as your generation encountered). Since Agenda 21 (UN 1992), ‘biodiversity’ became an issue of these ‘possibilities’.

Core aim of the first National Environmental Policy Plan (NMP1)

The core aim of the first National Environmental Policy Plan (Ministry of Traffic, Spatial Planning and Environment (NMP) VROM (1989) was the *preservation* of environmental-usage space (milieugebruiksruimte) for the benefit of 'sustainable development'[138].
So, the *production* of new environmental-usage space by building, the many possibilities of gain by urban and architectural design are thereby overlooked.

Building, health and biodiversity

After all, the proper task of building is to increase the utility of the space for human beings and their future generations. Building is good for human health, because, without buildings there would be distinctly fewer survivors. In addition, buildings can increase the biodiversity of an area[139]. This means not only gains for human health, but also demonstrable gains in terms of biodiversity in the built-up environment.[a] [140]
From the 500 wild plants that are found in Zoetermeer, Fig. 768 shows, above the line, the species that already occur more frequently in urban areas than on average in the Netherlands. Thus one can conclude that building not only takes over existing environmental utility space, but also produces — and to a much greater extent — environmental utility space for human beings, plants and, in some cases, even for animals. If one doesn't include that environmental effect in the calculation, then the bookkeeping of the environmental utility space is incomplete.

Urban and architectural contributions to environmental problems

However, in environmental policy the building industry is not appreciated for her environmental profits, but merely its negative impacts are taken into account (see Fig. 1021). In a supplement of the NMP (Ministry of VROM 1990) for the building industry, it has been established what 'contribution' this 'target group' (other target groups are: agriculture, traffic and transport, industry and consumers) makes to each field of problems (theme) within the estimated total for the Netherlands:[141]:

THEME	SPECIFICATION	CONTRIBUTION
Climatic change	air conditioning, isolation foam energy from fossil fuels for commuter traffic, the production of building materials, and heating	23% of the total CFC use > 33% of the total CO_2 production
Acidification	commuter traffic, building materials, heating	>16% of the total NO_x and SO_x production
over-manuring	household waste water, emissions into the ground and into groundwater	24% of the total nitrogen and phosphorus production
Dispersing environmentally damaging substances	solvents, preservation, upkeep, asbestos, heavy metal emissions when insufficiently re-cycled	9% of the volatile organic substances, 40,000 tons of heavy metals, 7,000 tons of pigments
Removal of waste materials	building and demolition waste	20% of the total waste
Disturbance	noise and foul smells due to traffic, building, production and quarrying building materials	2.85 million homes suffering from (serious) disruption due to traffic, 25% of the population in small towns irritated by foul smells
Wastage	careless use, not much re-cycling	120 milliom tons of raw materials per year, 90% of which are primary raw materials
Internal environment	health effects due to building materials, moisture, quality of the internal air, sound, vibrations	number of homes above the reference value: 90% NO_x, 80% radon, 80% airborne sound insulation, 60 % respirable substances, 15% moisture problems, 6% carbon monoxide, 40% of the offices are 'sick' buildings
Damage to ecologically functioning area	building surface with isolated ground ecology, quarrying for building materials	3,100 km^2 of hardened surface, 1,000 ha/year open-cast mining, of which 500 ha of definitive changes in destination

Fig. 1021 *The contribution of the building industry to environmental problems in the '90s*

The building industry was able to bring about reductions of spare parts of more than 20%, for example, by not applying foam containing CFKs to insulation material or by not basing air conditioning on these compounds, or by rendering them totally redundant. This applies to more of the contributions named in this table.
In 'Environmentally considered building' started by the Ministry of Traffic, Spatial Planning and Environment (VROM), discussions took place with the industrial branch as to which reductions in the different types of environmental pressures could be achieved in the long term (target values) and various shorter term limiting values that had to be met before a certain year[142].

