3 Diversifying content

3.1 Environmental design variables

Content

Paintings with equal *colours* may still differ in the *dispersion* of their colours on the canvas. Their *relations*, *effects* or *intentions*, all suppose 'colour' as the primary set of differences. The *content* of environmental diversification, then, is any category representing possible differences in a human environment, *except and regardless* of differences of its distribution in space (form), connections and separations (structure), uses (function) and intentions. Their different dispersion, structure, function and intention are excluded because they can be *superimposed* on differences of colour, moistness, movability or another category. They are studied separately as categories of *a* different 'order' in the next chapters.

Questions to be answered

Then, the questions to be answered in *this* chapter are:

- Which spatial differences are relevant for human experience and design?
- Within which radius R={1, 3, 10…300 000m} are they relevant?
- Could they be formulated as variables with an understandable sequence of values?
- Is one of these values a fixed 'zero-point' with different distances to other values?

The way they may take form and structure, get functions or intentions, can be studied later. However, to be *possible,* these next order categories *suppose* some content. Content then should be studied first, but it is not the core of design. Designers even may 'forget' to specify the legend of their drawing. Clients then may interpret the drawing in their own way. And, that can be an advantage. It is an advantage if they exclaim 'What a nice patio!' when they are referring to a surface that was intended as a room. Forgetting a legend may unveil their tacit wishes. But, specialists evaluating a design need a legend. They may ask, 'Is this wood or steel?'. They also can say: 'This should be steel, the profile is too small for wood.' That may be an advantage that accelerates the design process. But, if you directly accept that conclusion, you may forget about the many other possibilities. And, this study is intended to discover possibilities.

No other systemization than scale

There are many environmental variables that should be distinguished, and they often overlap. I cannot avoid gaps and overlaps. If I try to avoid them by a systematic categorization beforehand, then I may tacitly reduce the possible diversity. The choice of categories that determine your variables, and their values and legend units, are fundamentally free. This chapter then offers no other systematisation than the most relevant radius of effect. You should discover other differences that are not covered in this chapter yourself. It enriches design possibilities. Try to find a sequence of values and a zero point, and name it as a variable. That may give you access to an empirical evaluation, and it may diversify the brief. The other way around, the same variable may be relevant at different levels of scale. A category covering different levels of scale may have a different meaning a different levels.

Different meanings at different levels of scale

For example, 'Light'[a] is an important variable if you read a book sitting in a chair R=1m.
It is also an important environmental variable in a room R=3m, it divides the room into different places that are suitable to watch TV, read, sleep, eat and so on.
It is important in a building R=10m to distinguish rooms with a North, South, East or West orientation. It is important for the building group R=30m with their gardens and trees to determine where you can expect sun and shadow in the course of days and seasons.
Its differentiating power may seem to fade at the larger levels of scale, but if there are hills or mountains, it may diversify their slopes until R=3km (the radius of Mt. Everest).
R=10km then seems the ultimate scale where the variable 'Light' may have an effect.
However, at R=300km it starts again distinguishing different climate zones!
At all these levels of scale the variable 'Light' may get a different meaning or effect.
They just do not have separate names. If this is the case, you may distinguish them with an index: $Light_{1m}$, $Light_{3m}$, $Light_{10m}$, $Light_{30m}$, $Light_{100m}$, $Light_{300}$, $Light_{1km}$, $Light_{3km}$, $Light_{10km}$, $Light_{300km}$. If a variable can have different meanings or impacts at different levels of scale, then it may also require the consultation of different specialists. Each of these specialists may use different parameters, a different vocabulary and method to predict the impacts of your design. Expressing 'light' then in candela, lumen or lux is not sufficient. Design is oriented on human experience. It requires more values in its legends than the scale insensitive quantitative ones.

Different disciplines at different levels of scale

If any level of scale has its own content of relevant variables, then also any level requires a different selection of specialists in your design team. The design discipline that manages their integration will be different at different levels of scale. At any level of scale, the design team must cope with different values, legend units, different possibilities to combine them and different possibilities to use ande to want them. Moreover, any *combination* of variables shapes its own conditions, which limits your freedom to disperse their values in a drawing, to give an environment form, structure and possible functions. The importance of some variables will decrease, others will increase, and new ones will emerge. The content will be different at different locations, but the possible diversity itself, the available design means, may continue to increase by design and debate. This chapter, then, may only serve as the very beginning. The treasure-chest still may be poorly filled.

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[a] The name of a variable begins with a captal in order to distinguish it from its values.

The method used to find relevant variables

The list of environmental variables in the next section was originally made through the observation of various drawings. A large collection of 10x10cm drawings and maps at the scales 1:{20, 60, 200 … 6 000 000} was used. Some of them are depicted in the next section, in order to give you an impression of the scale. For every picture, I blindly placed my fingers spaced at 5cm on its surface. Then I looked at the two environments I had hit and asked myself 'What is the difference?'. But many other questions played a role at the same time:

What *could* be the difference?
What is in between?
Is the difference specific for this level of scale, or did I occasionally hit locations at two sides of a boundary that were conditioned by differences in a larger radius?
Are there other pairs of places with the same kind of difference?
Could I imagine larger or smaller differences of that kind?
Which extremes can I imagine then?
Is there an absolute value suitable as a zero-point?

Once Google Earth appeared, I could not stop zooming until the scale bar indicated a distance of {1, 3, 10 … 300 000m}. Then I compared places at that distance using the same method. I collected many kinds of atlases with thematic maps to study their legends and the distance between the centres of the legend units in the maps. In 1993, I received an assignment to compare the legends that were used in 28 designs that were submitted for a competition.[a] The number of legend units varied from 3 rough categories into 62 very explicit subcategories, or even objects.
If these objects are values in an imaginable range, how then would you define the variable? It is clear that you cannot avoid subjectivity in these exercises. It is not only an empirical exercise, it requires design oriented imagination. Empirical research may be the next step, using the variables to measure and to search for general relations. However, the choice of the variables precedes that research. This exercise should extend the possibilities of choice.

3.2 Variables identified

The list on the next pages (*Fig. 74*) summarises 136 variables that may be relevant for environmental diversification. It is only a selection of the variables that can vary in space and that are possibly relevant for design practice. Anyone may add other variables. The variables are not yet sufficiently elaborated to be fully operational for research and study. The selection is, however, sufficient to get an idea of the diversity of ´content´ that can be formulated as variables at any level of scale. The identified extreme values per variable are only two of the many (sometimes infinitely much) values. They may serve as legend units in a drawing. Legend units in a drawing, however, may be dispersed in a different order than the ordered values in the variable concerned. Some of the variables are elaborated in the next paragraphs as examples (indicated by ´E´ in the list). The name of a variable may be the same at different levels of scale, but its meaning and values can change. Some examples of extreme values show how their meaning may change through changes in their levels of scale. This change of meaning may be attributed to a change of resolution, but it also can indicate a substantially different meaning.

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[a] Jong;Witberg(1993) *Stromend Stadsgewest, Legenda-analyse* **IN** Klaasen;Witberg, *Het Stromende Stadsgewest derde Eo Wijers prijsvraag plananalyse* (Delft) Publicatiebureau Bouwkunde Delft http://team.bk.tudelft.nl/Publications/1993/legendaanalyse.doc

Examples 'E' elaborated on page	115	120	123	127	129	132	134	138	142	144	147	149	Examples of	0 ├──────── – – – –	
Nominal radius	**1m**	**3m**	**10m**	**30m**	**100m**	**300m**	**1km**	**3km**	**10km**	**30km**	**100km**	**300km**	Variables	Values	
General name															
Access		E	x	x	x	x	x	x	x	x	x	x	Access$_{3m}$	wall	door
			E										Access$_{10m}$	public	private
						E							Access$_{300m}$	pedestrians	cars
Agriculture								E	x	x	x	x	Agriculture$_{3km}$	fields	settlements
Allotment				x	E	x							Allotment$_{100m}$	detached	attached
Altitude				E	x	x	x	x	x	x	x	x	Altitude$_{30m}$	low rise	high rise
									E				Altitude$_{10km}$	centimetres	kilometres
											E		Altitude$_{100km}$	lowland	highland
Articulation			x	E									Articulation$_{30m}$	horizontal	vertical
Beauty	x	x	x	x	x	x							Beauty$_{1m}$	chaotic |boring	recognition |surprise
Backing		E	x	x									Backing$_{3m}$	corner	centre
Boundary Richness		x	E	x	x	x	x	x	x	x	x	x	B. Richness$_{10m}$	sharp	vague
Building Shape				x	x								Building Shape$_{30m}$	accumulated	dispersed
Building Size						E							Building Size$_{300m}$	small	large
Cables And Pipes			x	x	x	x	x	x	x	x	x	x	Cables And Pipes	matter	information
Catchment Area												E	Catchment Area$_{300}$	mountainous	delta
Centrality						E	x	x	x	x	x	x	Centrality$_{300m}$	centre	periphery
Change	x	x	x	x	x	x	x	x	x	x	x	x	Change$_{1m}$	seconds	millennia
Character	x	x	x	x	x	x	x						Character$_{1m}$	introvert	extrovert
Climate			E	x							x	x	Climate$_{10m}$	stable	variable
												E	Climate$_{300km}$	cold	warm
Colour	E	x	x	x									Colour$_{1m}$	black	white
Connection	x	x	x	x	x	x	x	x	x	x	x	x	Connection	1m	10 000km
Control			E	x									Control$_{10m}$	uncontrollable	controllable
Consumption	x	x	x	x	x	x	x	x	x	x	x	x	Consumption$_{1m}$	0	1Mg/m^3*sec
Coverage		x	x	E									Coverage$_{30m}$	sky	roof
Culture	x	x	x	x	x	x	x	E	x	x	x	x	Culture$_{3km}$	traditional	experimental
Curvature			x	x	x	x							Curvature$_{100m}$	straight	curved
Deliveries			x	x	x	x	x	x	E	x	x	x	Deliveries$_{10km}$	contribution	distribution
Demography									E	x	x	x	Demography$_{10km}$	homogeneous	heterogeneous
Density						E	x	x	x	x	x	x	Density$_{300m}$	vacant	built
Detailing	x	x	x	x	x	x	x	x					Detailing$_{1m}$	characteristic…	… marking
Difference	x	x	x	x	x	x	x	x	x	x	x	x	Difference$_{1m}$	equality	difference
Directions			x	x	x	x	x	x	x	x			Directions$_{10m}$	one	many
Dwelling Seclusion			x	x									D. Seclusion$_{10m}$	front	back
Dynamics			x	x	E	x	x	x	x	x	x	x	Dynamics$_{10m}$	sleeping room	workspace
							x						Dynamics$_{1km}$	quiet	busy
Ecology			x	x	x	x	x	x	x	x	x	x	Ecology$_{10m}$	homogeneous	heterogeneous
								E					Ecology$_{3km}$	lifeless	many species
Ecological Rareness		x	x	x	x	x	x	x	x	x	x		Ecological Rareness	1m	10 000km
~ Replaceability		x	x	x	x	x	x	x	x	x	x		Replaceability	1yr	1 000 000yr
Economy						x	x	E	x	x	x	x	Economy$_{3km}$	consumption	production
Economic Capital							x	x	x	x	x	x	Economic Capital$_{1km}$	0	$\text{1billion\$/km}^2$
~ Employment					x	x	x	x	x	x	x	E	Employment$_{300km}$	0%	100%
~ GDP										x	x	x	Gdp$_{1km}$	0	15 000billion$
~ Income					x	x	x	x	x	x			Income$_{100m}$	low	high
~ Power							x	x	x	x	x	E	Power$_{1km}$	dominant	serving
~ Sector							x	x	x	x	x	x	Sector$_{1km}$	primary	tertiary
Elevation			x	x	x								Elevation	flat	mountainous
Energy Conversion	x	x	x	x	x	x	x	x	x	x			Energy Conversion$_{1m}$	0	100kW/m^2
Expression	x	x	x	x	x								Expression$_{1m}$	inexpressible	expressible
Filling			x	x	E	x							Filling$_{100m}$	space	mass
Form	x	x	x	x	x	x	x	x	x	x	x	x	Form$_{1m}$	accumulation	dispersion
Formality				E	x	x							Formality$_{30m}$	street	backyard
Freedom Of Movement		E	x	x	x	x	x	x					Freedom O.M.$_{3m}$	stay	run

Examples 'E' elaborated on page	115	120	123	127	129	132	134	138	142	144	147	149	Examples of	0 ├──────── – – – –	
Nominal radius	**1m**	**3m**	**10m**	**30m**	**100m**	**300m**	**1km**	**3km**	**10km**	**30km**	**100km**	**300km**	Variables	Values	
General name															
Floor/Space (Fsi)					x	x	x	x	x				Floor/Space	0%	100 000%
Formality		x	x	x	x	x							Formality$_{3m}$	informal	formal
Function	x	x	x	x	x	x	x	x	x	x	x	x	Function	multi-functional	mono-functional
Furniture		E	x	x									Furniture$_{3m}$	bed	cupboard
Geology									E	x	x	x	Geology$_{10km}$	years	millennia
Geomorphology										E	x	x	Geomorphology$_{30kmM}$	erosion	sedimentation
History							E	x	x	x	x	x	History$_{1km}$	-300 million yr	10 yr
Housing			x	x	x	x	x	E	x	x			Housing$_{3km}$	single	family
Hygiene	x	x	x	x	x	x	x	x	x	x	x	x	Hygiene$_{1m}$	clean	contaminated
Identity	x	x	x	x	x	x	x	x	x	x	x	x	Identity$_{1m}$	equal|changing	different|stable
Identification Value	x	x	x	x	x	x	x	x	x	x	x	x	I. Value$_{1km}$	nondescript	striking
Image							E	x	x				Image$_{1km}$	homogeneous	heterogeneous
Imaginability	x	x	x	x	x	x	x	x	x	x	x	x	Imaginability$_{1m}$	inconceivable	conceivable
Influence	x	x	x	x	x	x	x	x	x	x	x	x	Influence	1m	10 000km
Involvement	x	x	x	x	x	x	x	x	x	x	x	x	Involvement	1m	10 000km
Information	E	x	x	x	x	x	x	x	x				Information$_{1m}$	poor	rich
			E										Information$_{10m}$	boring	chaos
Intensity							E	x	x	x	x	x	Intensity$_{1km}$	0hrs/yr	8760hrs/inh.*yr
Intention	x	x	x	x	x	x	x	x	x	x	x	x	Intention$_{1m}$	plan	desires
Landscapes									E	x	x	x	Landscapes$_{10km}$	natural	urban
Land Use									E	x	x	x	Land Use$_{10km}$	0	many hr/m^{2}yr
Legislation												E	Legislation$_{300km}$	free	strict
Life	E	x	x	x									Life$_{1m}$	a-biotic	biotic
Life Style					x	x	x	x	x	x	x	x	Life Style	consumer	careerist
Light	E	x	x	x								x	Light$_{1m}$	dark	light
		E											Light$_{3m}$	sun	shadow
Lineage					E	x	x	x	x				Lineage$_{100m}$	directed	undirected
Logistics						x	x	x	x	x	x	x	Logistics$_{300m}$	contribution	distribution
Management	x	x	x	x	x	x	x	E	x	x	x	x	Management$_{3km}$	laissez-faire	initiative
Market						x	x	x	x	x	E	x	Market$_{100km}$	local	international
Material	E	x	x	x									Material$_{1m}$	stone	organic
		E											Material$_{3m}$	air	solid
Meeting								E	x				Meeting$_{3km}$	home	work
Migration					x	x	x	x	x	x	x	x	Migration	0	high
Moistness		E	x	x									Moistness$_{3m}$	dry	wet
Movability	E	x	x	x									Movability$_{1m}$	fixed	moveable
Nature										E	x	x	Nature$_{30km}$	dry	wet
Nature Preservation			x	x	x	x	x	x	x	x	x	x	N. Preservation	isolation	connection
Network Density							E	x	x	x	x	x	Network Density$_{1km}$	0.7km/km^2	7km/km^2
Networks										E	x	x	Networks$_{30km}$	isolation	access
Noise				E	x	x	x	x	x				Noise$_{30m}$	silent	noisy
Occupation							E	x	x	x	x	x	Occupation$_{1km}$	natural	urban
Order	x	x	x	x	x	x	x	x	x	x			Order	content	intention
Orientation			E	x									Orientation$_{10m}$	undirected	directed
Organisation	x	x	x	x	x	x	x	x	x	x	x	x	Organisation$_{1m}$	anarchy	regulated
Overview		x	x	x	x	x	x	x					Overview$_{100m}$	closed	open
Parking				x	x	x	x						Parking$_{30m}$	0	5 parkingplaces/inh.
Passability			x	x	x	x							Passability$_{300m}$	unpaved	paved
Pattern			x	x	x	E	x	x	x	x	x	x	Pattern$_{300m}$	repetition	variation
Plantation				E	x	x	x	x	x				Plantation$_{30m}$	paved	green
Polarity	x	x	x	x	x	x	x	x	x	x	x	x	Polarity$_{1m}$	many sided	one-sided
Pollution							E	x	x	x	x	x	Pollution$_{1km}$	clean	contaminated
Population Density			x	x	x	x	x	x	x	x	x	x	P. Density$_{10m}$	0	100 000 inh./km^2
Population Growth							x	x	x	x	x	x	P. Growth$_{1km}$	0	10%/yr
Population Age		x	x	x	x	x	x	x	x	x	x	x	Population Age$_{3m}$	children	adults

