

ADAPTIVE CAPACITY OF BUILDINGS

A determination method to promote flexible and sustainable construction

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Abstract

The subject adaptive construction is already for decades on the agenda of the construction sector. The adaptive capacity of a building includes all properties and qualities that enable the building keeping its (economic feasible) functionality during the technical life cycle, under altered conditions and needs.

Meanwhile, the interest in flexible building has increased significantly from a broader perspective than before. This increased interest is caused by the high structural vacancy of buildings, the economic crises and the increased awareness of and interest in sustainability issues and circular economy.

The relationship between flexibility and sustainability is explicitly laid. Market developments demonstrate an increased demand for flexibility and sustainability as well as a growing awareness of the necessity of a circular economy in construction. This explicit sustainability constraint ensures a consciously look towards the sustainable efficiency of flexibility measures. These measures are sustainable only if they are actually used during the life cycle of buildings.

The Dutch Government, a number of companies and branches of the construction industry started a public-private initiative in 2012 to promote and accelerate sustainable building in the Netherlands with the project called: a method to determine the Adaptive Capacity of Buildings. The cause of the present research is the lack of a widely accepted method with assessment criteria for measuring the potential for adaptation into other possible functions during the life cycle of a building. In this research paper a full report is given of the development of this method to determine the Adaptive Capacity of Buildings (the AC Method), the research methods used and the preliminary results.

Keywords: Adaptable, Sustainable, Flexible, Vacancy, Assessment Method

INTRODUCTION

Adaptive building and sustainability

In recent decades the interest in flexible building, also called adaptive building, has grown substantially. In the Netherlands this interest is mainly caused by the structural vacancy of real estate, in particular office buildings, the economic crisis, the congestion of the housing market and the increased awareness of and interest in sustainability. A direct connection can be made between adaptive building and sustainability (Wilkinson, James et al. 2009, Wilkinson and Remøy 2011). Market developments show increased demands by for flexibility and sustainability by users and owners as well as a growing understanding of the importance of a circular economy (Eichholtz, Kok et al. 2008). This explicit motive for sustainability by clients results in sharper requirements for sustainable profitability of measures that can be taken for adaptive building. Assessment criteria for adaptability were

described in previous research (Geraedts and Van der Voordt 2007, Remøy and Van der Voordt 2007, Wilkinson, James et al. 2009, DGBC 2013). However, a comprehensive method for assessing the adaptive capacity of buildings is lacking. Most assessment tools that were previously developed focus on specific aspects of adaptability, like technical or functional aspects, or the adaptability of a specific kind of building. The aim of this research is to develop a method for assessing the adaptive capacity of buildings including technical, functional, economic and societal aspects.

Definition of Adaptive Capacity

The adaptive capacity of a building includes all characteristics that enable it to keep its functionality during the technical life cycle in a sustainable and economic profitable way withstanding changing requirements and circumstances. The adaptive capacity is considered a crucial component when scrutinizing the sustainability of the real estate stock ((Hermans 2013), p.3).

Sustainability depending of the long-term utility value of buildings

A building that can accommodate different types of users during its whole life cycle has a long-term utility value. The long-term utility value is a crucial precondition for sustainability. The adaptive capacity of a building represents this utility value, the future attractiveness of the building. The adaptive capacity is not the goal itself, but the means to ensure the future use of the building.

Societal perspective

To consider the adaptive capacity of a building the main focus is its future value. From this perspective not only the present user or owner of the building is important, but also to a large extent the attractive force of the building for next generations of users. The societal benefit of the future use of buildings forms the higher goal of this research project. To secure future use, the current users and owners need to be involved.

Accountability and research methods

This research aims at developing a determination method for the adaptive capacity of buildings (AC method), and is as such the first step in the development of instruments to assess specific projects. The AC method gives a clear insight and an overview of aspects that need to be concerned when assessing the adaptive capacity of buildings. The method combines existing knowledge (Berg 1981, Houtsma 1982, Geraedts 1989, REN 1992, Geraedts 1998, Geraedts 2001, Geraedts 2007, Schneider 2007, Beadle 2008, Geraedts 2009, Wilkinson 2009, DGBC 2013) on flexibility and sustainability into one overview of important aspects to determine the adaptive capacity.