[a] Jong, Taeke M. de (2003) Milieuwinst en milieuverlies door bouwen. In: Boersema, J.J.; Pulles, T.; Straaten, J. van der; Bertels, J. (2003) De oogst van het milieu (Amsterdam) Uitgeverij Boom html

Environmental problems and targets

The NMP1 distinguished environmental problems according to the level of scale they can be solved (not according to their effect, which is always local):

- Global problems: ozone layer and climate change;
- Continental problems: border crossing air pollution, ozone on living level, acidification, smog, heavy metals;
- Fluvial problems: rivers, regional waters, salty waters, water bottoms;
- Regional problems: accumulation of pollution, over-manuring, pesticides, heavy metals, removing waste, soil pollution, drying up;
- Local problems: noise pollution, smell pollution, urban air pollution, inside environment.

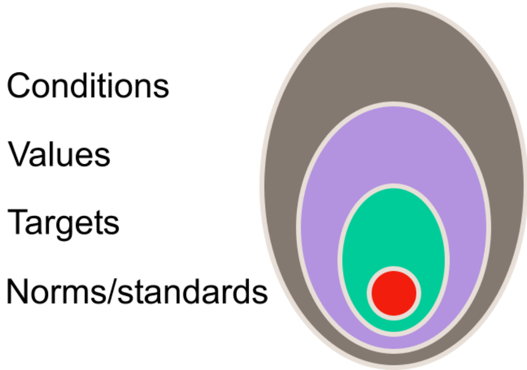


Fig. 1022 Conditional suppositions of norms/standards

According to these levels, targets were elaborated into standards according to limit values (see *Fig. 1022*) in cooperation with international, national, provincial and local authorities.

From an effect-oriented into a source-directed policy

The NMP1 marked a change into source-directed policy by making separate appointments with target groups like:

- agriculture;
- industry;
- refineries;
- energy supply companies;
- building companies;
- trade, services and governmental institutions;
- traffic;
- consumers;
- waste processing companies;
- participants in the water chain;

However, effect oriented measures remained actual for:

- problems herited from the past;
- source-directed measurements not coming in time;
- preventing calamities;
- failing source-directed measures.

The source-directed measures were distinguished into:

- emission directed;
- volume directed;
- structural measurements like integral chain management, energy saving and quality improvement.

These measures were discussed with the target groups (see Fig. 1023).

An agenda to discuss with target groups

The NMP used the following policy outlines as an agenda to the discussions with target groups:

<table>
<tr><td colspan="3">effect oriented (main emphasis of the ‘70s: ground, water, air)</td></tr>
<tr><td rowspan="5">source oriented (the ‘80s)</td><td colspan="2">emission oriented (removal at source)</td></tr>
<tr><td colspan="2">volume oriented (less consumption and production)</td></tr>
<tr><td rowspan="3">structural</td><td>energy saving (energy)</td></tr>
<tr><td>integral chain management (material)</td></tr>
<tr><td>quality improvement (information)</td></tr>
</table>

Fig. 1023 *Outlines of environmental policy*

In these ‘policy outlines’, environmental care is recognisable within effect, emission and volume oriented policy[143]. It is only when it comes to ‘structural’ policy that innovational environmental techniques are dealt with.

Strategic agenda

The government itself handled a strategic agenda of:

- reducing uncertainties;
- making choices from scenarios;
- formulating themes, instruments and cooperation.

These themes, instruments and cooperation are elaborated below.

Environmental themes supposing each other

Since the first National Environmental Policy Plan environmental themes have been: wasting, removing, disturbing, drying up, spreading, acidifying, over-manuring (the ‘VER-thema’s’ in Dutch)[144].

However, a conditional analysis of these (VER-) themes " (zie Fig. 1024)[145] shows they overlap. For example wastage has been tacitly presupposed as an environmental problem in all of them. If wastage is the main problem, then sunlight, rain, and leaf-fall in the autumn should also be avoided. The theme words are interpreted here according to their meaning in everyday language[146].

In a professional sense, a clarification of that is presupposed, but is sometimes forgotten. What is meant by ‘dispersion’ is the dispersion of environmentally toxic substances, excluding CO_2 (climate).

The tacit presupposition is thus: ‘in so far as it is not connected with the dispersion of acidifying or manuring substances, or CO_2 .