Examples 'E' elaborated on page	115	120	123	127	129	132	134	138	142	144	147	149	Examples of	0	——— – – – –
Nominal radius	**1m**	**3m**	**10m**	**30m**	**100m**	**300m**	**1km**	**3km**	**10km**	**30km**	**100km**	**300km**	Variables	Values	
General name															
							x						Population Age$_{1km}$	starters	elderly
Public Transport						x	x	x	x	x	x	x	Public Transport$_{300m}$	10km/hr	1000km/hr
Precipitation			x	x	x	x	x	x	x	x	x	x	Precipitation$_{10m}$	0	200mm/hr
Production	x	x	x	x	x	x	x	x	x	x	x	x	Production$_{1m}$	0	1000kg/m^3*sec
Reach	E												Reach$_{1m}$	within	outside
Regulation			E	x									Regulation$_{10m}$	wasteland	property
Relief					E	x							Relief$_{100m}$	flat	steep
Resources											E	x	Resources$_{100km}$	internal	external
Risks										E	x	x	Risks$_{30km}$	nuisance	floods
Road Width						x	x	x	x	x	x		Road Width$_{300m}$	3m	100m
Routing						x	E	x	x				Routing$_{1km}$	points	surfaces
Selection	x	x	x	x									Selection$_{1m}$	non-selective	selecting
Separation	x	x	x	x	x	x	x	x	x	x	x	x	Separation$_{1m}$	open	closed
Size	E	x	x	x	x	x							Size$_{1m}$	large	small
Soil						E	x	x	x	x	x	x	Soil$_{300m}$	rock	water
											E		Soil$_{100km}$	clay	rock
Specialisation	x	x	x	x	x	x	x	x	x	x	x	x	Specialisation$_{1m}$	1m	10 000km
State Of Matter	E	x	x	x									State Of Matter$_{1m}$	solid	gas
Status					E	x	x	x	x	x	x	x	Status$_{100m}$	poor	rich
Street Furniture				E									Street Furniture$_{30m}$	kerb	lamppost
Structure	x	x	x	x	x	x	x	x	x	x	x	x	Structure$_{1m}$	connection	separation
Sun		x	x	x	x							x	Sun$_{3m}$	sunlight	shadow
				E									Sun$_{30m}$	morning	evening
Surface	E	x	x										Surface$_{1m}$	hard	soft
Task Division											E	x	Task Division$_{100km}$	agriculture	services
Technology	x	x	x	x	x	x	x	x	x	x	x	x	Technology$_{1m}$	combination	separation
								E					Technology$_{3km}$	energy	information
											E		Technology$_{100km}$	drainage	irrigation
Temperature	E	x	x	x									Temperature$_{1m}$	cold	hot
		E											Temperature$_{3m}$	cool	warm
Territorality			E	x	x								Territorality$_{10m}$	public	private
Time Use	x	x	x	x	x								Time Use	0	8 760hr/yr
Traffic					x	x	x	x	x	x	x	x	Traffic$_{3km}$	local	trough traffic
Transfer										E	x	x	Transfer$_{30km}$	walk	fly
Vegetation				x	x	x	x	x	x	x	E	x	Vegetation$_{100km}$	wet	dry
View		E	x	x	x	x	x	x					View$_{3m}$	wall	window
Visibility		E	x	x	x	x	x	x					Visibility$_{3m}$	invisible	visible
Water				E	x	x	x	x	x	x	x	x	Water$_{30m}$	land	water
Water Storage									E	x	x	x	Water Storage$_{10km}$	0	1 500km^3/day
Waterways										E	x	x	Waterways$_{30km}$	natural	artificial
Wind			x	x	x	x	x	x	x	x			Wind$_{10m}$	directed	turbulence
Zoning						E	x	x	x				Zoning$_{300m}$	natural	artificial
…															

Fig. 74 Variables relevant for design

3.3 Design variables R=1m (0.3 - 3m)

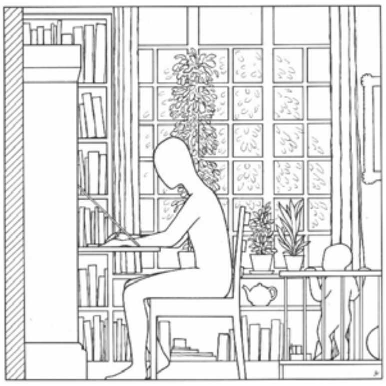

Fig. 75 Example 2x2m[a]

	0	
Light$_{1m}$	dark	light
Colour$_{1m}$	black	white
Temperature$_{1m}$	cold	hot
State Of Matter$_{1m}$	solid	gas
Surface$_{1m}$	hard	soft
Material$_{1m}$	stone	organic
Size$_{1m}$	large	small
Movability$_{1m}$	fixed	moveable
Reach$_{1m}$	within	outside
Life$_{1m}$	a-biotic	biotic
Information$_{1m}$	poor	rich

This list of possible design variables R=1m is not complete. The values mentioned are supposed to be extremes, with many in between values. Most of them do not have a proper name. One of the extremes is supposed to be an absolute value (zero-point), from which the other values are a specific distance away from. The names of the extremes are the best I could find, and perhaps they are still not the most appropriate.

Light$_{1m}$

Differences of 'Light', as they appear in a radius R=1m (0,3m - 3m), diversify environments in nature, in public spaces, gardens and interiors within arm's reach. The sources of light are sky phenomena, such as the sun or fire, lamps and electronic screens. The framing of light by windows, the character of the sources, their locations and those of the nearby objects that are illuminated with more or less reflection, may all play a role in your design. If you design the local diversity of light only by locating its absolute values expressed in lumens or lux, then that 'required' quantity is a small part of the design variable. It ranges from 'dark' to 'light', with the infinite and changing values in between you may experience.

More than a quantity of light

The accommodation of your eyes makes relative differences between these values more decisive than the measured or prescribed absolute ones. The proportional contribution of different sources may change if a cloud darkens the sun or if the evening falls and you put the lights on. The differences between direct, filtered and diffuse light caused by refraction, reflection and shadows, the colour of the source, and its eventual dynamics compared to what you remember, may generate a complex and often unexpected environmental diversification in your playpen, on your desk, or outdoors. In the open air, the changes during days and seasons, amongst other changes, determines the natural selection of plant species. A growing tree will change the scene through the seasons and the years. If the outside world is covered with snow, then your room will look different. The reflected white light from below, entering upwards through your window, reflected by the ceiling downward, changes everything.

Infinite qualities between darkness and light

You may categorize the design variables in many other measures, but their unpredictable and changing combinations are, in the end, what defines your design. It belongs to the portfolio and repertoire of architects as 'light-artists'. To determine the intermediate values you should make your own palette of light-forms, based on your own experience. Once you

[a] Huffener(1977) drawings in: Jong(1978) *Milieudifferentiatie; een fundamenteel onderzoek* (Delft) THD Bk Thesis

find a remarkable kind of light somewhere, make a sketch from the sources and nearby reflective objects. If you apply them in your design, then they will not have the desired effect all the time. However, even if the desired effect only occurs sometimes, it is fixed in the memory of the users, or by a photograph, as a particular historical quality of the place. In a museum, a laboratory or an office you may try to make it permanent, but change may be a quality in and of itself.

Compositions, structures and functions of light values

The same local content, e.g. the values you chose from that design variable $Light_{1m}$, still may be differently *distributed* in space, but this will not to be discussed further. The same value may be scattered throughout the view, or it may be concentrated at one spot by a beam shaping different compositions of light. Different adjacent values at your desk may then contrast each other through their sharp boundaries, or they may shade into each other, structured by their sources and the 3D illuminated surface. These alternatives of light-form and -structure subsequently may or may not be useful for different functions. They also may or may not be intended.

Orders of diversity

However, these values of form, structure, function, and intention are superimposed on the dark-light content itself, as second-, third-, fourth- and even fifth-order design-variables. They diversify your environment again, but in a different way. Since these higher-order variables can be applied at any content, they will be discussed in the next chapters. However, it is not always easy to separate content from form, structure and function. They can all be used as legends for design, as contents with a distribution in space. What you can call ‘content’ at one level of scale may appear as form at another level. Even light can be described as waves, as different sinus-forms at the nanometer scale. That is why the content and its variables should at least be bound to scale.

$Colour_{1m}$

Colour supposes light. It is the selective reflection of light by surfaces in the direction of your eyes, but you experience it as a characteristic of that surface itself. It is the most important and fastest way to distinguish surfaces from each other. In the dark, you need other senses such as touch, to do so. If anything in the environment would have the same colour, then you could not see anything. Vision supposes *differences* of colour. Without these differences, at R=1m you would not be able to read, to distinguish objects, to take them if you need them, or to avoid bumping into them. Different people may experience colour differently, but even colour-blind people see differences. Touch, taste, smell and even hearing may help the blind, and they inform you of depth. Synaesthetic people connect impressions of other senses directly to colour. Categories of colour then may exist in your mind and your vocabulary separately from their external existence. And these categories depend on your cultural background. They can get shared associations as ‘red’-‘danger’ or ‘green’-‘safe’ as used in traffic lights.

Levels of diversity

A single colour can be measured by instruments as the frequency f or the wavelength λ, connected by the constant velocity of light $c = \lambda f$.
But for humans, colour is scale sensitive. Seen at some distance, a mixture of colours may produce a different ‘colour’. This implies that for designers, $colour_{1m}$ is different from $Colour_{3m}$. It is also influenced by the differences between $light_{1m}$ and $light_{3m}$, since colour supposes light. For a child’s book or room, a reduced palette of primary colours, sharply separating the objects, is popular and supposed to be instructive. However, gradual transitions and less contrasting elements in the evening may cause less arousal.

Composition beyond content

Designing as ‘giving form to material’ makes colour differences less popular in 3D architecture and sculpture than in 2D painting, since they emphasise the form. Colour is sometimes used to distinguish repetitive forms, such as the storeys of a gallery flat, in order to mask ‘poor design’. The use of colour in this manner may improve the perceived quality of a poor design. It then may strengthen the impression of poor design if you apparently have to use colour to get identity. However, potential clients with a different aesthetic taste may be put off by the design. Colour can stress details as points of orientation, or indicate functions, such as entrances, public post boxes or policemen. Darker window frames may suggest shadow and depth, developing a sculptural effect when one views the façade. Since R=1m, 3D furniture and cars appear in many colours. The whish to use colour differences may be scale sensitive. There are a few examples of towns or villages in one particular colour (e.g. ‘white villages’ as Thorn in the Netherlands or blue-and-white villages in Greek holidays travel advertisements representing the colours of the Greek flag).

Temperature$_{1m}$

At R=1m, the temperature of objects may be more relevant than air temperature. Air temperature differences become more important at other levels of scale. Even temperature then is scale sensitive. You may doubt if temperature is a R=1m design variable at all, but it is worth the effort to explore its possibilities. If you have been in a space without floor heating, you may have experienced a warm head and cold feet at your desk, table or in a chair. In natural environments, R=1m temperature differences definitely play a role, causing different plants and insects to be located in different areas. But for indoor plants must endure the dynamics between cold windows providing light and heating elements below. Cold downward flows from the windows intersect the warm upward flows in an unpredictable turbulence. Cold flows mainly descending to the floor may be relevant for young children, old and sick people. I once asked a 3 year old girl “What is a mother?”. She answered “Big and warm”. Could you invent more ‘big and warm’ objects or surfaces? To *avoid* contact with the hot surfaces of a furnace or heating elements may be a concern of R=1m design anyhow.

State Of Matter$_{1m}$

The boundary between land and water is favoured by people to stay, yet many waterfronts are designed as sharp boundaries, steep quays or even as dangerous fenced places. In natural environments, less steep banks provide many alternatives between wet and dry for their flora and fauna. But you do not have them in your bathroom, your kitchen or even in your garden. You probably do not enjoy rain as much as people from dry climates. On rainy days, the wet outdoor environment and your dry room is strictly separated by walls and windows, with a transition boundary of only a few centimetres. Could you design more extended and accessible values in between? Many people like an aquarium, a little pond or a moisty indoor sunroom. Children like to play with clay, sand, and water.

Ventilation systems remove gases such as CO_2 to provide O_2, but odours and smells from kitchens, churches, laboratories, people and flowers may remain unconsciously in your memory as a ‘sense of place’. They are seldom an object of design. However, perfumes are designed and their formulae are kept secret. Aerosols such as smoke may be attractive or repulsive, but either way, they diversify environments. Smell is added to cooking gas as a warning, but smoke generators create a mysterious, misty atmosphere around performances or in discos, in an attempt to unchain the power of your imagination.

Surface$_{1m}$

You need a hard, flat surface to write, but a soft, curved one to sit at your desk. The difference between hard and soft surfaces is immediately understood as locations for movement and rest. In natural soils and vegetation, the surface differences of objects alternate at many levels of scale. But in artificial environments, soft surfaces are mainly used as smaller indoor additions, such as curtains, carpets, pillows, or soft furnishings. Softness can change the surface of a form, such as the adaptation of the human body by clothes. The skin of humans is soft and curved, but their artefacts are mainly hard and straight. However, industrial designer increasingly add soft and curved surfaces to ballpoints, tooth brushes and cars. Architecture increasingly allows curved surfaces, but its materials remain rigid and hard, in order to resist movement. But, moving your legs under a table, you have to take care of your knees.

Material$_{1m}$

Buildings, walls, columns, ceilings and roofs should be stable, strong and rigid, as you can learn in building structures lessons. These primary requirements of building construction are mainly fulfilled through the use of common building materials, such as concrete, steel, brickwork and wood. But at a smaller scale than buildings, these materials are often finished by plasterwork, paint or wallpaper, hiding their inner nature. The walls of buildings are interrupted by doors and windows made of wood, plastics and glass. Their rooms are filled with even more materials chosen by other manufacturing and use requirements. However, you will still find the greatest diversity of materials in nature. Organic matter consists of an inconceivable amount of chemical compounds, differentiating the natural environment at many levels of scale. They do not only serve stability and strength, but also growth, recycling and reproduction. But, they seldom serve rigidity. Organic material is more flexible, and less rigid than building materials. Will these numerous possibilities between stone and organic material remain irrelevant for future buildings?

Size$_{1m}$

Size is obviously a design variable, but it contains more than the square metres of your brief and the millimetres measured out in order to detail your drawings. It is also spatial variable diversifying your environment at different levels of scale. The objects that surround you, differ in size. At home you may be surrounded by small-sized objects and outside by large-sized objects, but this difference already plays a role within a radius of R=1m. You can express any size in metres, but your concept of size starts with the *difference* of sizes, and their proportions. Your experience of size changes by distance and age. As a child, everything was bigger for you. Your playpen was your room. If something frightened you, then you could run away to make it smaller. If it was small enough, then you could safely turn around to have a look, in order to put it in perspective with what you already knew. Your parents may have given you small models to understand the large objects they represent (e.g. dolls, toy cars, building blocks). You got a teddy bear, figurative toys, dangerous looking transformers to overcome your fear of what you may have seen or dreamed but never 'really' touched R=1m. By holding them in your hands, they became less threatening. You could manipulate them, throw them away to decrease their size, and learn that it was still the same object, be it out of reach, out of your playpen, or out of the box. You have learned that the face of your mother filling your scope while she took you up in her arms was the same as the small figure appearing at the door. You learned to call her when she was out of reach and sight. Sitting at your desk, you may have kept the smaller objects, such as ballpoint pens and paper, close by, and the larger objects, such as your dictionary, printer and storage boxes, further away. You may have done it in the kitchen too.