The AC method has been developed after an extended survey of international literature about characteristics, definitions and assessment instruments of adaptive building, on the boundaries of adaptive capacity, sustainability and financial business cases for real estate. The literature survey has resulted in a number of basis schemes presenting relevant aspects and mutual relations of adaptability characteristics and instruments. The most important schemes are presented in this paper. Next to the literature survey a substantial number of experts has been interviewed. The basic schemes shaped the input for discussions in two different expert panels: one with representatives of the clients (demand side) and one panel with representatives of construction companies and suppliers (supply side) in the construction process. The results from several discussions with both expert panels produced input for the AC method ((Hermans 2013) p.4).

Target groups

The AC method for measuring the adaptive capacity of buildings offers possibilities for owners or investors in real estate to formulate wishes or demands about the adaptive capacity of buildings on the one hand, and assess the adaptive capacity of new or existing buildings on the other hand. Owners or investors usually are the actors involved in expressing the ambitions of the projects and they are responsible for choices made during the construction and utilization phase of the buildings. Depending on the nature and the stage of the project they can take more or less fundamental decisions about the adaptive capacity of the project. This method can be used for three different investment decisions: purchasing an existing building, constructing a new building, or renovating and transforming an existing building.

Aim of the method

The AC method offers building clients and investors a step-by-step procedure for:

- Formulating the demand for the adaptive capacity of a building,
- The assessment of the supplied adaptive capacity of offered solutions (in design or in a building),
- The evaluation of the financial and sustainability impact of these solutions,
- The determination of the most sustainable and efficient business case when dealing with adaptability.

The AC method therefore consists of three different modules:

1. The determination of the adaptive capacity; formulating the demand for or assessing the supply of flexibility.
2. The determination of the financial-economic profitability.
3. The determination of the sustainability impact of the several measures.

In this paper only the first module will be described: the adaptive capacity of buildings. This method does not yet lead to absolute statements about "the" adaptive capacity, but a definite judgement if a specific offered design or building fits a given demand for flexibility.

The method to determine the adaptive capacity will be equal for each project, while the assessment criteria could be project or client specific. In this manner new techniques and understandings can be easily processed in the near future.

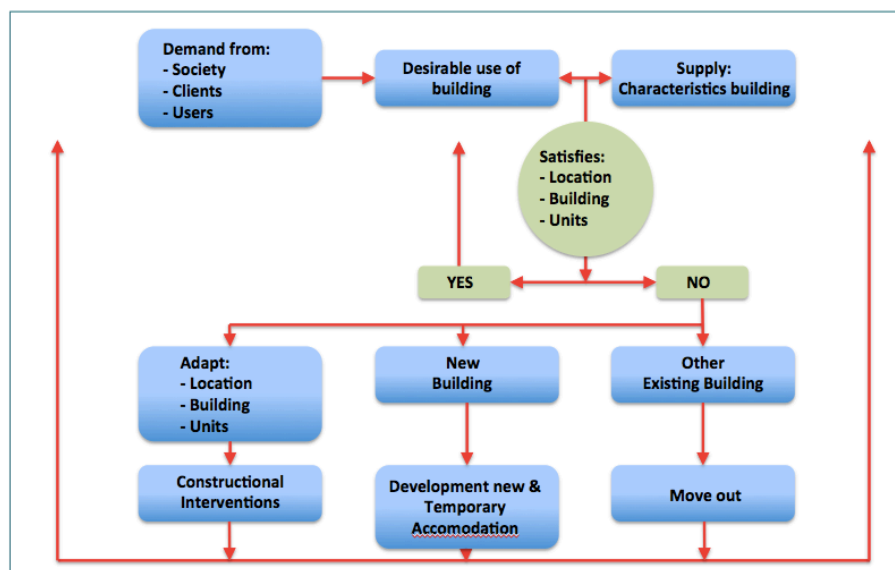


Figure 1: the accommodation cycle of real estate and the demand for change

ADAPTIVE CAPACITY METHOD

When a building no longer meets the changing demand

Real estate is a product with a high economic value and can be characterized by a very long technical life cycle with a large spatial-physical impact. That is why it is of great societal importance to use real estate as efficient as possible. To enable a high-quality use and a high occupancy rate, a building must be able to move along with qualitative and quantitative changes in demands for the specific accommodation. There are three basic ways to act when a building no longer meets the users needs (see figure 1).

1. Adapt the location, building and/or unit (transformation/conversion);
2. Design and construct a new building;
3. Move to another and more suitable existing building.

Perspectives of the demand for change

The need for change has three different actor perspectives: the society, the owners and the users of the building (see figure 2).