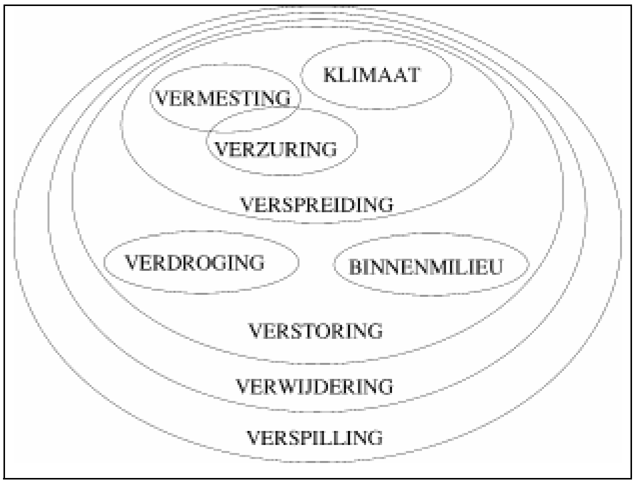


Fig. 1024 *Environmental themes from the NMP, shown according to their conditionality*

However, in everyday language, one cannot imagine climate problems, acidification and over-manuring without the dispersion of substances responsible for this. Ecologically, this dispersion is irrelevant, in so far (again, according to everyday language) as it causes no disturbances. However, ‘disturbance’, in professional language refers mainly to disturbance of the living environment due to noise, foul smells, insecurity, and is thus, in contrast to climatic problems, very local. The tacit presupposition is then: disturbance in so far as it is not connected with drying up, interior environmental problems and dispersion.

Double counting

The government prefered to convert environmental effects into these themes. That means that, in effect analysis, there is a danger of double counting, due to environmental values that presuppose each other. In methods such as LilfeCycleAssessment, an attempt is made to add up the effects by theme, but if a certain environmental pressure has more than one effect, it is unjustifiable to include that pressure several times in the calculation.

Calculations by RIVM

That is why for each theme, the environmental planning bureau RIVM yearly checking governmental policy results, repeatedly asked itself the same question: 'and why is that bad?'. The conclusion remained unchanged, that it is hardly possible in the Netherlands to determine the effects on health, but that, for each theme, 'a possible loss of biotopes' should be regretted.

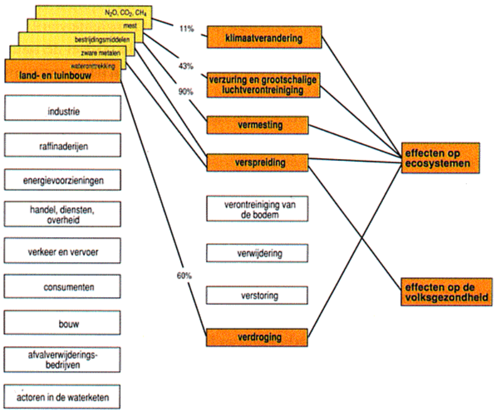


Fig. 1025 Calculating impacts of target group 'agriculture' on every theme, reduced to impacts on biodiversity and health

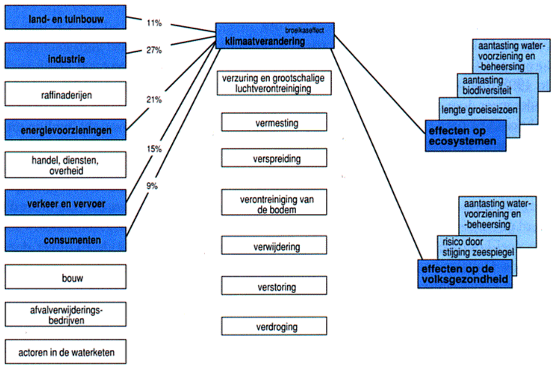


Fig. 1026 Calculating themes from contribution of every target group, reduced to impacts on biodiversity and health

Instruments and cooperation

NMP1 distinguished the following instruments:

- regulations by law;
- liability;
- financial regulations;
- environmental care in companies;
- product norms;
- information and public relations;
- technology;
- energy saving.

in cooperation with: international, national, provincial and municipal institutions.

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National policy documents after NMP1

Fig. 1027 *Four national plans concerning the environment*

There are four more recent national policy documents with environmental criteria for plans on different levels of scale from the Ministries VROM[a], LNV[b] and V&W[c]:

- The 5th National Plan of Spatial Policy NRO5, VROM (2000),
- The National Plan of Nature Policy LNV (2000),
- The 4th National Plan of Environmental Policy NMP5, VROM (2001),
- The 4th National Plan of Watermanagement PolicyV&W (1998) (stressing environment), and
- its successor 'Anders omgaan met water' V&W (2000) (stressing security).