Movability$_{1m}$
Left and right in *Fig. 75* on page 115, ‘wall’ and ‘ball’ represent extremes of movability$_{1m}$. In between values may be recognized in cupboards, chairs and books. From any move into another home or rearrangement of your room, you may have experienced the importance of the objects’ movability strongly related to their size and weight. But, movability is more than size and weight. ‘Movability’ is a separate design variable$_{1m}$, because design can separate it from size and weight, by applying a wheel, a hinge or curtain rails. Manipulating objects, pushing a carriage and learning to cycle have played an important role in the development of children. Since Piaget demonstrated the importance of the motor senses for learning, early education and school interiors have changed. Gymnastics and sports were recognised as more important for the development of orientation and coordination abilities than previously thought. How to get an optimum between fixed and moveable by R=1m design? That optimum may be different in an office compared to a living room. But sitting for hours in an office may raise a demand to make chairs less rigid. Movability may be a design variable that is relevant in nearly any environment. Even walls and floors can be made moveable, which is often done in conference environments and air cushion playground equipment. But, if you make everything moveable, then the user may become disoriented or lose control of their coordination. Movability can be restricted to translation or rotation, which can be found in doors, windows or even rotating shelves in corner cupboards.

Reach$_{1m}$
Within a radius R=1m, not everything is always immediately accessible or within reach. Constructive parts may be out of immediate reach or sight, parts may be locked with a key or out of reach for the physically disabled. Reach is an ergonomic design variable, which is important in kitchens, desks or other workplaces that are intended to serve repetitive actions and for disabled people. The reach of pathogens, is also a variable of hygienic design.

Life$_{1m}$
Many of the above mentioned variables such as Light, Temperature and State of matter, influence the emergence and survival of living organisms, whether it is desired or not. But, their actual presence can be a design variable itself. It determines the environmental diversity of the natural environment at any level of scale, of public spaces, gardens and indoor spaces. People love and fear life. Within their houses they may keep plants and animals to differentiate their direct environment. Other strategies include fish bowls, birdcages or houseplants on their windowsill, table or desk. But they avoid vermin. Within a R=1m radius, the range between dead and living matter may contain memories or associations. A wooden tabletop is easier accepted than a concrete one. Fossils in natural stone may be appreciated. Climbing vegetation on exterior walls and fences are often welcomed. How to enrich the mainly dead human environments with living content?

Information$_{1m}$
The information content of an environment approaches its diversity in the following manner. For human appreciation, it should not exceed the borders into too little or too much, boredom or chaos. Between these limits it should enable recognition and surprise. Information comes down to the diversity that can be recognized and understood. It is enabled and conditioned by culture, age and employment. Busy managers may need a clean desk to compensate for their hectic day, but quiet scientists or artists, able to cope with much information amid diverse information categories, may have a messy desk. Information is scale sensitive. One level of scale may compensate the other. An information content R={1, 10, 100m} may be high if it is low at R={3, 30, 300m}, or the reverse.

3.4 Design variables R=3m (1 - 10m)

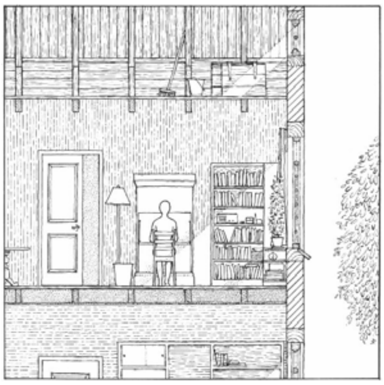

Fig. 76 Example 6x6m[a]

	0	
View$_{3m}$	wall	window
Light$_{3m}$	sun	shadow
Visibility$_{3m}$	invisible	visible
Temperature$_{3m}$	cool	warm
Moistness$_{3m}$	dry	wet
Material$_{3m}$	air	solid
Backing$_{3m}$	corner	centre
Freedom of movement$_{3m}$	stay	run
Furniture$_{3m}$	bed	cupboard
Access$_{3m}$	walls	door

The variables Colour$_{1m}$, State Of Matter$_{1m}$, Size$_{1m}$, Movability$_{1m,}$ Life$_{1m}$, Information$_{1m}$ are already named in 3.2. But, in a radius of R=3m, e.g. a room, they produce a different kind of environmental diversity than they did in a radius R=1m. Their values changed. The variables may have changed also. If they do not have a different name at this scale, then they still have a different index.
For example, Temperature$_{1m}$(cold-hot) is intended to be related to solid objects. That is something else than Temperature$_{3m}$(cool-warm) , which is intended to be related to air temperature. The environmental characteristics experienced walking 3m are different from those sitting at your table with a personal reach of 1m. There may be a diverse array of disciplines involved, from industrial design and ergonomics into interior design. But, it is not always as easy as talking about temperature.
For example, instead of Light$_{1m}$(dark-light) I arbitrarily chose Light$_{3m}$(shadow-sun), but I am still not convinced if that exactly covers your experience at R=3m. The same *variable* name in radii R=1m and R=3m may cover two fundamentally different sets of *values*.
To describe the differences in a radius of R=3, you also need *new* variables. I will explore some earlier named variables again to show the difference, but then I will only elaborate on the additions in the list below. That list is certainly not complete. You should always keep looking for your own legend units. In trying to name units as particular values from a range of possible values I still did not name as a variable here and in the lists of additions to follow at the next levels of scale.

View$_{3m}$

Take off your spectacles, stand up, stretch your legs and look around. Your desk with papers, your ballpoint and your emptied coffee cup becomes one of the scenes between the others. You look at a picture at the wall, you see your child playing, and you walk into the window where the sun shines on the floor, on some books in your bookcase and on your plants at the windowsill. You feel a draught of cold air. Through the window you see the tree in front of your house waving in the wind, the houses at the opposite side, and looking down you see people walking and cars driving. Looking back into your room, you see the furniture fading against a darker background. The diversity of views that you experience between the desk and the window vary according to the design variables that are present in your room. You saw their values of light, colour, size, material and so on appear and disappear in different sequences, as views. They appeared at a larger scale when you were at the window, than when you were sitting at your desk, with different contents. And, there are still other design variables than those represented in the views. They may appear by movement,

[a] Huffener(1977) in: Jong(1978) *Milieudifferentiatie; een fundamenteel onderzoek* (Delft) THD Bk Thesis

repair activities or (unconscious) use. And, any chair has its view. Did you realize that when you were putting them in their place in the room? What did your visitors see talking to you? It is amazing to study the location and orientation of banks in a park. How often the designers force you to look at asphalt with a beautiful landscape right behind you.

Light$_{3m}$

The size, position and orientation of your windows condition the potential access of daylight. Its effect changes at the surfaces it hits. Parts of its spectrum are reflected or diffused, fading with the distance to the windows, eventually mixing with other sources of light. They will replace daylight in the evening or during the day, if you turn on the lights and close the curtains. Different windows and other light sources receive a different combined effect at any location in the room. The produced differences *between* R=1m light sources experienced in a radius R=3m is something else than the diversity *within* each R=1m light source. You might name them as differences between 'desk light', 'table light', 'chair light', 'kitchen light' and so on. But that still will not cover the possible shades averaged for every R=1m light source in a radius of R=3m. They simply do not have a name. Painters may suggest some of them in their paintings with clair-obscur and sfumato, but how to cope with them in spatial design?

Visibility$_{3m}$

In your room, not everything is visible. But invisible objects and areas may still be essential for use. Many utensils are hidden in drawers or behind cupboard doors, to hide a mess. This chaotic view causes you to lose time when you are looking for something. The construction and material of the floor, the walls, windows and doors are hidden behind a layer of plaster, paint, carpets or curtains. The ventilation, electricity, sewage and water supply systems, and their cables and pipes, are hidden in the construction. But, you need them and you eventually have to uncover them when system repairs become necessary. That is not only the case in your room, but also in your garden, public spaces and even in nature. Under your feet, there is still an invisible world that is essential for the visible world. But still, designers make a sharp division between the visible and invisible. And that is not always necessary. In a school of architecture, you can omit the ceiling that covers the cables and pipes. It is cheaper and easier to maintain, and it may serve an educational purpose. The visual effect is not disturbing in that context, and it can even provide an improvement to the typical room, if the ceiling is higher than normal.

Temperature$_{3m}$, Moistness$_{3m}$, Material$_{3m}$

Within an action space R=1m, the object temperature may be relevant to avoid burns or cold limbs, but the air temperature in that radius is more mixed into an average. Within a radius of R=3m (ranging form 1 to 10m), the air temperature becomes more important. But, it will reach its peak at R=10m, where the boundaries between indoor and outdoor spaces are drawn. Temperature is often related to moistness. Cold surfaces attract moisture. But that is not always the case in kitchens and bathrooms where even warm surfaces may become wet. Moistness, then, is a separate design variable that requires a different surface material at areas where you may expect moisture and water. The diversity of materials in your environment is probably greatest in your living room. There may be a difference of material between the wall, the floor and the furniture. Coatings, sheeting, and curtains may differ. These values are different from the materials that diversity an environment R=1m (see page 118). There I chose values based on their inner properties of construction and production. Here I would make choices based on the more visual values of their surfaces, with the zero-point being 'air'.

Backing$_{3m}$, Freedom Of Movement$_{3m}$, Furniture$_{3m}$

In the corner of a room, your freedom of movement is restricted by the walls that meet in an angle. The spatial corner affects the possibilities for using the space, and the location of the furniture. If you place a square table surrounded by chairs in a square corner, then people in the corner will have problems passing by the other chairs. This problem can be solved by choosing a triangular table, as I once did. If you cover the corner with a cupboard, then you cannot access the spaces in the corner itself, except if the cabinet has rotating round shelves, as I constructed once. If you put your bed there, then it becomes difficult to make the bed in the morning. If you put a chair or playpen there, then you get a quiet place with a solid background, or shelter. But, it is not a place to run or play around, since you will bump against the walls. The centre of the room is better suited for such activities. You could call the design variable involved ‘backing’. It appears in any bounded area, and it is related to freedom of movement and the kind of furniture that is in the area. However, detailed designing may eliminate these relationships, as I mentioned above. That is why they are still presented as separate variables.

Access$_{3m}$

Access will also play an essential role in the larger radiuses. But, within a radius R=3m, doors already have an access-effect, different from that of R=3km roads. Any room has at least one door, and a zoning around that door that ends at the corners of the room, where mobility and movability are lowest. However, the *access* design variable is related to structural questions of connection and separation that *allow* more or less access. Connections and separations are the subject of chapter 5 on structural diversification, a variable of a higher order that can be superimposed on any of the previous variables. Windows and doors give more or less access to a room or a building. That connecting property is not the same as the properties of materials within the structure of walls, windows and doors connecting perpendicular to their performance of giving access.

3.5 Design variables R=10m (3 - 30m)

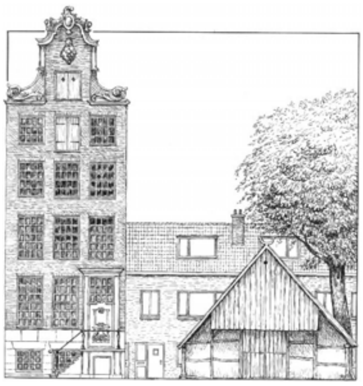

Fig. 77 Example 20x20m[a]

	0	
Access$_{10m}$	accessible	inaccessible
Orientation$_{10m}$	undirected	directed
Climate$_{10m}$	stable	variable
Boundary Richness$_{10m}$	sharp	vague
Information$_{10m}$	boring	chaos
Territorality$_{10m}$	public	private
Regulation$_{10m}$	wasteland	property
Control$_{10m}$	uncontrollable	controllable

Access$_{10m}$

A counter-intuitive zero-point

Access to your garden, your house or its attic may be enabled by connections, such as paths, passages, and staircases, or it may be hindered by separations such as fences, walls, doors and windows. But, as a primary design variable, motoric or sensoric access for people is not the same as the connections and separations they meet. Access is more related to the time and effort they have to spend. Any place within a radius of R=10m is accessible, but climbing a tree to reach its summit will take more time and effort than climbing the staircases into your attic. Total accessibility then is (somewhat counter-intuitive) a zero-point. It is anything within your Reach$_{1m}$ from the area you are in. If you would look for a numerical measurement of Access$_{10m}$, then you should add up all the time and efforts you need to reach every other area within a radius of R=10m. Since that calculation would include calculating the time and effort to reach every other area separately, such an attempt is only useful as a thought experiment. This calculation allows you to make a rough estimation of access, for example, to roughly determine your intuitive awareness of access and reach from the toilet to your children that are playing outside.

Access to and from a building

Anyhow, any area then *has* its own value of (outward) access$_{10m}$ to all the other areas within that radius. It is counter-intuitive, because a *higher* access-value indicates a *less* accessible environment. You can always add more barriers. You may suppose that areas inside buildings have a higher access-value than areas in the open air with its freedom of movement$_{3m}$, because a building usually has more separated spaces that must be passed through to get from one side to the other. But, if you do not have a key, then entering a house takes more time and effort than going out. If children go out to play (increasing their freedom of movement$_{3m}$), then the buildings around them are inaccessible, except if they have their keys. So, even for a rough estimate, you need at least some assumptions.

Sensoric access

If you include sensoric access (view and audition), it may be easier for parents inside the house to observe their children playing outside, than for their children to see their parents in the relatively dark interior, or peeping through the curtains. The children may not hear their parents calling them from the house, if they are surrounded by street noise that is closer to the children than the parents. The parents may hear their children easier from their quiet area than the reverse. The calculation of visual outward access per area, known as Isovist

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[a] Huffener(1977) in: Jong(1978) *Milieudifferentiatie; een fundamenteel onderzoek* (Delft) THD Bk Thesis

calculation, cannot easily include these kind of contextual parameters such as differences of available light or closed curtains. But still, you are painfully aware of sensoric access when you close the curtains or go to bed while the neighbours have a party. Even if you cannot calculate access in all of its meanings, its rough estimation remains a crucial design variable for locating separations and connections in a drawing.

Orientation$_{10m}$

The orientation of an area with the sun, the wind, the plantations, gardens, streets and other buildings, influences every access type. But, two areas with the same access may still have different orientations by design. That is why orientation should be treated as a separate design variable R=10m. It is important for many areas, such as streets, gardens, playgrounds, the perforations of a façade, the rooms behind them and the galleries or balconies attached to them. Orientation, then, is more than the directions of a wind rose. You have to take other environmental objects within a radius of R=10m into account. It is not easy to name intermediate values between the extremes, ‘undirected’ and many-sided ‘directed’, and organize them in such a way as to balance the extremes. A building should be open on at least one side, in order to provide physical access to public space. The position of a main entrance is crucial. Its orientation often determines the ‘front façade’, but that is not necessary. The front façade receives more meaning at a R=30m scale.

Climate$_{10m}$

Buildings are primarily intended to exclude wind, moisture, and rain, and to stabilise a useful inside temperature. However, the inside climate of a building may differ per room, and the micro-climate in its immediate environment may vary. There are many unnamed in between values between ‘stable’ and ‘variable’, useful for environmental diversification.

Boundary Richness$_{10m}$

In an urban environment you mainly find sharply separated boundaries, such as walls with sudden changes of altitudes or sharp boundaries, between paved and unpaved surfaces. In ecology, vague boundaries are known to produce many in between values that are utilised by different (often rare) plant species. Wide transition zones with vague or curved boundaries between wet and dry, acid and alkaline, more and less nitrogen and so on, are called ‘boundary rich’. However, a designer seems to love sharp boundaries, in order to develop clear drawings that allow them to clearly convey their ideas to the client. It could be worth the effort to search for opportunities to broaden boundaries. Even humans like ambivalent micro-environments between sun and shadow, windy and windless, noisy and quiet, wet and dry, odourless and fragrant. It decreases the many forced choices that are usual in their daily lives.

Information$_{10m}$

Information$_{10m}$ has different contents when compared to the Information$_{1m}$ already discussed earlier in on page 119. I will mention examples from larger levels of scale (i.e. R > 10m), and even concerning its form, in order to clarify its possible role in a radius R=10m.