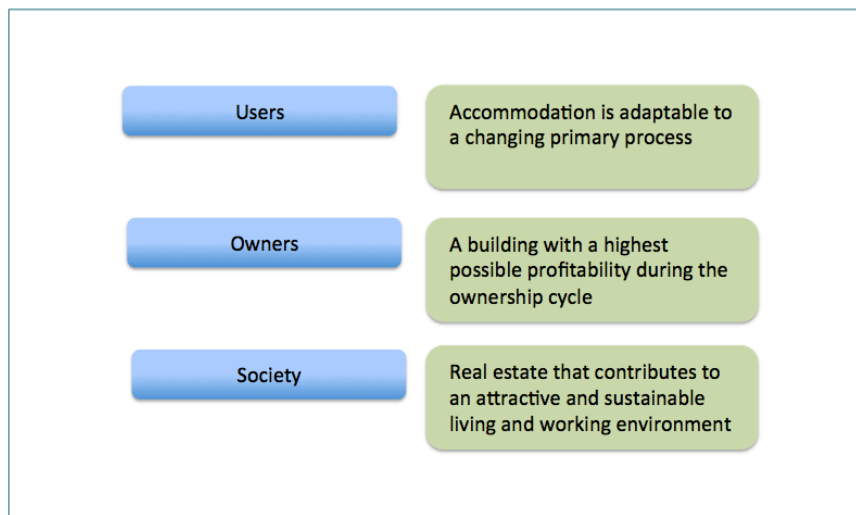


Figure 2: *the need for change from three different perspectives*

From the societal perspective the preservation of the use value of a building is of utmost importance. A building must be attractive for different generations of users as a guarantee for a long life cycle. The owner of the building would like to have a long-term profitability and for the users it is important that their core business will continuously fit the building offered.

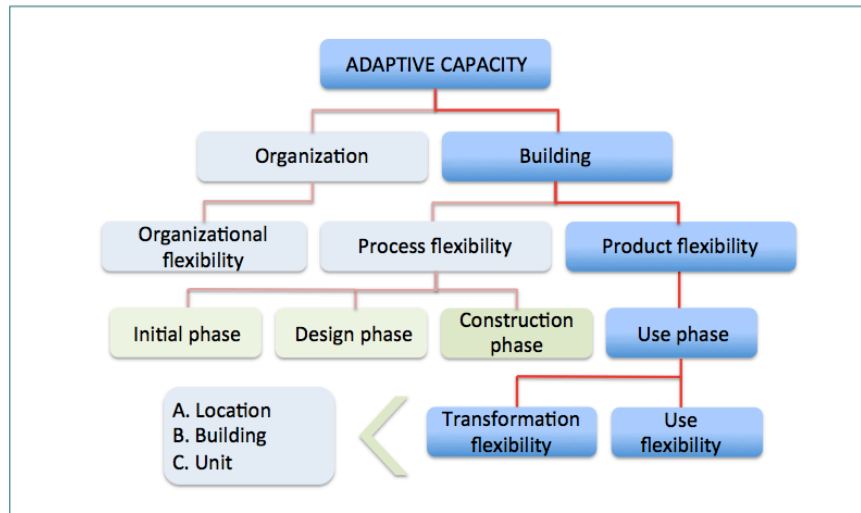


Figure 3: several appearances of adaptive capacity and the focus of the AC determination method

Appearances of adaptive capacity

The adaptive capacity can be split into three different appearances (see figure 3):

1. Organizational flexibility

The capacity of an organization or user to respond adequately to changing demands of the built environment;

2. Process flexibility

The capacity to react to changing circumstances, wishes or demands during the initiative, the design and the construction phase;

3. Product flexibility

The capacity of a building (the product) to respond to changing circumstances, wishes or demands during the use phase of the building.

The demand: use dynamics and transformation dynamics

The focus of the AC determination method is exclusively the product flexibility during the use phase of buildings. Target here is the translation of the demand into transformation and use dynamics on three different levels: location, building and unit (see figure 4).

Use dynamics

The demands for a building can be formulated by the demands of the users. The building must be able to move along in time with these (changing) demands. This may lead for instance to the demand that the building must be parcelled into smaller or bigger units or that specific facilities can be added to the units or building. This is called use dynamics.

Transformation dynamics

This concerns the demands for a building that should be able to accommodate totally different user groups or different functions in the near future. This may lead to specific demands for rearranging the building for different user groups. This is called transformation dynamics.