Some of these policies are elaborated in a regional policy. The RIVM[d] is supposed to test plans on the subjects of health, environment and nature. Some of the produced criteria are summarised below.

Spatial claims

Claims as mentioned in the 5th National Plan of spatial policy NRO5, VROM (2000) are summarized below left. The expected shrinkage of agriculture surface cannot compensate the growth of other claims to the needed zero on the fixed surface of Deltametropolis. So, many claims will not be satisfied or perhaps be solved in space-saving combinations. From the drawing on page 135 of the mentioned plan one can count the claims in the Deltametropolis. Below right these claims are expressed in km2 and in circles of 1 and 3km occupying the same surface[147].

	Nederland				Deltametropolis		
	1996	claims			claims	km radius	
	km2	low	high		high	*3*	*1*
					km2	*number*	
living	2242	390	850		210	7	3
working	959	320	540		120	4	2
infrastructure	1340	350	600		90	3	1
nature, recr & sport	5439	4770	4770		970	34	2
water	7653	4900	4900		380	13	3
agriculture	23508	-1700	-4750		-1050	-38	7
	41141	**9030**	**6910**		**720**	**23**	**18**

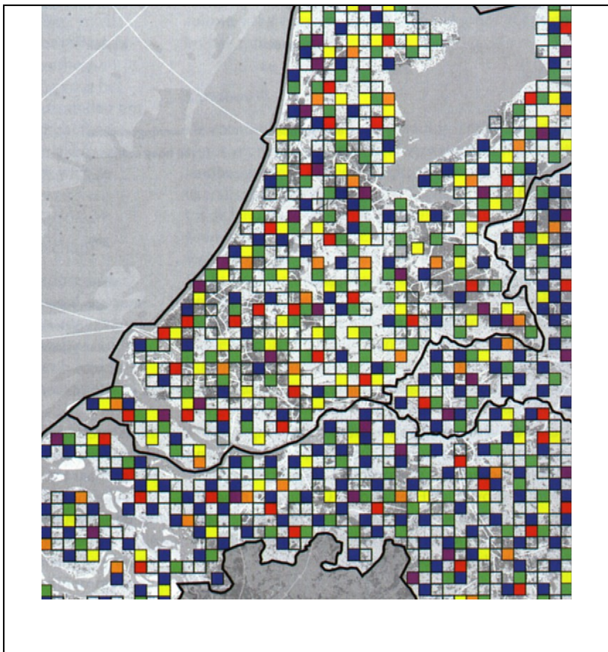
Fig. 1028 *Claims derived from the national plan*

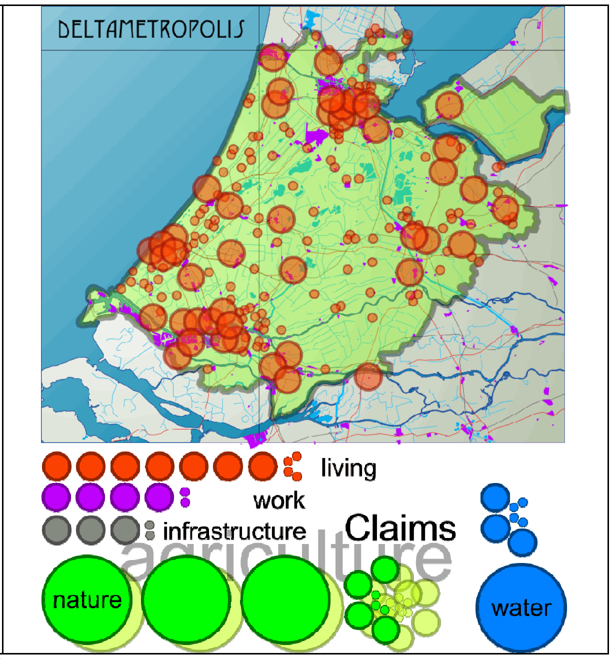
Visualising the supposed claims

These circles are drawn at size in the figure below right. So, 10 circles of 3km radius are put together to 1 circle of 10km radius. In the same way one can 'decompose' any circle in 10 smaller ones to picture more precisely the location, eventually till the picture has reached a photographic halftone