Recognition and surprise

An environment$_{10m}$ may contain homogeneous, repetitive or mixed information of all kinds. Too little information is experienced as boring, too much as chaos. A balance of recognition and surprise between these extremes is aesthetically appreciated (see *Fig. 6*). But, that is personal, and it is dependent on one’s recent experiences. If you travel trough a sequence

of surprising environments, you appreciate recognizable stretches situated in between, in order to recover from that surprise and to become ready for the next. Otherwise, its sequence becomes chaotic, and without anchor points. A surprising $environment_{10m}$ may be accentuated and compensated for through the provision of recognizable adjacent $environments_{10m}$. The result, then, is $recognition_{10m}surprise_{10m}recognition_{10m}$.
This creates diversity in a radius R=30m. This $diversity_{30m}$ is interesting for walkers, but not for cyclists, if you repeat the same $diversity_{30m}$. The same sequence constantly repeating becomes boring for cyclists, if they move three times faster than pedestrians. They may need a surprise every 100m. This diversity at_{100m} ($recognition_{30m}surprise_{30m}recognition_{30m}$) requires some $homogeneity_{30m}$ to experience the difference of $environments_{30m}$ and to sense the boundaries they are passing. The same story repeats for car drivers appreciating surprising $diversity_{300m}$,and consequently is alternated by recognizable $homogeneity_{100m}$.

The distance of surprise

To summarise the preferences of recognition (r) and surprise(s): walkers like $r_{10m}s_{10m}r_{10m}$, cyclists $r_{30m}s_{30m}r_{30m}$ and car drivers $r_{100m}s_{100m}r_{100m}$. Looking at these formulae you may identify a problem. Car drivers like two times 100m repetition r to become surprised s (or awakened, aroused) by the third 100m stretch. That is once per 300m. But, cyclists want to be surprised once per 100m after two times recognition. And if you would provide that kind of diversity, then the walkers are disappointed, because accepting two times $recognition_{10m}$ they want to be surprised once per 30m before they become bored. The solution is simple: make another *kind* of diversity at each scale. For example, make the $surprise_{30m}$ different by another kind of architecture, make $surprise_{100m}$ different by the kind of trees and plantation and make $surprise_{300m}$ different by passing a facility. You also can incorporate remarkable points or big signs every 300m, less remarkable ones every 100m and even smaller ones every 30m.

Spatial $Rythm_{10m}$

In poetry, stress patterns are known as iamb (rs) trochee (sr), spondee (ss), anapaest (rrs), dactyl (srr), amphibrach (rsr). The examples above may advocate the last three, but less intense surprises allow the first three to alternate by two or more intense surprises, even four or more. In poetry, rrs, srr and rsr are different depending on how the verse rule starts. In music, there are time signatures and rythms, and at a larger time scale, themes and variations. Melodies and themes are seldom repeated more than three times before something changes. If the above mentioned approach for distributing information by spatial design could produce an appropriate environmental diversification in larger radiuses, what then is an appropriate $rhythm_{10m}$?
Numerous façades have a front door and two windows at the ground floor. The information density is highest at the entrance. The front door has different profiles, a post box, a nameplate, a bell, a lamp and so on. It is either flanked by windows as an amphibrach, preceded as an anapaest or followed as a dactyl. There is often a sequence of road-garden-building perpendicular to the façade. But, there may be many more variables to name.

Back to content

However, the *distribution* of information in space approaches the subject of the next chapter (form). The subject here should be the *kind* of information that may be distributed in space. In the examples above, information is related to the different kinds of Urban $Functions_{300m}$, $Plantation_{100m}$,$Architecture_{30m}$, and the Land $Use_{10m,}$ such as paved surface, garden, built-up, the Openings In The $Façade_{10m}$ such as doors, windows, post boxes or $Attachments_{1m}$ such as lamp, bell, nameplate. All of them can be distributed in space between the extremes of dispersion and accumulation. How to name the variables of information enabling environmental diversification in a radius R=10m? ‘Information’ may be a coordinating variable that includes every other variable. But here its familiarity between recognition and surprise is emphasised.

Territorality$_{10m}$Regulation$_{10m}$ and Control$_{10m}$

, Any individual, family, tribe or nation has territorial claims with biological roots. Their territory is their familiar and safe environment that is defended against outsiders. The familiarity with your home makes daily routines efficient, the safety of locked doors enables a defenceless sleep. But, leaving your home, you enter a collective territory with other rules. Land and buildings are still the most literal territories that are owned and defended by someone, but people easily move and sell them in exchange for money. For humans, capital or moveable property is part of their 'territory', and is not to be appropriated by others. In modern society, the boundary of a private territory is clearly outlined and administrated. The rest is collective or 'public' space.

Private and public

The difference between public and private environments is experienced as self-evident, mainly visually clear and subject to different kinds of regulation and control. Different environments may have different regulations. Roads may have other regulations than parks or private plots. In a residential area$_{10m}$, these differences are shown by different kinds of surface for cars, walkers, greenery, private gardens (often fenced), and built-up areas. The roads are regulated by traffic rules, which are embodied locally through traffic signs and ~lights. In pedestrian areas, cars and bicycles are not allowed. You cannot enter private gardens if you cannot clarify your intentions and purpose. When entering a house, you have to know its particular rules. Perhaps you are not allowed to smoke, perhaps you are supposed to take off your shoes.

Regulation and control

In public space, you can recognise regulation through traffic signs, different kinds of pavement and fences. The observance of collective settled rules is controlled through collective executive powers, such as a police organization, or an army, based on law. It is often obvious what is allowed and what is not allowed. Control in private territories is mainly left to its owners, recognisable by many details, either written or depicted announcements (e.g. beware of the dog, no entrance, private, bathroom, no smoking allowed). There are, however, interesting in between-areas where it is less clear how to behave. It may be a designer's challenge to detail the R=10m environment properly according to this variable.

3.6 Design variables R=30m (10 - 100m)

Fig. 78 Example 60x60m[a]

	0	
Sun$_{30m}$	morning	evening
Altitude$_{30m}$	low$_{30m}$	high$_{30m}$
Articulation$_{30m}$	horizontal	vertical
Water$_{30m}$	land	water
Coverage$_{30m}$	sky	roof
Plantation$_{30m}$	paved	green
Street Furniture$_{30m}$	kerb	lamppost
Formality$_{30m}$	street	backyard
Noise$_{30m}$	silent	noisy

Sunlight$_{30m}$

The sun is your main source of light. It colours your environment by an infinite number of shades that change per hour, per season and by occasional weather conditions. That is particularly the case in a radius of R=30m, where your range of view is between 10 and 100 metres. Façades at different sides of the street may look the same only for one minute of the day, but at any other moment they will be different. Then you have got a choice to walk in the sun or in the shadow. It would be nice to see the food stores in the morning sun and sunny shops for clothes and jewellery in the afternoon. I doubt if any planner takes that into account. There may be more to take into account than the position of rooms within a building to save energy. Careerists may like having access to the sun during their breakfast and in the garden in the evening. Familists like having access to the sun earlier in the garden and at dinner. The sun colours the memories of your parent's home. It may diversify the dwelling types at both sides of the street. Anyone likes parking spots without sun and trees, except in winter. Then, the sun helps you clean your car from snow and ice.

Altitude$_{30m}$

At different floors, you have different views. It is most rewarding at street corners. There, higher buildings will overshadow less gardens or only the streets, if they are located at the right corner. Differences in building altitudes articulate a street façade. Design has its greatest freedom at the top of a façade. Relief at the ground articulates gardens and streets with sunlight, shadow and different views. Bridges offer exceptional points and curbs divide pedestrians from other traffic sources.

Articulation$_{30m}$

Sometimes I wonder why buildings and streets terminate through right angles. Corners where pedestrians and other traffic stop for a while to get an overview on the traffic from different directions are opportunities for articulation. Buildings seldom give way to views or emphasize the crossing, e.g. by vertical articulation of their surface, or making a step forward or backward. Buildings are predominantly articulated horizontally by their floors. But, if walkers like a surprise every 30m, why not give them some rhythm for their walk? It may give them an idea of progress in long, monotonous streets. Why not let them look upwards sometimes along the lines of a proud taller building, instead of always depressively looking downwards at the tiles they walk on, because there is nothing more interesting to see.

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[a] Huffener(1977) in: Jong(1978) *Milieudifferentiatie; een fundamenteel onderzoek* (Delft) THD Bk Thesis

Water$_{30m}$
Urban water is a barrier and a circulation means for boats, it moderates extreme temperatures. it stores and drains the water of heavy or enduring showers, and it may remind people of their history. It is dangerous for children, but it is also dangerous if they never get used to it. If there is enough space, then make gentle slopes instead of steep quays. It allows for a diversity of vegetation, and a diversity of leisure grounds, as well as a diversity of choices for people. The dynamics of water differs from the dynamics of roads. It is a strong variable to diversify environments, if you remember Venice.

Coverage$_{30m}$
Roofs on a building are accepted as self-evident, but covered outside places are rare. Umbrellas, parasols, covered terraces, shopping malls and bus stops show their need. Covered outside areas provide many in between values. Solar cells covering a promenade may provide the necessary economic incentive for the shaded space. Trees have provided covered spaces for millions of years, through their leaves filtering sunlight to the ground in many shades and degrees of coverage, reacting on a season that requires more light.

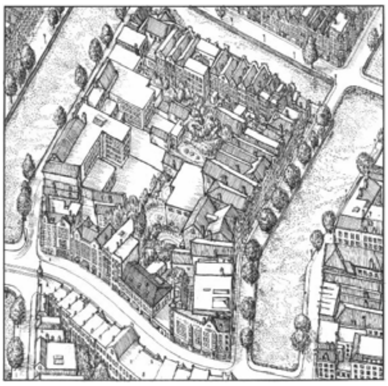
Plantation$_{30m}$
Where humans fail to diversify their environments, vegetation can. Plantations may give any place an identity. They provide shade from sunlight, shelter from rain and they cover the view of ugly or boring façades, empty streets or squares. Its own diversity in altitude, form and colour is inconceivable at any level of scale. Plants dynamics in the wind or per season remain fascinating.

Street Furniture$_{30m}$
The moment street lights start to compete with sunlight in the evening and people turn on their lights behind the windows, your environment$_{30m}$ is changed dramatically. It announces the end of a working day, the dinner, your leisure time. Do only traffic engineers care about the effect of street lights? You may remember your break at a public bench that was facing car traffic, instead of the park behind it. Who cares?

Formality$_{30m}$
Many buildings have a public front and an informal backside with a private backyard. Buildings are often grouped as urban islands in a network of roads that are visible in a radius of 100m. But, the enclosed informal world of gardens, sheds and back paths are separated from public space at a radius of R=30m. Sometimes you can find in between values of formality in the courts of almshouses that do not have motorized traffic.

Noise$_{30m}$
Contemporary traffic produces public spaces that are full of noise. Backyards, courts of almshouses, pedestrian areas and parks are quiet counterparts.

3.7 Design variables R=100m (30 - 300m)



	0	
$Filling_{100m}$	space	mass
$Relief_{100m}$	flat	steep
$Lineage_{100m}$	directed	undirected
$Allotment_{100m}$	loose	attached
$Dynamics_{100m}$	quiet	busy
$Status_{100m}$	poor	rich

Fig. 79 Example 200x200m[a]

$Filling_{100m}$, Density

The extremes are a bare plain and a fully built-up surface. The Dutch auction building in Aalsmeer completely covers a a nearly 1x1km surface with one floor. But theoretically, there is no limit to the surface and the number of floors. Filling, then, is open ended at the ´mass´ side, but empty ´space´ is a clear zero-point. The density is often expressed in %built-up and %floor space, where %floor space / %built-up = the average number of floors. The %built-up has a maximum of 100%, but the %floor space and consequently, the number of floors, is theoretically unlimited. However, these density measures are averaged over an arbitrarily chosen surface. They do not give any impression about the dispersion of mass in space and their form, which are the core of design. But, the same data can be drawn as a dot map. If you choose dots with a radius r=10m, than they represent a floor space of πr^2, that is approximately $300m^2$. You then can fill a 200x200m surface with 133 dots. If you want to design open space for gardens, public greenery and pavement for traffic, while keeping the same density, then you simply may remove some dots, and put them on top of other dots. The overlaps indicate where you need more than one floor. The built and vacant spaces now get a form. Your drawing begins to look more realistic as a rough sketch.

Relations with other variables

From such a sketch, you immediately get some impression of the other variables. You now can imagine differences of Size, Information, View , Visibility , Freedom Of Movement, Boundary Richness, Altitude, Water, Plantation, Formality, Relief, Lineage, Allotment, Dynamics, Status. It remains easy to change your sketch according to your imagination. You can see and even measure the increased diversity of densities by choosing an arbitrary surface and counting the dots. A computer will count the dots for you, if you select them.

Possible functions

But, your dot map enables more. On average, an inhabitant of the Netherlands uses approximately $30m^2$ of floor space. The dots of $300m^2$, then, represent approximately 10 inhabitants each. If you know from statistical sources that there are 16 million inhabitants, and some 13000 cafés in the Netherlands, then you may conclude that you need at least some 1250 inhabitants (125 dots) to support a café. If they are available in your map, then you can plan a café. But, there are statistics about any business that enable you to quickly estimate what other functions may be possible, in order to develop a functional diversification of the area. Do not forget to reduce the number of inhabitants available if you use floor space for non residential functions. A dot map communicates this way between numbers and form, empirical research and design.

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[a] Huffener(1977) in: Jong(1978) *Milieudifferentiatie; een fundamenteel onderzoek* (Delft) THD Bk Thesis

Content or form?

Discussions on the possibilities of form and even function are subjects of the next chapters. Density is applicable to many kinds of content, such as buildings, floor space, inhabitants, trees, parked cars and so on. It limits the possibilities of form, but does it indicate form?. What, then, is the variable of filling varying between space and mass? Is it a form variable, or does it have a meaning as pure content, imaginable without any dispersion in space? That is also a valid question for the other variables, such as Relief, Lineage and Allotment below. The criterion is, *if it can serve as a legend in a drawing*. And, filling with mass or 'built up area' can serve as a legend R=100 indeed. But, 'density' may serve as a legend too, if there are differences within the frame of the drawing. That condition is the key for finding answers to these questions. It depends upon the scale, and a sufficient distinction of classes. I do not know of any density maps that cover only a radius of R=100m, which are mainly concerning one urban island. But, I know drawings$_{100m}$ where building masses and numbers of floors are dispersed as legend units. I call that a value of 'Filling', but that is an arbitrary name for something I want to indicate at this level of scale. 'Density', then, becomes a variable in larger radiuses where different urban islands have different densities. 'Form' is scale sensitive. What is 'form' at one level of scale may become an example of a category covering different forms in a larger radius. It can be represented in a legend. Molecules also have a form at the nano scale, but at the level of daily experience they become a chemical substance. This is an example of the category 'materials' in a larger radius.

Relief$_{100m}$

Differences in altitude at ground level, between different kinds of plantations and buildings, may extend, bound and diversify your views that you have walking through an environment$_{100m}$. At ground level, you may meet slopes, and even staircases, that separate buildings, gardens, sidewalks and streets. By climbing a bridge, you may have nice views. Specialists calculating wind velocities by looking from above, distinguish 'roughness classes', in order to classify different kinds of relief.

Lineage$_{100m}$

Curved building lines and adjacent sidewalks show façades from different angles. They reduce your view, and probably disturb your orientation. But, if the opposite façades of a street have a mirrored curvature or they draw back in the middle, then the diversity of street widths may provide space for some greenery and concentrated parking spaces. A narrower street entrance with larger buildings (keeping the ground floor free for providing an overview) gives the residential area an interior, an intermediate value of territory between public and private.

Allotment$_{100m}$

Allotment is primarily a question of form. But, the difference between attached dwellings and detached houses introduces a difference between introverted and extraverted environments. Detached low-rise houses with front gardens side-entrances (with larger windows at the front) and large backyards may be best located at the sunny side of the urban island. The shaded side, then, may be more suitable for introverted dwellings with parking at the street, oriented around sunny backyards. The morning and afternoon sun differentiates the façades of the buildings across the street, which contributes to a diversification of lifestyles on both sides of the street. The gardens are full of noise in the evenings, and children meet each other in the backyards the other parts of the day.