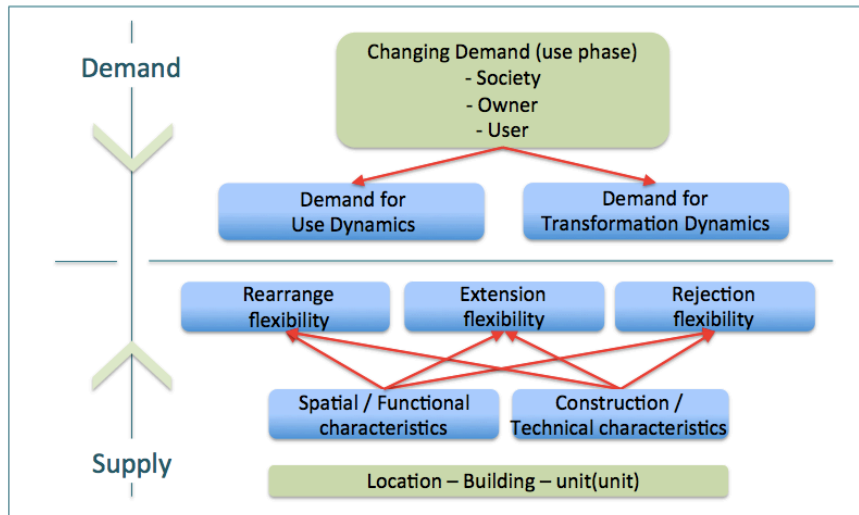


Figure 4: framework AC method for the demand (for use and transformation dynamics), and the supply (of rearrange, extension and rejection flexibility) on three different levels (location, building and unit)

The supply: rearrange, extension and rejection flexibility

Within the method the flexibility of the supply is translated into three spatial/functional and construction/technical characteristics. They determine if a building can meet the requirements: rearrange flexibility, extension flexibility and rejection flexibility (see figure 4).

- *Rearrange flexibility*
To which degree the location, the building or the unit can be rearranged or redesigned.
- *Extension flexibility*
To which degree the location, the building or the unit can be extended.
- *Rejection flexibility*
To which degree (part of) the location, the building or the unit can be rejected.

Supplied by spatial/functional and construction/technical characteristics

Two types of characteristics influence the three possible flexibilities of a building as described: spatial/functional and construction/technical characteristics. Furthermore three different levels of scale will be taken into account: the whole building as the collection of all user units, the units within the building and the location of the building as far as it influences the use and the adaptability of the building. Figure 4 shows the framework of the assessment method for the adaptive capacity. On top, the demand for change is shown and at the bottom the supply with the characteristics of the building, which determine if the building can meet the flexibility demands.

Demand and supply: two target groups

The demand for adaptive capacity by the owner or by the users of the building and the flexibility supply that meets these demands is shown in figure 5. The previously mentioned third target group - the society - will not be taken into consideration any further. The other two target groups will also cover the societal demand for the adaptive capacity of buildings.

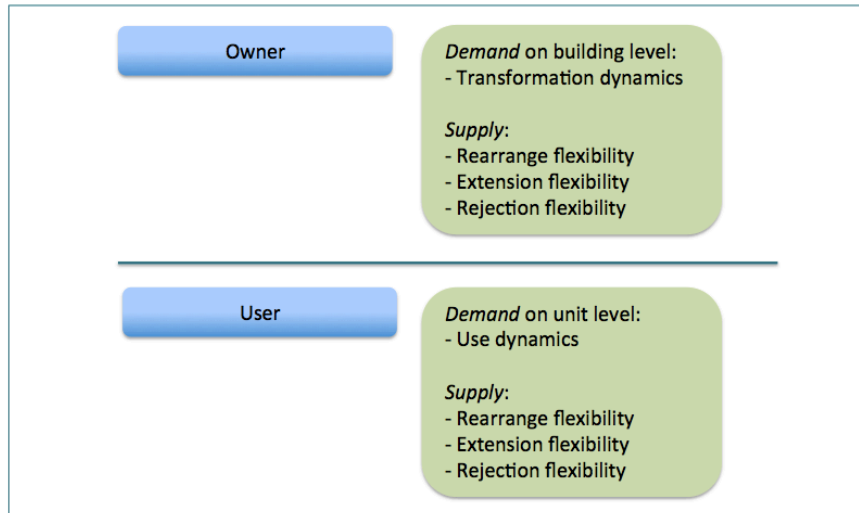


Figure 5: demand for and supply of adaptive capacity translated to two target groups

SEVEN INDICATORS FOR TRANSFORMATION DYNAMICS - OWNER

The AC method uses seven Transformation Dynamics Indicators from the perspective of the owner of a building (E) to formulate his wishes and demands for the adaptive capability of the building and the user units (see figure 6).