[a] http://www.minvrom.nl/minvrom/pagina.html
[b] http://www.minlnv.nl/
[c] http://www.minvenw.nl/cend/dco/home/data/index.htm
[d] See http://www.rivm.nl/

appearance with countable spots in different colours (pointillistic representation). This representation for instance shows at a glance the living environments of metropolitan, conurbation or urban centre (1km⊙[a] or 10,000 people surrounded by 30, 10 or 3km urban area), urban outskirts (1km⊙ outside the centre in at least 3km⊙ urban area not bordering on green areas of the same size), green urban areas (such an urban outskirt bordered on at least 1km⊙ green area), village (1km⊙ surrouded by green areas of the same size) or rural (0.3km⊙ or 1.000 people surrouded by green areas of at least 1km⊙) and the number op people enjoying such living environments[148].





VROM (2001) page 135

Fig. 1029 *Claims dispersed over the surface*

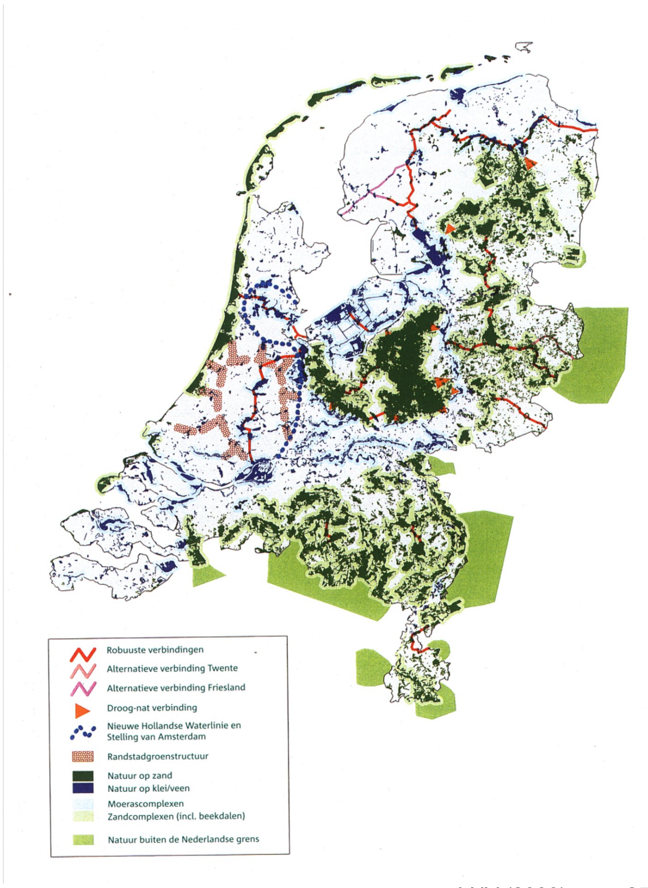
Fig. 1030 *The same claims compared with the existing sprawl of cities and villages in Deltametropolis*

Alternatives by design

With the stock of too much paint indicated in the right figure below we can picture many different perspectives of a future Deltametropolis. We necessarily have to omit claims. The perspectives will not only differ in the specific claims they accept or disappoint, but also in the way each colour is concentrated in larger units in favour of their own function or dispersed in smaller ones in favour of synergy with other functions. projects should support this own function or on the other hand synergy.

[a] ⊙ means 'radius' or 'around'

Claims of nature



LNV (2000) page 25

Fig. 1031 *Map of the National Plan of Nature Policy*

The National Plan of Nature Policy LNV (2000) publishes on page 25 of its programme the newest version of the accompanying map.