Dynamics$_{100m}$

The hierarchy of roads that stem from larger radiuses may border an urban island through 20m wide residential streets, 30m wide main streets, 40m wide district roads, and even 60m wide urban highways. They diversify the dynamics found at these boundaries, just as schools, shops, and other functions sometimes do. This diversification may require other filling, relief, pavement, lineage and allotment.

Status$_{100m}$

Wealthy people may choose wealthy, low-density districts or neighbourhoods to live. High density neighbourhoods, however, may offer them higher, but large houses without a garden with a view at the crossings of streets. An urban island that has high-rise articulated corners which give way at the ground, can extend from the building at the other floors through curved balconies giving passengers space and shelter from the rain. They may extend into the adjacent streets to get an even larger floor space. The lack of garden space at such corners may be compensated through sunny balconies and roof gardens with a view.

3.8 Design variables R=300m (100 - 1000m)

Fig. 80 Example 600x600m[a]

	0	
Soil$_{300m}$	rock	water
Zoning$_{300m}$	natural	artificial
Density$_{300m}$	vacant	built
Access$_{300m}$	pedestrians	cars
Building Size$_{300m}$	small	large
Centrality$_{300m}$	centre	periphery
Pattern$_{300m}$	repetition	variation

Frame Of *Fig. 79* Inserted

Soil$_{300m}$

Soil maps seldom contain smaller legend units than r=100m. Soil differences mainly become recognizable in a radius R>100m. They determine the kind of vegetation and foundation of buildings until some 30m depth. A zero-point of 'Soil' could be the barren rocks at the highest mountains. From there until the soils of the oceans, the 'Soil' variable ranges form gravel, sand, clay to peat and underwater sediments. Its value changes on average at a radius of R=1000km, but local differences appear everywhere in between. At the scale of R=300m, groundwater levels and the bearing power of sub-soils are already important additional characteristics of soil for agriculture and urbanism. Dikes, raisings, foundations and drainage systems may influence these characteristics artificially. Ditches or brooks at a mutual distance of 30m on the map may indicate peat, 100m clay and 300m sand.

Zoning$_{300m}$

An R=300m residential area is approximately 30ha. It contains at least 1000 inhabitants (often called a 'neighbourhood'). It may be the smallest surface to make a zoning plan. It may have a neighbourhood park R=100m, and it may share a primary school for 2000 or 3000 inhabitants with adjacent neighbourhoods. If 1000 inhabitants use 30ha, then there is 300m^2/inhabitant urban area. However, in more central parts of the country and its cities, that may be 100m^2. These neighbourhoods, then, may count 3000 inhabitants, enough for their own primary school, a café, some corner-shops, services and small businesses. The zoning plan may cover different fillings, densities, functions and their access.

Density$_{300m}$

Differences in %built-up, %floor space, and the number of floors may appear. If there are 3000 inhabitants using 30m^2 of floor space, then you need nearly 10ha of floor space, or 1/3 of the total surface. If you also need 1/3 for public pavement and 1/3 for public greenery, then the remaining 1/3 private urban islands in a neighbourhood should have some 100% floor space. If you want private gardens, then the urban island may have 50% gardens and 50% built-up space. That requires an average of 50% built-up space in the urban island, and on average two floors, which is very common. The average %built up of the neighbourhood as a whole, then, is 50% of 1/3, or 17% of the whole. The average %floor space, then, is 100% of 1/3, or 33%.

[a] Blaeu(1649)[a]

Access$_{300m}$
There is some evidence that collecting traffic flows every third road may be efficient from a viewpoint of time use and investment.[a] That would make, at average, every third residential street a neighbourhood road, every third neighbourhood road a district road, every third district road an urban highway, and so on. Looking at the topographical maps of the Netherlands, I could distinguish road hierarchies through the road widths. Between the buildings, there are strets and roads of approximately 20, 30 or 40 metres wide, according to their residential, neighbourhood or district function. Their width is often related to the functions they house, such as shops, services and businesses. A neighbourhood, then, will not only have residential streets. There is at least a wider neighbourhood road, and perhaps roads of higher order stemming from larger structures. Their presence diversifies the neighbourhood through the provision of values of access.

Building Size$_{300m}$
The buildings in a neighbourhood may vary in size. There may be detached houses, dwellings attached in a block, a school and so on. If the neighbourhood is the centre of a district$_{1km}$, a town$_{3km}$, a conurbation$_{10km}$, a province$_{30km}$, a region$_{100km}$ or even a country$_{300km}$, then much of the floor space will be used for shops, services, businesses and so on. That allows larger and higher buildings, which determines the form of the neighbourhood, and its composition. It increases the demand and the budget for design. The extremes are concentrated in a centre, or dispersed, in order to generate focal points.

Centrality$_{300m}$
Concentration or dispersion may be a question of form, but it also diversifies a neighbourhood between its centre and periphery. That contrast may be low if the neighbourhood itself has a peripheral position in a district$_{1km}$, a town$_{3km}$ and so on. But, if its location is in the centre of many larger radiuses, then the neighbourhood becomes diversified, due to its centrality$_{300m}$ (see *Fig. 80*). Until the 1600s in the Netherlands, the majority of towns as centres of a larger area had a radius of R=300m. Nowadays, these towns are the size of remote hamlets, and function as small centres of agriculture, often with a church as a central focal point.

Pattern$_{300m}$
Surfaces, lines and focal points may *repeat* every 100m. This causes *variation* in a neighbourhood R=300m (see *Fig. 7* on page 21) affecting the 'image' of Lynch[b].

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[a] Nes;Zijpp(2000) *Scale-factor 3 for hierarchical road networks a natural phenomenon?* (Delft) Trail Research school
[b] Lynch(1960) *The image of the city* (Cambridge Mass.) MIT Press

3.9 Design variables R=1km (0.3 – 3km)

	0	
History$_{1km}$	-300 000 000yr	+10yr
Occupation$_{1km}$	natural	urban
Network Density$_{1km}$	0.7km/km^2	7km/km^2
Intensity$_{1km}$	0hrs/yr	8 760hrs/inh*yr
Pollution$_{1km}$	clean	contaminated
Routing$_{1km}$	points	surfaces
Image$_{1km}$	homogeneous	heterogeneous

Frame Of *Fig. 80* Inserted

Fig. 81 Example 2x2km

History$_{1km}$

History ranges from millions of years in the past, until approximately 10 years in the future. This is dependent on the time span of existing urban plans$_{1km}$. Existing plans for any future are a part of history. The remote past owes its interest to the sub-soil, and the more recent centuries to their subsequent remains and monuments.
Dutch gas is found in fields to a depth of 3km, R=30km wide and 300 million years old.[a]
The approximately 5cm/century subsiding lower delta has Pleistocene layers until 20m below ground level. Large buildings there may require long foundation piles to reach those layers with sufficient bearing capacity. The Pleistocene ranges from 3 million years ago until 10 000BC. The Holocene was the next period with human occupation. Archaeological remains may have been buried under layers of sediments after that period.
Some Dutch mediaeval towns at R=300m extended into a radius of R=1km after 1600. Extensions until R=3km appeared after 1900. Rapid extensions up to R=10km were developed after 1960. The urban surface then increased by ten each time, making them 1000 times larger than their mediaeval centres.

Occupation$_{1km}$

The occupation by humans is strongly related to the development of their technology. After a prehistoric occupation of scarce fertile grounds along waters for fishing and trading in the Netherlands, the Romans occupied the land until the river Rhine, building roads and canals. In 1000-1100AD, a substantial occupation started to transform moors into fertile polders created by farmers building dikes, dams and ditches drained into larger canals by windmills. Their outlets produced navigable waterways that provided the counts of Holland with enough tolls to decrease their taxes on farmlands. This introduced an early 'republican' spirit against any feudal rule pretending to own the land you have made yourself. It stimulated shipping, trade and industry, which was concentrated in a high density of defended towns. The lowland towns were drained through canals, structuring their extension, up to R=1km (see *Fig. 81* on page 134).
The resulting republic, the 'United Provinces' of the Netherlands', occupied after 1600AD many parts of the world as colonies, founding 157 towns and trade settlements[b]. Their yields and the local energy sources from wind and peat produced a Golden Age. The power of this

[a] Doornenbal(2004)*Geological Atlas*(Utrecht)TNO
[b] Oers(2000) Dutch Town Planning Overseas during VOC and WIC Rule 1600-1800. (Delft) TUDThesis Walburg Pers

early republic, however, declined after 1700AD due to a lack of manpower for the colonies and the army. The enlightened republican heritage had been exported just in time by Prince William III after his campaign through England in 1688. As its king, he allowed an unprecedented powerful parliament. This enlightening 'Glorious Revolution' enabled an early industrial revolution that was based on coal, the main source of energy of the 19^{th} century. The declaration of independence of the Dutch Republic (1581) of William I shows similarities to Jefferson's declaration (1776). The USA then developed an economy largely based on petrol, the main source of energy of the 20^{th} century. the Netherlands, however, became part of France after 1800AD until the battle of Waterloo. A short revival of royal centralism improved the Dutch infrastructure, preparing its late industrial revolution after 1850. After 1900, towns all over the country crossed the threshold of R=1km into a tenfold surface of R=3km. Transport technology based on petrol loosened the dependency of towns on having a location with adequate resources. After 1950, urban planning failed to stop sub-urbanization and sprawl across R=3km. After 2000, sprawl even across R=10km became accepted.

Network Density$_{1km}$

The Dutch 17^{th} century lowland network of waterways and ferry services dominated national road networks, until 1850.[a] After 1900, a paved road network covered the country, crossing the rivers through steel bridges. The government gradually re-arranged the radiating road networks of towns into a grid, interfering the water network with bridges. After 1950, accordingly grid-like urban extensions$_{1km}$ hampered the pedestrian access of their district centres and schools. After 1960, the dominance of the car stimulated new separate radial networks for pedestrians$_{1km}$ and cyclists$_{3km}$, with smaller bridges and tunnels. District centres became pedestrian areas that were surrounded by parking and provision space. That story repeats for town$_{3km}$ centres$_{1km}$, , and is sometimes separating these conflicting functions vertically. There, cyclists and pedestrians go upward with empty shopping bags, and downward with heavy ones.
After 1900, tree like drainage and sewage networks became accompanied by networks for water, energy and information supplies in the sub-soils of roads. However, these became separately planned and maintained by separate companies. The network density, then, may become a crucial variable for change and planning$_{1km}$ in the years to come.

Intensity$_{1km}$

The more and less intense use of public space starts to diversify urban environments in a radius of R=1km. If 2/3 of its urban space is public ($2km^2$), and it is used by 10 000 inhabitants for 200 hours per year each, then its public space is used 2 million hours per year. That comes down to 1 hour per m^2 per year! The rest of the year that m^2 is for the birds. You would not expect that, if you see crowds walking on a normal Saturday at 14:00hr in a district centre. But that intensity may vary by period per 24hr (night, peak hours), per week (working days, Saturdays) and per year (holidays, normal). Moreover, the time spent at different places may vary from 0 hours/m^2*year in quiet public spaces to some 150 in shops. If half of the 2 million hours per year spent in public space concentrates in a district centre, then there are 1 million hours/year spent there. If that concentrates in 50 weeks of the year, then there are 20 000hrs in a normal week. If half of it is concentrated on Saturday, then it is 10 000hr/Saturday, or some 1000 per hour. At the peak, between 14:00 and 15:00, you then may meet 2000 people or 33 per minute! You are not aware of the emptiness of public space if you primarily visit the most intensely used dots at peak hours.
The survival of many kinds of shops and services depends upon the intensity of the location.

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[a] Vries(1981) *Barges and capitalism, passenger transportation in the Dutch economy 1632-1839* (Utrecht) HES publishers

If one of the 10 people passing by your shop in a district centre spends 10 Euro, and you need 1 million Euro per year to survive, then you need 1 million people per year to pass by your shop. If they spend 1 million times 1 hour in your district centre every time they pass by your window, then you may survive. But if you are located one street further, you may not.

Pollution$_{1km}$

The reach of pollution by odour, dust, noise or danger seldom exceeds 1km from its source. The primary strategy to deal with nuisances is to mitigate them at their source. But, if the nuisances are unavoidable, then keeping a distance around the source or the victims reduces their effect. Avoiding vulnerable functions within the nuisance radius of a source is called outward zoning, and avoiding sources within radiuses around vulnerable functions is called inward zoning. Environmental regulations and measures decreased the many sources of nuisances, and reduced the size of their outward nuisance radius substantially. That allows more mixing of businesses in residential areas. But, even silent cars generate noise through their tires when they are on the road, and they become more dangerous if you cannot hear them approaching. Outward zoning and mitigating measures around traffic is still the most dispersed and space consuming effect of pollution in districts. Urban highways with noise-barriers require at least 60m between the façades, regional highways 80m and the largest highways 100m. But, you can still hear them at a distance of 1km. Completely silent areas have become rare, just like completely dark environments at night. Silence and darkness at night in natural reserves, then, should be protected by inward zoning.

Routing$_{1km}$

Finding your way in a district$_{1km}$ is enabled through the provision of recognizable points, lines, surfaces and volumes, as Lynch[a] elaborated as Paths, Edges, Districts, Nodes and Landmarks. They are most effective when one is walking within in a radius R=1km. In larger radiuses, your route along the roads and turning points is sufficiently directed by maps, signposts, or navigators. An electronic navigator in your car primarily announces the turning points, and tacitly shows the lines in between. The points, then, are the most important details to find your way. Lynch supposes that paths are the most important details for your total image of the city, but that image contains many routes. On a single route, you always move from a starting point into a destination, by passing recognizable intermediate points from one point to the other. However, 'points' may be crossings, roundabouts, or even squares with views in any direction. The points or locations, then, are extended or 'labelled' by these views. A passenger will explain the points you have to follow by their labels: " … , and then you cross a large road with traffic lights. And then you see a blue building at your left hand. And then you reach a small square…". You may remember the points by these labels, but you follow the points.
If the points of your route are recognisable through a detail, a particular building or even a large surface such as a square, then these points can have a different order, a different importance, or a hierarchy based on their size. In The distance of surprise on page 125 I suggested, then, to give them also a mutual distance, according to that order. For example, a surprising architectural detail every 30m, a deviating building every 100m and a square every 300m.

[a] Lynch(1960) *The image of the city* (Cambridge Mass.) MIT Press

Image$_{1km}$

The image of a district$_{1km}$,then, is determined by the number of substantially different routes that you can follow in the area. If they are all similar, the value is ‘homogeneous’, otherwise it is ‘heterogeneous’. The name ‘Image’ may be applicable at any radius, and it is perhaps not the best one to express the number of characteristic routes. But, the ‘image of the city’, in the context of iconic city marketing, is a well known concept that was developed by Lynch. However, in this chapter it is supposed to be most operational in a radius of R=1km, which is a 20 minute walk. The ‘image’ of a town$_{3km}$ usually does not emerge through its outskirts, but through its (historical) centre (‘city’), and that is at most its central district$_{1km}$. On the other hand, in a radius of R=300m, ‘routing’ is less important. A 7 minutes walk nearly covers the reach of your view. At that distance, you will seldom speak about ‘routing’, if it only covers two or three points (lines, surfaces). Such a small sequence is not specific enough to be distinguished from many other cities.

3.10 Design variables R=3km (1 – 10km)

Fig. 82 Example 6x6km 1930[a]

	0	
Ecology$_{3km}$	lifeless	many species
Housing$_{3km}$	attached	detached
Agriculture$_{3km}$	fields	settlements
Technology$_{3km}$	energy	information
Economy$_{3km}$	consumption	supply
Meeting$_{3km}$	home	work
Culture$_{3km}$	traditional	experimental
Management$_{3km}$	laissez-faire	initiative

Ecology$_{3km}$

Wild Life

If you count the number of wild plant species per km^2 in towns, then you may be surprised by the urban diversity of wild life. Surrounded by a fertilized agricultural ‘desert’ that has at most 10 wild plant species/km^2, a town$_{3km}$ may count more than 350 non-cultivated plant species/km^2 in its centre![b] That is more than you can find in many natural reserves. If the town is embedded in a larger conurbation$_{10km}$ (I will call such a town a ‘city’), then the area with the most biodiversity may not be in the busy, stony and ‘fertilized’ city centre, but in the more outward areas, in the city centre’s surrounding districts. That phenomenon may have emerged only since the urban environments became cleaner, but the apparent urban ecological potential may be explained by the local boundary-richness. Plants, insects and other animals may discover and appreciate the urban diversity, and the many transitions of sun, wind, water, soil and their rare combinations, easier than humans.

Human ecology

The human population created a diverse techno-sphere, full of physical separations at every level of scale. For millions of years, people have lived without them, in wandering communities of hunters and collectors. But, since the emergence of agriculture some 10 000 years ago (Neolithic Revolution), separate families occupied land and settled as private owners of durable farms. Through the development of their defences, fenced and stable territories no longer had to rely on larger communities for survival. Their surplus production could be exchanged through trades in markets. Markets produced a specialised population of traders and craftsmen in defended towns. Individuals diversified in separate shops and workshops.

Since the Industrial Revolution, individuals and couples with children were separated again from their larger families, in smaller urban dwellings. Their private lives were closed off from public space, and individuals of local communities became strangers, through fenced gardens, walls, locked gates and doors. Many tasks of the former extended family were farmed out in urban functions.[c] Education, care, and religion developed internal specialisations, employment and buildings, such as school, hospitals and churches, separated people from family life. Any urban nuclear family received its own specialisations. In order to buy goods and services required for survival, a family had to sell its specialised labour. The number of specialisations increased, and so did the size of towns, in order to

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[a] Bonnekaart(1929)

[b] Jong(2011) Urban ecology scale and identity **IN** Bohemen**,** The Sustainable Built Environment (New York) Springer

[c] Mayntz(1955) *Die moderne Familie* (Stuttgart) Ferdinand Enke Verlag

house a 'sufficient' community of specialists that ensured their survival. A town, then, is a concentration of specialised people that 'sufficiently' provide each other with each other's immediate needs to survive. But, what is 'sufficient' if towns still need to exchange with their immediate or remote environment? Why, then, are villages so different from towns? Specialisation saves time, but it takes space. The larger a settlement becomes, the more self-sufficient it can be. But still, what is 'sufficiently' large.
It may have to do with the proportion of time that is spent for internal and external exchange.

Time management of consumption and production

Until 1800AD, mainly small towns (R=300m) provided their inhabitants with the sufficient specialised products and services that were needed for their immediate survival, within a 7 minutes walk. That still may be your walk to the nearest supermarket, but new technologies of transport and logistics extended your radius that was accessible in the same time. The time you need for consumption, and to collect the products and services you consume, has to be balanced against the time to produce your counterpart in return. The more specialised you are, the more you probably have to travel to produce it, leaving less time for consumption. To save consumption time you reduce the time to collect its requirements. You look at what is available in the immediate neighbourhood, your more remote district~, town~ and conurbation centre R={0.3, 1, 3, 10, 30km}. You visit R=300m several times a day (e.g. to bring and pick up your children), R=1km only once a day (the supermarket), R=3km only weekly (the town centre), R=10km only monthly (the city centre) and only incidentally larger radiuses. The time balance of settlements as a whole, between their time spent for external production and internal consumption, may show something similar. However, what you call the 'consumption' of a settlement, then, should include the internal 'production' and mutual deliveries in the local market. What you call 'consumption' of a family also includes the private 'production' of meals in the kitchen, and any other mutual delivery. The distinction between production and consumption, then, is scale sensitive. Micro-economics and macro-economics, then, are different. Both do not specify the mutual deliveries that are hidden in the consumption figures. However, just the mutual deliveries are crucial to understand how cities, conurbations and regions function. It requires complex input-output analyses of 'Meso-economics' or ecology.

Values of ecology

If the number of species per unit of surface determines the values of the variable 'Ecology', then the human species is one of the many species you may find in an urban environment. However, just as any species has a specialised role in an ecosystem, different people play different roles in a town. If you subdivide the human population of a town into different kinds of people, as if they where different species with their own role and mutual exchange in the system, then you may observe a kind of environmental diversification that is also relevant for physical design. Human ecology is a discipline stemming from the University of Chicago in the first half of the 20th century. It studied the distribution of people with a different age or status (wealth) in towns. For example, Burgess[a] supposed a concentric diversification around a Central Business District (CBD), ranging from a factory zone, a zone of transition, residential zones with working and higher class people, into a zone of commuters in the outskirts. Hoyt[b] supposed industry sectors that radiated from the CBD in the low class residential half of a town, and in the other half, a middle class residential area, and a high class residential sector. It is worth the effort to develop 'Human Ecology' as a variable in that perspective. Michelson[c] distinguished between different types of people based on their choice of dwelling types. Different dwelling types are often bound to different locations in

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[a] Burgess(1927) *The determination of gradients in the growth of the city* (American Sociological Society Publications)21 p 178-84

[b] Hoyt(1939) *The Structure and Growth of Residential Neighbourhoods in American Cities* (Washington) Federal Housing Administration

[c] Michelson(1970) *Man and his urban environment: a sociological approach* (Menlo Park, California) Addison-Wesley Publishing Company, Inc. Philippines

towns, as if they are different species in a landscape. Age and status are usual categories, but Michelson also could derive different 'lifestyles' from dwelling advertisements in journals. He distinguished advertisements appealing to 'careerism', 'familism' or 'consumership'. Careerists prefer fast access to their work, familists like quiet suburbs for their children and consumers like to go out in city centres. Looking at the survival strategies of wild plants, you can find a similar distinction between competitors, stress-tolerators and ruderals[a].

Agriculture$_{3km}$

An agricultural area is often a monoculture that cultivates or breeds one plant species, in order to export them to towns, other regions, and even overseas. The size of specialised farms may range from 1 to 200ha (2km^2). Their fields and pastures look like a patchwork of rectangles in a radius of R=3km (30km^2). Traditionally (until 1950AD), they had a small village as a central place, while six villages in a radius of 10km had a small town as a centre.[b] The Dutch Noordoostpolder has a radius of 10km, and it was clearly planned accordingly. The development of agriculture into larger units and markets by improved technologies can be observed in the next (Flevoland) polders in the South of the Noordoostpolder, which have larger towns. Between fields and settlements, a range of values may be distinguished.

Technology$_{3km}$

The use of energy is an indicator of applied technology. It may diversify the urban environment through the density of energy use. In 1974, I could recognise a Hoytian high class sector in Amsterdam plotting the energy use of families in the city. However, the use of information is also measurable nowadays, but that may unveil differences at a higher level of scale, as the use of twitter does on a map of Europe. But, most important for urbanism is the distinction of roads: residential streets, neigbourhood main roads, district roads, urban highways. In the Netherlands water management diversifies environments in a larger radius, if you plot pumping stations, dikes and polder levels. Industries and their risk zones, sewage systems, (semi-) public water, gas, electricity and information supply may diversify urban environments at this level.

Economy$_{3km}$

Micro-economics concerns e.g. the balance between demand and supply of specific products and services of individual enterprises. If there are national statistics about services available, then you can divide the number of national inhabitants by the number of specific services, in order to determine how many inhabitants you need to support one enterprise. You then may discover e.g. that a town of 100 000 inhabitants could support a hospital, a theatre, three swimming pools and so on. Macro-economics calculates the total earnings of families as Gross National Product (GNP). That should be equal to the total consumption (I), the taxes they pay (T) and the savings they bring to the bank (S). It should also equal the consumption of families (Cf) and government (Cg), the investments (I) of government and enterprises, export (E) and import (-I). It then studies changes in formulas, such as GNP=C+T+S=Cf+Cg+I+E-M, T+S=Cg+I+E-M and S-I=E-M. You may have some insight of these figures for 100 000 inhabitants *on average*, but it neglects intermediate deliveries between companies *within* the national boundaries, useful for urban design. If you take the boundary of a town, or a region, then you could determine these deliveries through Meso-economic input-output tables. They determine the economic requirements for urban

[a] Grime;Hodgson;Hunt(1988) *Comparative Plant Ecology* (London) Unwin Hyman

[b] Christaller(1933) Die zentralen Orte in Süddeutschland: eine ökonomisch-geografische Untersuchung über die Gesetzmässigkeit der Verbreitung und Entwicklung der Siedlungen mit städtischen Funktionen (Jena) G. Fischer

infrastructure, be it roads, cables or pipes, relevant for their mutual location. Much energy could be saved if you would succeed to arrange energy-users in a temperature-cascade. Transporting heat is distance-sensitive. What then may be the values of economy between macro-economic consumption and micro-economic supply, relevant for urban design?

Meeting$_{3km}$

A town is primarily a place of meeting. There are many places for *planned* meetings, such as workplaces, schools and clubhouses. However, *accidental* meetings between people of different background are a broadly accepted source of new ideas, innovation and social cohesion. Alexander thoroughly advocated for the provision of places of accidental meeting at any level of scale.[a] De Hoog calls them ‘interaction environments’, and he describes different types and examples in the Dutch Randstad to be developed.[b] This provision requires a kind of urban diversity that invites you to leave your home, and to avoid loneliness, which is a paradoxical disease of our time. The accessibility for children, disabled, unemployed and old people, then, is crucial.

Culture$_{3km}$

The urban diversity between traditional and experimental environments is probably most apparent in a radius of R=3km. Designers are inclined to choose experimental values, but the increasingly different cultural backgrounds of many inhabitants raises a demand for the identity of urban islands$_{100m}$, neighbourhoods$_{300m}$ and even districts$_{1km}$, in a town$_{3km}$. A mix of different values *within* a radius of R=100m (an urban island or residential street) may not be the best level. Even if mixture at that level is often advocated by public management and government, it may lead to conflicts, rather than to social cohesion. This may separate the culture into other cultures. Giving form to the boundaries between homogeneous areas may be the crucial challenge for design, and the best location for accidental meeting.

Management$_{3km}$

The most obvious appearance of public management is the town hall of a municipality. But many public services, such as the police, the fire brigade, refuse collection, maintenance of public space and so on, should have local access points that are open for feed-back from the responsible politicians. On the other hand, an increasing size of a town may force it to split up a municipality into partial municipalities of a conurbation$_{10km}$.

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[a] Alexander(1977) *A pattern language* (New York) Oxford University Press

[b] Hoog, C.M.d. (2012) De Hollandse Metropool, ontwerpen aan de kwaliteit van interactiemilieus (Bussum) Toth

3.11 Design variables R=10km (3-30km)

	0	
Altitude$_{10km}$	centimetres	kilometres
Geology$_{10km}$	years	millennia
Water Storage$_{10km}$	0	1 500km^3/day
Landscapes$_{10km}$	natural	urban
Land Use$_{10km}$	0	many hr/m^{2}yr
Deliveries$_{10km}$	contribution	distribution
Demography$_{10km}$	homogeneou s	heterogeneou s

Fig. 83 Example 20x20km[a]

Altitude$_{10km}$

Altitude$_{10km}$ is definitely different from Alitude$_{30m}$. That is true for any variable that seemed to repeated having the same name at the beginning of the sections above. But Altitude$_{10km}$, is a good opportunity to refresh that awareness. Even the *values* high$_{10km}$ and low$_{10km}$ have a different meaning from high$_{30m}$ and low$_{30m}$. For example, if a radius of R=10km contains mountains, it becomes obvious that Altitude$_{10km}$ cannot have values, such as bridges and floors, as mentioned as Altitude$_{30m}$ on page 127. However, it is not only the order of size that makes them different. In lowlands, the small differences of altitude$_{10km}$ may be not visible, but they have a great observable effect$_{10km}$. Moreover, it is a design variable that should be manipulated regarding their effects. One of these effects is the natural flow of water. The course of brooks and rivers, and their treelike branched form is an immediate result of local differences of altitude. The local groundwater level determines if you could only breed cattle, or also cultivate crops, and if so, the kind of crops that you can cultivate. If the soil subsides for 5cm/century or even more on peat soils or by gas drilling, then that will have consequences for planning$_{10km}$.

Geology$_{10km}$

Geological differences in a radius of R=10km may clarify differences in historical developments at R=1km, as mentioned (see page 134). In the future, it may influence the costs of foundation, which is its chance of subsidence, to find valuable raw materials or archaeological treasures in the sub-soil. It cannot be designed, but it diversifies locations in a radius of R=10km.

Water Storage$_{10km}$

Climate change may force lowlands to store water from the rivers and the rain in cases of high runoff, heavy showers and slow outlets into the sea. If the runoff of the river Rhine multiplies by 8 once in 50 years, then 16 000m^3 water enters the Netherlands per second. It can fill a 1m deep reservoir of 1km^2 in one minute. Enduring showers of 30mm/day may add some 10 000m^3/second in the lowlands. The largest pumping station in Europe is on the coast in the Netherlands (IJmuiden), and may pump out 260m^3/second into the sea. That is

[a] Atlas van Amsterdam

only 1% of the water that fills the country. If the rivers take care of 10 000m^3/second without flood, then you still need a storage of 1 km^2 per minute in the kind of reservoirs mentioned. That is 1440 km^2 per day, or 5% of the country. This approximate surface size, according to the number of rain days expected, should be planned, in order to avoid floods at a radius of R=10km. On the other hand, water storage is also important for dry regions or periods, even in the Netherlands. Drinking water, then, is less a problem than water for agriculture.

Landscapes$_{10km}$

In a radius of R=10km, the diversity of rural and urban landscapes becomes observable within 20 minutes, an hour or three hours, respectively by car, cycling or walking. From the centre of Amsterdam, you may choose for water in the East, Waterland or harbours in the North, residential areas, parks and dunes in the West, and lakes in the South or heath land and villages on sandy soils in the expensive Gooi area (see *Fig. 83*). The other way around, you can choose to live in different landscapes within a distance of 10km from a city centre. However, not many conurbations or rural areas with a radius of R=10km can offer that choice. That may be a challenge for their planning and design.

Land use$_{10km}$

Little or no land remains unused by people. It is a theoretical zero-point of waste land. How to measure land use beyond that point of no use? Land use is mainly distinguished by functions, such as residential, recreational, traffic and work. But, the *kind* of use is the subject of Chapter 6. Instead of functional differences, you may choose the number of hours every km^2 is visited per year, similar to Intensity$_{1km}$ (see page 135). It may give a much larger figure for residential areas than for any other function. However, is visiting the same as use? You may use coffee plantings all over the world daily in your living room or work place. You then may choose the contribution to the GNP, or the value per km^2, of your legend units.

Deliveries$_{10km}$

In Economy$_{3km}$ on page 140, I mentioned the mutual deliveries between enterprises causing traffic and transport that could be influenced through spatial design (e.g. the idea of cascading on page 140). The delivery of goods and services from producers to consumers (distribution), and the delivery of labour from families to enterprises (commuting), both cause a different kind of transport and traffic. Together they are relevant for the location of different kinds of land use. In a radius of 10km, that could be studied in a more general sense of logistics than a detailed calculation of sources and destinations as usual by traffic engineers. It may come down to determine the flows around nodes as ‘technological-logistical stretches’, at different levels of scale. The efficiency of durable dependencies usually take time. It happens through incidental movements into locations that are more appropriate for inward and outward deliveries. Sometimes it results in concentrations of similar enterprises (Silicon Valley, greenhouse concentrations), stimulating innovation.

Demography$_{10km}$

The structural homogeneity of population, concerning age, status, and lifestyle, require specific lay-outs and facilities. In a map$_{10km}$, differences of employment may become observable, resulting in ‘problem districts’ asking for attention of government, planning and design. Structurally unemployed neighbourhoods and districts may receive more public meeting space, denser public transport facilities, and signs of municipal involvement.

3.12 Design variables R=30km (10-100km)

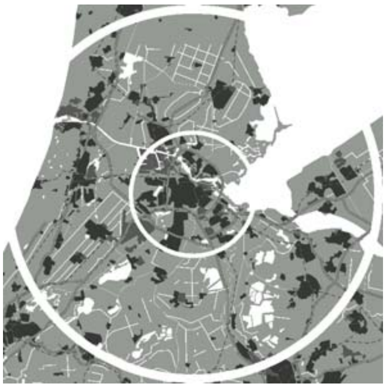

Fig. 84 Example 60x60km

	0	
Geomorphology$_{30km}$	erosion	sedimentation
Nature$_{30km}$	dry	wet
Waterways$_{30km}$	natural	artificial
Networks$_{30km}$	isolation	access
Transfer$_{30km}$	walk	fly
Risks$_{30km}$	nuisance	floods

Geomorphology$_{30km}$

The surface of the Earth between the lithosphere and atmosphere, between the mountains and coasts, shows its diversity clearly anywhere, even in a radius of R=30km. It is based on geological processes in the sub-soil, but it is finally shaped by sun, wind, water, vegetation, animals and man, resulting in erosion and sedimentation. Both may contain physical, chemical, biological and artificial processes. Subsiding lowlands are shaped by sedimentation. But the sedimentation has stopped, since winding rivers have been captured within dikes. Rivers and brooks cannot change their course anymore by flood the lands to disperse their deposits of sand and (where the water slowed down) clay. The locally raised land, then, forced the water to take another course, which in the end covered the lowest lands everywhere.