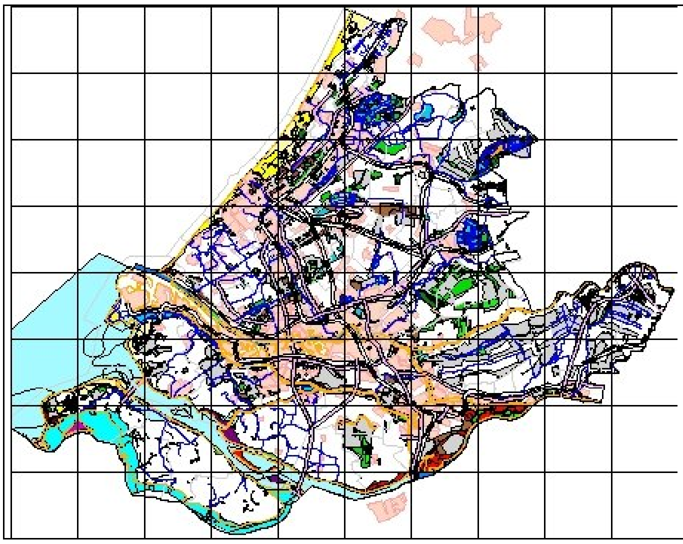
Deltametropolis counts three robust connections[149]:

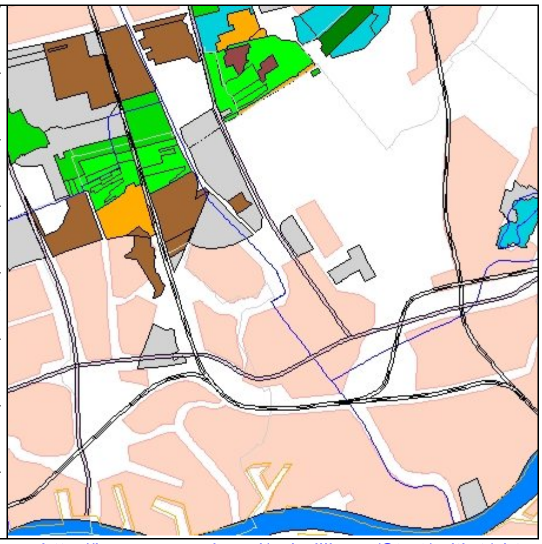
- randstadgroenstuctuur,
- Nieuwe hollandse waterlinie en stelling van amsterdam, and
- the robust ecological connection between Biesbos and IJmeer.

The biological identity of dispersed natural areas and projects in a large part of Deltametropolis from this programme and their role as aimed nature type (natuurdoeltype) is elaborated by the Province of Zuid-Holland and clearly represented on the Internet http://home.wanadoo.nl/w.heijligers/Start/ndtkrt1.htm by W. Heijligers. On the accompanying map one can zoom in to the level of the nature projects[150].

Provincial elaboration and local effect

Perspectives and projects are evaluated in the way urban areas in the Deltametropolis reflect this diversity and biological identity.





http://home.wanadoo.nl/w.heijligers/Start/ndtkrt1.htm

Fig. 1032 *Ecological infrastructure in South-Holland*

Fig. 1033 *Quadrant South-East Delft*

The basic ecological criterion for evaluation is global diversity lo leave possibilities open for future life. Diversity on a high level of scale is operational as rarity (as strong identity) on a lower level[151].