Centuries of vegetation filled the lowland with peat. But, man removed the vegetation, burned the peat and drained the land with straight ditches, at regular distances. Then, when water was pumped out, the land subsided even further. And, it still does. It then may unveil some former sandy courses of brooks that, through little differences of altitude, colour the vegetation differently, when viewed from the air. But mainly, the land equalised physically, chemically and biologically by its human inhabitants, in order to maximize their yields. However, centuries of bursting dikes, floods, and excavations left its tracks, moors, ponds and lakes. Locally, the land was artificially raised for terps, dikes or for building purposes, digging ground elsewhere. The result of these forces is a great diversity of water at the surface, or in the sub-soils. It resulted in a diversity of soils and wet vegetation. On the higher grounds, the course of the eroding rivers have been more stable, but in their worn out valleys, they may show a local diversity that are similar to lowlands.

Nature$_{30km}$

Differences in altitude, groundwater levels and soils condition the potential of different kinds of nature still allowed by (or useless for) human land use. Their sequence along, and perpendicular to the coast or rivers, condition many values of nature from brackish to fresh, from dry to wet, from sand to clay, from acid to alkaline, dynamic to quiet and so on. Planning and design may utilise these variables to extend their legends with intermediate values, and their infinite number of combinations.

Waterways$_{30km}$

Concave and consequently steep banks of rivers have offered historical opportunities for settlements everywhere. Their quays, small or large harbours are their gates to fishing grounds, regional or worldwide trade. However, to become a central place for trade, they required a bearing land surface with a radius, apparently until now, stabilizing at R=30km. The inland distance from the coast into Rotterdam and Amsterdam is approximately 30km, and the boundaries of their regions meet each other in between, at the same distance on the banks of the Old Rhine (see *Fig. 84*). The dams giving them their names dammed the smaller rivers Rotte and Amstel, which drained vast peat areas at both sides of the Old Rhine between the older towns of Utrecht and Leiden.
However, nearly everywhere in a radius of R=30m, you will find at least one river or main road that is fed by brooks or side roads from higher or inland areas.

A historical bridge or dam served the natural road along the larger waterway, where a town found sufficient bearing surface to develop into a central place. The same structure gets at any time or place a different form, but their crucial bridge or dam is often neglected and forgotten as the historical origin. They are outdone by the modern steel bridges that are able to cross the larger waterway as focal points in a larger regional system of highways and railways. The system of villages, towns and conurbations along waterways may show a regular sequence, but perpendicular to them, you may find a similar sequence making a difference between inland towns and villages, and those with access to the main waterways. Nowadays, the identity of towns is a crucial part of their city marketing. The differences given by nature may be a durable starting point for local identity: difference from the rest and continuity in itself.
Apart from the traditional sequence of settlements with quays and harbours, the remaining quiet banks of rivers have been covered by separate inland terminals for industry or trade, and by parallel and crossing roads. But, the in between values are part of the regional planning and design legends.

Networks$_{30km}$

A grid of highways or railways has different mesh-widths. At approximately every {3, 10, 30, 100, 300}km, there may be urban (every 3km), conurbational (every 10km), regional (every 30km), national (every 100km) and even continental (every 300km) highways with different design speeds and exit distances. If you leave one of the orders out, then local traffic will use roads of a higher order and speed than necessary. That requires more exits than necessary, and it may cause traffic jams.
Each order has its own network density. For example, if a regional highway network has meshes of (at average) 30kmx30km, then half of the roads (shared with the adjacent meshes) or 60km road length divided by the covered surface of 900km^2 , produces a network density of 0.07km/km^2. But, a different length/width proportion of meshes may produce the same density. Elongated meshes produce less crossings than square ones. A density of 0.07km/km^2 even may be produced by parallel roads without any crossing. Then, they have got their minimal mutual distance of 15km at that network density of 0.07km/km^2. The network density represents an amount of investment required.
These dry networks are superimposed on the older wet network of waterways. The combined meshes isolate the in between areas. Wet and dry networks may have a different form (grid or tree), but they have a surprisingly similar hierarchy and density per order. Wet and dry networks interfere with different mesh-widths, requiring a different number of crossings, bridges and tunnels. Elongated meshes require less viaducts, bridges and tunnels. That law is often forgotten in their mutual planning. Some of their crossings become transfer points from one mode of traffic to another, within walking distance.

Transfer$_{30km}$

The transfer from slow to fast traffic, from private car to public transport, from road transport to boats, from any wet or dry transport into aeroplanes require space and time consuming facilities, such as airports, railway stations, highway exits and so on. They nearly always need vast parking space, walking and waiting areas, offices and constructions. Waiting areas offer opportunities for shops and other public services. Transfer points, such as airports and railway stations, determine and diversify regional environments

Risks$_{30km}$

Regional risks range from earthquakes and floods to noise nuisance (a financial risk if it decreases the value of your property). You may draw contours around the sources ('outward zoning') or the vulnerable areas ('inward zoning'). Such contours limit the possibilities of future land use. The risk of disasters, such as earthquakes and floods, is calculated ranking the magnitude of earlier occurrences. For example, if magnitude 1 has occurred I time every year, 2 times every 10 year and 3 times every 100 year, then you may expect that maginitude 4 will occur every 1000 year. Such expectations are drawn in a so called 'Gumble graph', with the recurrence time 1, 10, 100, 1000 years on the x-axis and the magnitude 1, 2, 3, 4 on the y-axis. If you want to avoid these risks, then you have to pay according to their magnitude.
For example, if you want to avoid moderate floods every year, then you have to raise the dikes less than if you want to avoid a serious flood once in the 1000 years. The decision to determine if it is worth the effort to avoid floods, depends upon the costs of their damage d, and the costs to avoid them a. If d>a, then you may take according measures. However, both may increase with a larger magnitude that occurs less often. The damage you may expect once in the 10 000 years may be very large, but to avoid it now may cost even more. You then may accept a flood once in 1000 years. The Dutch Parliament once accepted serious floods once in 1250 years. Moreover, the expected damage may be different in different parts of the region. You may accept a flood once in the 100 years on agricultural lands, once in 1000 years in urban areas and once in 10 000 years at a nuclear power plant.

3.13 Design variables R=100km (30-300km)

Fig. 85 Example 200x200km

	0	
Altitude$_{100km}$	lowland	highland
Soil$_{100km}$	clay	rock
Vegetation$_{100km}$	wet	dry
Technology$_{100km}$	drainage	irrigation
Resources$_{100km}$	internal	external
Market$_{100km}$	local	international
Task Division$_{100km}$	agriculture	services

Altitude$_{100km}$

What is called high and low in a radius of R=100km has a different meaning and different effects from those in a radius of R=30m and R=10km. Lowland regions, compared to highlands, do have a different soil and vegetation. On average, they use different techniques and resources, resulting in a different task division, market, culture and so on. The Altitude$_{100km}$ differences do not *cause* these differences, they *condition* them through their location or distance to the coast. They cannot be changed through design, but they do condition the possibilities of planning and design. The lay-out of towns in the lowlands, with their canals, is different from towns at higher altitudes. The example of *Fig. 85* may seem rare, but mountainous areas do have their own relative 'lowlands' too. The cross section of the Alps is approximately 100km. Any time an inhabitant of flat lands chooses for holidays in the mountains, (s)he chooses for this kind of environmental diversification. And, that is a different kind of environmental difference than the difference between mountains and valleys that you may experience at your destination in a radius of R=10km.

Soil$_{100km}$

Average compositions of soil in a radius of R=100km diversify environments of R=30km, definitely in a different way compared to the differences mentioned in Soil$_{300m}$ on page 132. The nature differs, the roads are bordered by different trees, the agricultural land use differs, the different kinds of gardens and public green in towns are different. Design may cause local deviations from these general gradients of a larger scale. For example, many extensions of cities in the lowlands on peat and clay sub-soils are raised with sand as anomalies in the natural landscape. But, the value of diversity$_{100km}$ is increasingly recognised as a matter of identity$_{100m}$, and brought back in the detailing of their lay-outs.

Vegetation$_{100km}$

Landscape, park and garden architecture designers may choose trees and plantation more from a viewpoint of composition than ecology. But, the natural vegetation, and its accompanying populations of insects, birds and other fauna, may change substantially over a distance of 100km. The different ecological possibilities for design between lowlands and higher grounds may be overlooked, if they do not get a recognizable proper and more common name. However, the possibility of choice decreases, since we have already lost some 100 000 species. Our population required their space and resources.

Technology$_{100km}$
The majority of windmills is still found in lowlands near the coast. In the higher parts, they are less dispersed and grouped. In the lowlands, you may find pumping stations to regulate water levels everywhere. At the higher grounds, irrigation appears a more urgent problem. But, environments in a radius of R=100m still may differ most by their isolation and access to highways. At this scale, you still may distinguish the rare silent areas where you can experience full darkness at night. Aerial night photographs most clearly show the differences in illumination.
However, the development of technology has increased the dispersion of people, in order to realise nearly anything, anywhere. People and buildings have become more independent from their physical context. The social boundary conditions of economy, culture and management have become more important. Costs, fashions and initiatives determine the environmental diversity in a radius of R=100km, more than physical constraints. But that may change.

Resources$_{100km}$
A doubled world population will half the average surface per person in 40 years. Your resources will be a quarter of those of your parents, if their use per person is also doubled. If that continues, then those of your children will be a quarter of yours. The development of technology may have compensated for these kinds of decreasing possibilities up until now. But, if the free exchange of scarce resources begins to stagnate through local protection, then different technologies will diversify local environments again. One region will want to keep its gas, the other its coal. If China and Morocco want to keep their remaining phosphates for themselves, then agriculture will change dramatically everywhere else. If states begin to protect their rare earth elements, then regions will have to exploit their own possibilities, resources and technologies more intensively. But, one resource remains for everybody, be it differently available according to your distance to the Equator: solar energy. Any material can be recycled, if you have enough energy. Recycling, then, is a crucial regional industry that will be increasingly dependent on the local availability of energy.

Market$_{100km}$
Companies diversify the price of their products according to different local markets. These markets differ by many physical and social factors. Their differences may increase if they begin to protect their own resources, and consequently, if they have to pay more for those of other regions. Their internal and external market, then, will become even more different from other regions, according to their increasingly selective imports and exports. That will change their possibilities and environment. That environmental diversification may become increasingly observable, even at a radius of R=100km.

Task Division$_{100km}$
Regions recently may have become increasingly dependent on the global market. But, the symptom of an economic crisis every 40 years may be connected to a symptom of local protection and appointments with neighbour regions. Physical differences in a radius of R=100m may result in a task division that is increasingly observable in the differences of living environments.

3.14 Design variables R=300km (100 – 1000km)

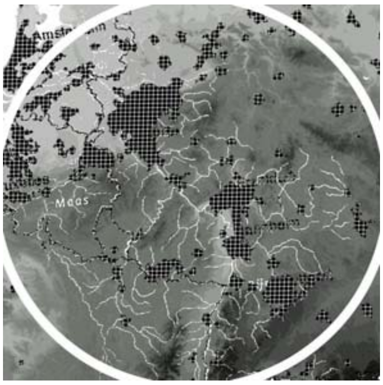

Fig. 86 Example 600x600m

	0	
Catchment Area$_{300km}$	mountainous	delta
Climate$_{300km}$	cold	warm
Economic Power$_{300km}$	dominant	serving
Economic Employment$_{300km}$	0%	100%
Legislation$_{300km}$	free	strict

Catchment$_{300km}$

The catchment area of a river mainly covers a radius of R=300km, ranging from inland areas to coastal deltas. It supposes a variation of altitude, it conditions many other variables, and it diversifies environments. Local climate varies with altitude. The population density and hierarchy of settlements followed the hierarchy of water courses for a long period of history. The Industrial Revolution, with its network of roads and rails, has disturbed that original order substantially. But, the historic layer is still observable. Particularly where resources in the sub-soil crossed the course of the main river, such as in the Ruhrgebiet, a substantial inland industrial power could develop. The lower reaches of the river into the coast, then, may have produced a different economy around its harbours.

Climate$_{300km}$

A radius of R=300km shows substantial differences in average climate. It conditions differences of agriculture, different ways of building (combined with different local building materials), public life and the composition of economic activities.

Economic Power$_{300km}$

If you compare Gross Regional Products in a radius of R=300m, then you may observe differences in economic power, differences in the availability of products and services, and accordingly, different environments.

Employment$_{300km}$

Already in a radius of R=100km, you may observe differences in employment, resulting in a different culture and political preference, with more or less public facilities.

Legislation$_{300km}$

Crossing governmental boundaries, you may experience differences in the environment that are related to (the historic development of) legislative rules.

3.15 Added diversities of form, structure and function

The combinatoric explosion of form

Two drawings with the same legend still may differ through the dispersion of their legend units in space, their lay-out, and their form. The number of different drawings you can make with the same legend depends upon the resolution of the drawing. For example, if your drawing has two locations, each to be filled by either red or green, then you can make four drawings (see *Fig. 87*, first scheme). If you have three locations to fill, then you can make 8 drawings (second scheme). With four pixels, you can make 16 pictures (third scheme). With 400 pixels filled by only two colours, you can make 10^{120} pictures, which is as many as there are atoms in the universe! A simple Windows icon with 256x256=65536 pixels and a palette of 33 colours, however, even has inconceivably more possibilities.

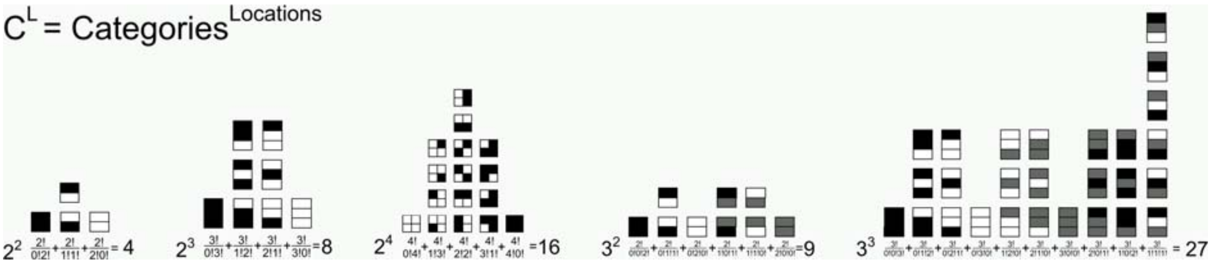

Fig. 87 Combinatoric explosion of possible forms with two or three legend units

If you fill two locations with *three* colours, then you can make 9 pictures; with three locations, you then can make 27 pictures (see *Fig. 87* the last two schemes). The combinatoric formula for the number of pictures you can make, then, appears to be $colours^{locations}$. The number of Windows icons you possibly can make, then, should be 33^{65536}. Most of them will produce a mess. Only some of them make sense, but even *their* number is still inconceivable.

#Possibilities[a] of a given proportion

In design practice, there may be a programme of required surfaces. For example, *Fig. 87* (third scheme) shows all the possibilities that can fill 4 locations with red or green. If red represents 'built-up area', then the programme could be 2 red, 2 rest. The number of design possibilities, then, is 4 x 3 x 2 x 1 / (2 x 1) x (2 x 1) = 6, or in mathematical notation: 4!/2!2![b].

> The division of two categories is called 'binominal distribution', with a general formula #possibilities = #locations! / #filled!(#locations – #filled)! Or P = L! / F!(L – F)!.
> That 'Binomium of Newton' is used in statistics to calculate the probability of any proportion. The more locations there are, the more the third scheme of *Fig. 87* will look like a probability curve.
> This proves that two legend units always offer the most design possibilities, if they are 50/50% available. If you can choose a programme yourself, then choose an equal proportion of the categories, in order to get the highest freedom of design possibilities!

The last scheme of *Fig. 87* shows all the possibilities that can fill *three* locations by red, green or blue. You could call that a 'trinominal distribution'. If you want to use all 3 colours at 3 locations, then there are 3!/1!1!1!=6 design possibilities (the last column of the last scheme).

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[a] The sign # means 'the number of'.

[b] An expression 4x3x2x1 is usually called 'four faculty' and written as 4!. 'Zero faculty' is supposed to be one: 0!=1.

The many values that may take form

Fig. 74 showed 136 variables that could get a different meaning, at 6 different levels of scale, on average. That produced approximately 816 variables for environmental diversification. If any variable has on average 3 values that can be used as legend units in a drawing, then at one of the 12 levels of scale, there are on average some 816/12=68 legend units available at every level of scale. This is one of the ‘palettes’ that can be used to diversify the human environment through design. But, every legend unit may fill numerous locations. Suppose that you were asked to fill every square metre of land on Earth, with the 30 legend units of *Fig. 74* available for R=1m. Your freedom of design to make a picture of the approximately 150 000 000km^2 ,then, would be $30^{150\,000\,000\,000\,000}$ possibilities. Only one of these possible worlds is the present one (if 30 variables would be sufficient to describe its actual diversity). The possibilities for change, then, may be substantially reduced by the actual lay-out, and the time to realize your plan.

Values of different scale superimposed

Such an assignment is not very probable. But, suppose you get an assignment to design a neighbourhood of 30ha (R=300m with 72 legend units). Then, you still would have to choose from 72^{10} possibilities to make a rough sketch, which distinguishes 10 ensembles. In order to divide the ensembles of 3ha (R=100m with 51 legend units) further into 10 different building groups each, you would still have to choose 10 times from some 51^{10} possibilities, in order to distinguish 100 building groups. The legend units at R=300m, then, are superimposed on those of R=100m. Ten building groups *share* the characteristics of one of the ensembles of the neighbourhood.

Overlays

But, also at the same level of scale, a location may share values of *different* variables. You then may make separate overlays, with each variable as a legend for the same area, in order to generate different insights from different variables. For example, if you make one map of a neighbourhood indicate the colours of its surfaces, and another indicating the hours of shadow in the summer, then their combination is what the inhabitants on average will experience visually. If there are more variables, the combined effect may make a combined map with legend units, such as ‘red in the sun with low density’, ‘red in the shadow with high density’, ‘green in the sun with low density’, and so on.

The more values of different variables you combine at each location, the less accessible your legend will be for a systematic empirical evaluation that relates variables with ranked values through multi-criteria analysis. They become less comparable to other examples, because their difference may be caused by more variables than those chosen for comparison.

Combined and separate values

The 253 ‘Patterns’ of Christopher Alexander[a] can be interpreted as local designs, where many different variables are present and combined with one value each.

Alexander’s ‘Pattern language’ ,then, suggests a legend with these Patterns[b] as legend units for drawings at a larger scale. The legend is the vocabulary of a drawing. It allows a designer to tell many stories in different directions. The same legend unit then appears as the same word in different sentences. *Fig. 88* shows an estimation of the radius R where these Patterns are applicable.

Fig. 89 shows the number of the extreme +1 values of *Fig. 74* for every R. The added value ‘+1’ is 1 supposed intermediate value between the extremes.

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[a] Alexander(1977) *A pattern language* (New York) Oxford University Press

[b] The concept of ‘Pattern’ is written here with a capital. In this text the term ‘pattern’ without capital will be used in a different sense as intended by Alexander.

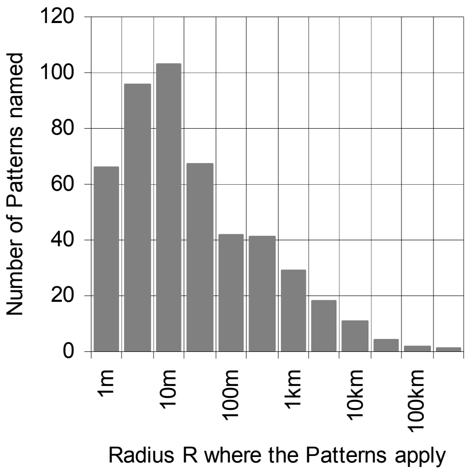

Fig. 88 The number of Alexander's Patterns per radius R

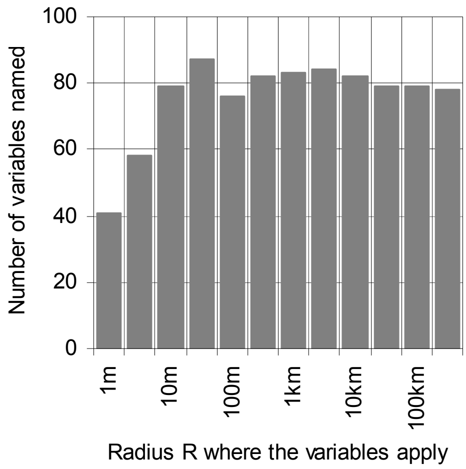

Fig. 89 The number of values per radius R

If any variable of *Fig. 74* would provide 3 values, then *Fig. 89* shows the number of values that could be applied within any radius R. For example, in *Fig. 74* the column R=1m represents the 11 variables already identified in *Fig. 75*. In *Fig. 89* , they are multiplied by 3, supposing any two extremes to enclose one intermediate value, thus arriving at 33 values.

More values to be explored

Alexander's Patterns indicate that there may be more relevant variables than identified in the previous sections. And, any design may produce new variables and values. For example, Alexander often refers to public meeting opportunities in residential areas that can be afforded through design. They are not mentioned at the variable 'Meeting' of *Fig. 74* That variable starts at R=3km, where 'Meeting_{3km}' has got the extreme values 'home' and 'work'. Alexander's Patterns, then, could be analysed further into named values and added to the list of *Fig. 74*, as Meeting_{10m}, Meeting_{30m} , and so on. It demonstrates once more, that the 80 variables, and their values that were identified in the previous sections, are not complete. And, they are not intended to be complete. They are intended to show how the 'palette' of a designer, the legend of a design, and the 'content' of environmental diversity, can be described by values of environmental variables. The list is large enough to become aware of their extensiveness, the number of their possible combinations in a legend, their impact on the (even larger number of) alternatives to disperse them in space, and the alternatives of form.

Relations between values

Based on that awareness, the next issue, then, is the relation of shared or adjacent values. Shared values at one location can produce synergy, as supposed in Alexander's Patterns, or they may hamper each other, forcing a separation. The same may occur if values appear as legend units that are accidentally dispersed in a drawing. They can meet each other at the boundary of two locations in many ways, as demonstrated in *Fig. 87*. To avoid nuisance both ways, and to stimulate synergy, their mutual relations can be studied. But, if there are 1000 values (see *Fig. 89*), then there are 1 000 000 relations possible to be studied.
It is self-evident that empirical research restricts itself to categories of values that can be ranked in a variable, as physics did with such impressive results for mass, space and time. *Fig. 74* names 136 categories of variables, each of which have an individual meaning, on average, at 6 levels of scale. Between these about 816 variables, approximately 600 000 relations are possible. That is a substantial reduction by 10, compared to the 6 000 000 relations between their values, if they would have 3 values each.

Reductions by ranking values

Empirical research then prefers quantification, but this still neglects many factors that designers have to include. Moreover, the ordinal ranking in variables relates only to specific pairs of values, such as x_1 to y_1, y_2 to y_2, x_3 to y_3 and so on. But, in a drawing, x_1 may meet x_2, x_3, y_1, y_2, y_3 and so on. The problem is well known in environmental zoning strategies. It is then solved through prescribed distances between different kinds of industries and residential areas, based on different kinds of nuisances, such as noise, odour or risk. But that is a limited xy-matrix of values, and it changes through developments in mitigating technologies. Design may introduce nuisance-mitigating separations, such as noise-barriers, that may reduce the necessary distance. On the other hand, it may introduce *connections*, in order to stimulate synergy.
It is worth the effort, however, to first explore the problems by studying the relations between ranked variables and non-numerical values . That will clarify the 'wicked' problems of naming variables and their values, in order to identify a relation that can be studied.

Relations between variables

There may be a positive relation between variables such as $Access_{1km}$ and $Noise_{1km}$ (the more access, the more noise). However, you can make a noise-barrier along access roads if that relation is undesired. That possibility changes the original probability by adding a *separation*. The prediction of noise, then is a 'self-destroying prophecy'. If there is a probable negative relation between $Access_{30m}$ and $Altitude_{30m}$ (the more floors, the less accessible), then you can make an elevator that changes that probability through a new *connection*. Connections and separations (structure) may change the primary probability.
It may be useful to separate these technological possibilities from 'primary probabilities' first. Many of the 600 000 relations may not be relevant. But, you could check them systematically in a matrix to determine if adjacent legend units in your design need additional structures, in order to reduce undesired relations, or to improve desired ones, instead of their primary probability.

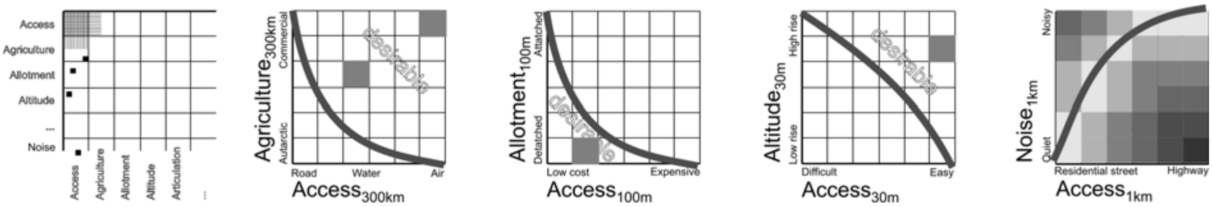

Fig. 90 Primarily probable relations between variables in a field of possibilities

The first scheme of *Fig. 90* shows the first variables of such a matrix based on *Fig. 74*
The spots drawn in the matrix are tentatively elaborated in the next schemes.
Their location in the cells give an impression of the levels of scale that are involved, from the smallest left-above to the largest right-below, in each cell.
The investigator still is free to choose the relevant scale, the relevant values, and their mutual dependency, as a hypothesis for research.

Determining relevant and operational values

The relation between the first two general categories of *Fig. 74* (Access and Agriculture) already raises these questions of choice about their possible relations:

- at which levels of scale will such a relation be relevant and operational?
- which values, then, are relevant and operational for a relation at each level of scale?
- is one of the variables (y) dependent from the other one (x), or the other way round?

The second scheme of *Fig. 90* suggests an operational relation in a radius of R=300km.
At that level of scale, $Access_{300km}$ may have a meaning for Agriculture, if you distinguish e.g.

values of Access by road, water or through the air. Which values, then, should Agriculture$_{300km}$ get, in order to suspect a relation with that interpretation of Access? I chose here autarkic (self-sufficient) and commercial agriculture as extreme values. Between these variables, there may be a relation: roads$_{300km}$ open up a market for commercial production. But, is that also the case for access by waterways$_{300km}$? Slow transport$_{300km}$ is not very appropriate for perishable products, and most of the agricultural products are perishable. However, if there are harbours$_{100km}$ and ships with cooling installations, then there may be a relation between waterways and an agricultural area, at a radius of 300km. But *without* such technical suppositions, a positive relation is less probable. Even more technical suppositions are required to find a positive relation between agriculture and air transport$_{300km}$. For example, there should be greenhouses, in order to produce light-weight agricultural products with high value, and an airport$_{100km}$. The usual mass of agricultural products by itself is not very appropriate for transport by air. The primary probability (curve in the second scheme of *Fig. 90*) ,then, is negative, if you do not suppose additional technical facilities and services. Additional techniques are shown as grey cells that are beyond the primary probability in the matrix of technical possibilities (the other cells). That matrix, then, is a search-field for design.

A search-field for design

If more access for commercial agriculture is desired, then the search-field for technical solutions is at the right side of the primary probability line in the second scheme of *Fig. 90*. The third scheme represents a hypothesis that detached buildings$_{100m}$ have a more expensive access$_{100m}$ than attached ones. They require more length of roads, cables, pipes, maintenance and travel time than attached buildings. There, the search-field for technical solutions is at the left side of the primary probability. The design challenge is then, to decrease the costs of access for detached buildings (the grey cell). The fourth scheme supposes less access$_{30m}$ for high rise buildings$_{30m}$, with a technical solution space again at the righ side, e.g. an elevator. The last scheme supposes a positive relation (not in the sense of desirability) between Access and Noise, with a solution space at the right side, e.g. a noise-barrier. In that scheme, shades of grey deviate from the primary probability. The shades of grey may represent the effort required for technical solutions.

Ranked values as a gradient

Some environments already show values in a ranked order, or they can be designed that way. For example, noise, light or heat may decrease with the distance to their source. The altitude of buildings may gradually increase towards the centre of a town, and slopes gradually differ from high and dry into low and wet. But, *designing* gradients seems to be unusual and difficult, since any intermediate value requires its own design effort. Contrast or repetition requires less effort. Sharp boundaries are easily drawn. Properties, then, are clearly divided. Gradual transitions between environments make calculated surface programmes uncertain. However, slow transitions of soil, moistness and altitude may have great ecological advantages. They offer many more species a chance for survival, than two homogeneous environments that are divided by a sharp boundary. Gradual transitions in residential and recreational areas offer more freedom of choice for people with different preferences. The experimental design of gradients may produce more intermediate values with unexpected possibilities. A gradually altering *form* (the altering dispersion and boundaries of one value or legend unit in space) introduces another possibility of gradation that is not easy to design. They will be elaborated in Chapter 4.

Non-ranked values
Empirical research may once have found 665 000 primary relations between values ranked in 816 variables, but then there are still ample 5 000 000 values left that occasionally can be designed next to each other, in a drawing that does not obey any pair-wise ranking. A value x_1 may meet x_2, x_3, y_1, y_2, y_3 and so on, in your drawing. Their relation cannot easily be studied, if there are no other existing examples to compare. They then create a unique situation, as one of the six million possibilities. Their effect cannot be predicted without enough existing examples. It has to be estimated by designerly intuition, or neglected.

Structural diversity
'Structure' is defined here as the way parts are separated and connected into a whole. If these separations and connections concern only a visual (or otherwise sensory) impression, then I would name it 'composition'. 'Structure' then is further restricted to the set of physical separations and connections that prevent or allow movement or change. In that sense, it may change the 'primary probabilities' , as distinguished before. Columns prevent floors from falling down, walls prevent the movement of air, and ventilation systems cause them. The human environment contains a great diversity of those kinds of technical connections and separations, thus preventing undesirable primary probabilities. These issues are the subject of Chapter 5. These structures make many functions in human life *possible*.

Functional diversity
Different human functions, such as living, working, recreation, and travelling, are dispersed over different environments. These environments are specialised and structured to serve these particular functions. But, some structures make many functions possible, and some functions may perform in many environments. 'Function' is an ambiguous term, even if it is defined here as 'working for people' , as it is elaborated further in Chapters 6 .

Intentional diversity
Human intentions are diverse. There are individual and collective intentions, vague intentions, multiple intentions, and intentions that are clearly formulated in their aims. Environments with the same content, form, structure and function still may differ by intentions and plans for change. These plans may have an impact on actual use and maintenance. That diversity is elaborated in Chapter 7,

Sequences of design
The orders of content, form, structure, function and intention may suppose each other in this sequence (see *Fig. 72*), but this does not determine the sequence a designer has to follow. The sequence of design is fundamentally free. Form may follow function, or the reverse, but the possibilities of form are practically infinite. This is probably why many designers start thinking about form with only a vague idea about intentions and functions. It gives them the greatest freedom to develop new ideas about the intentions, the intended functions, the possible structures, and their contents. Structuralists may start thinking about parts that add new parts to a whole, or the reverse. Functionalists may start closer to the client, by first studying their program of requirements. Contextualists may first start to study the location, its existing content and potentials. The client, the policy maker or the real estate manager may start to formulate intentions. But, not only the starting point is free. Any next step is free, too. Any sequence is free. However, at any stage, there are hidden suppositions about the other orders. All of them have to be clarified, once the design has to be realised. There, they have a *conditional* sequence (not a *causal* one). The building materials should be available, in order to generate a shape, by being properly assembled into a structure, before they can perform the functions that may serve the many possible intentions of the users. This is the sequence that was chosen for the chapters of this thesis.