Comparing incomparable values

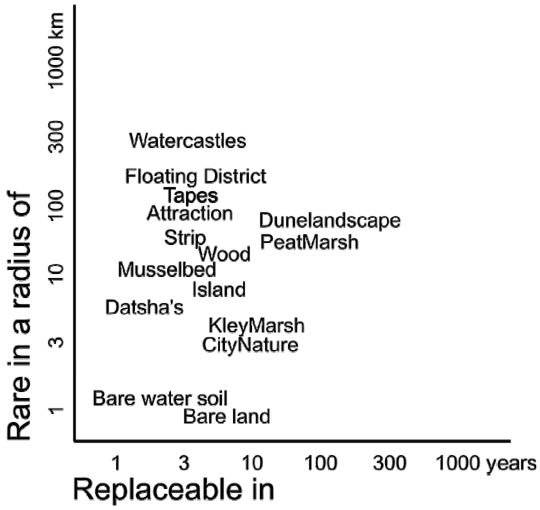


Fig. 1034 *Rarity and replacebility of natural and artificial objects*

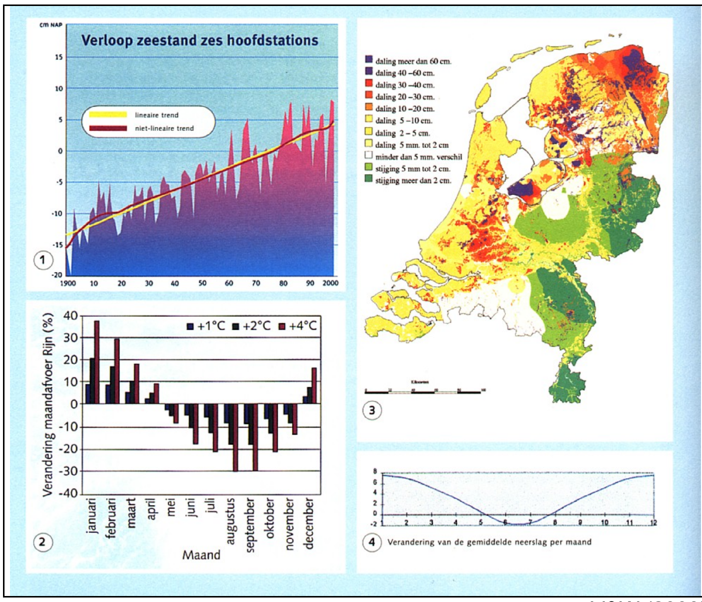
Perspectives and projects are evaluated on the preservation and production of worldwide (10,000km⊙), European (1000km⊙) and national (100km⊙) rarity of objects[a]. So, rarity can be expressed in km⊙. The second criterion, important for planning and design is replacebility of removed objects, expressed in years. It evaluates the possibility of compensation of rare objects. Once rarity of natural and artificial objects is determined on different levels of scale, they can be evaluated with regard to their replacebility.

In Fig. 1034 living areas of 1km⊙ or 0.3km⊙ designed and named by TKA TKA (2001), Hosper Hosper (2001) and H+N+ H+N+S (2001) in Almere (see *Fig. 906*) are located in a diagram for evaluation.

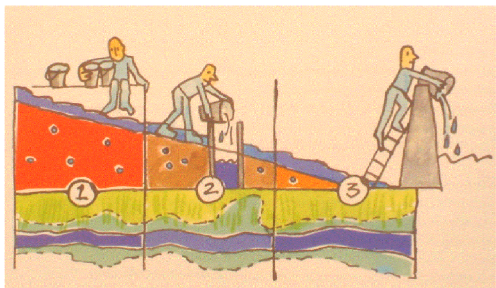
The product of both gives an ecological value for comparison and subsequent evaluation as discussed in 5.4 (see page 494). Natural areas are represented generally more right in the diagram, because they are less replaceble than the mentioned artificial objects.

Physical environment and water

The 4th National Plan of Watermanagement Policy V&W (1998; V&W (1998; V&W (1998; V&W (1998) (stressing environment), and its last successor ‘Anders omgaan met water’ V&W (2000) (stressing security) mark a change from accent on a clean to a secure environment, just as the 4th National Plan of environmental policy NMP4, VROM (2001) compared with its predecessors[152]. Several floodings in The Netherlands and elsewhere in Europe has focused the attention on global warming and watermanagement. The future problems and proposed solutions are summarized in the figures below[153].



In Fig. 1035 above most left, global warming, in the figure right the ground descend of the western and northern part of the Netherlands are shown.
Bottom most left, different scenarios of temperature increase, right of it, the expected increase of precipitation in winter and decilne in summer are shown.



V&W (2000)

Fig. 1035 *Expected problems*

Fig. 1036 *Strategies: 1 care, 2 store, 3 drain*

[a] The objects can be ecosystems on different size of 100m⊙, 300m⊙, 1km⊙, 3km⊙, 10km⊙, or 30km⊙.

The storage of water requires heavy surface claims. The lowest areas collect water and pollution, so local altitude lines, waterlevels and drain systems fix the possibilities and risks for nature and human living. They have to be listed. Relatively high locations favour both as concurrent functions. Lower areas are more suited for water.
In the short term energy saving by concentration is important to stop global warming, in the long term sunlight will provide enough electric energy to sustain the current worldwide demand several times.
The best indicator of a clean environment is the presence of rare nature. Its greatest threat is no longer the city but intensive agriculture.

European policy

P.M.

6.5.7 References to Environment

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