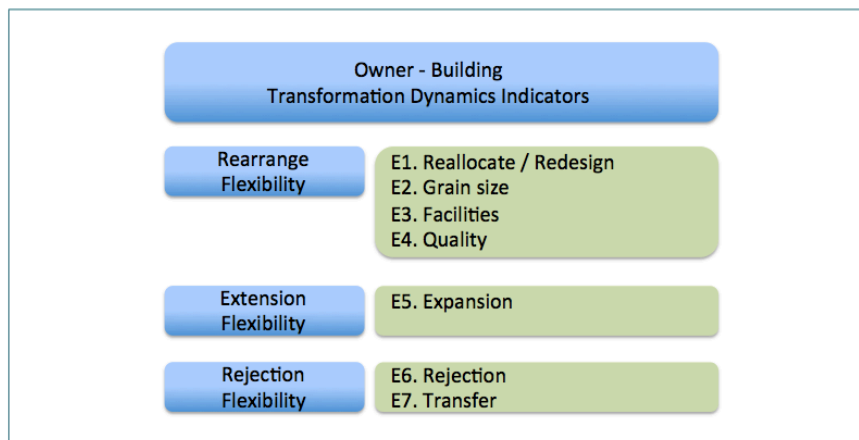
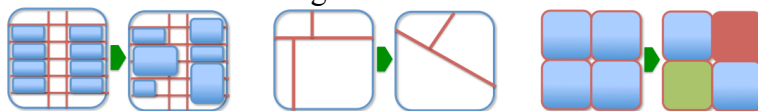


Figure 6: the 7 Transformation Dynamics Indicators from the perspective of the owner of a building (E1-E7), joined together in Rearrange Flexibility, Extension Flexibility and Rejection Flexibility

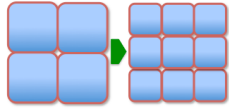
E1. Reallocate / Redesign

This factor comprises wishes/demands concerning the change in size or division of user units within a building (join, split up or rearrange); wishes/demands concerning the possibilities of changing the design, the arrangement on building level and/or the possibilities of changing the functions on building level.



E2. Grain size

This factor concerns the wishes/demands about the possibility to change the number of user units in a building (increasing or decreasing).



E3. Facilities

This factor concerns the wishes/demands for the change of the facilities in the building and/or outside the building at location level.



E4. Quality

This factor concerns the wishes/demands for the change of the layout and finishing per user unit or per building (upgrading).



E5. Expansion

This factor concerns to which extent the use surface of a building can be increased in the future (horizontal and/or vertical).



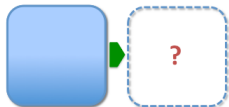
E6. Rejection

This factor concerns to which extent the use surface of a building can be decreased in the future (horizontal and/or vertical).



E7. Transfer

This factor considers whether or not the building can be transferred to another location.



SEVEN INDICATORS FOR USE DYNAMICS - USER

The AC method uses seven Transformation Use Dynamics Indicators from the perspective of the users of a building (G) to formulate their wishes and demands of the adaptive capability of the units and the building (see figure 7).

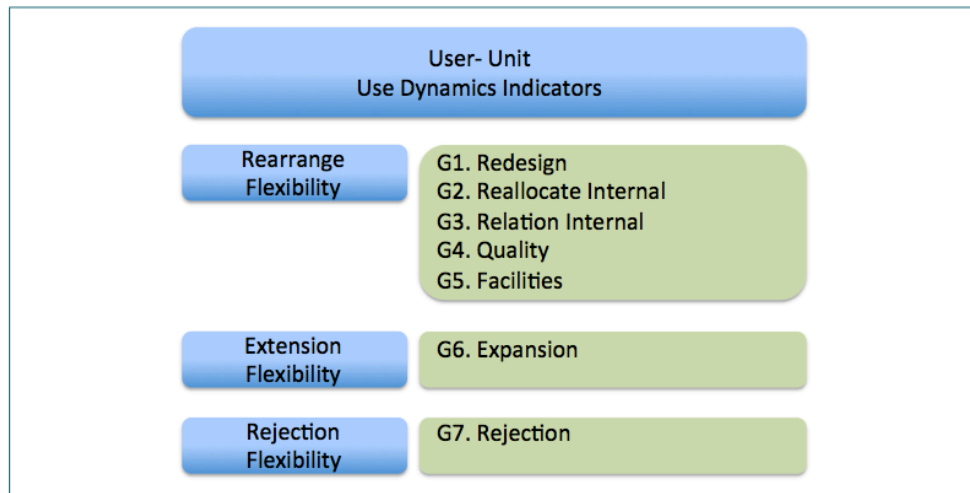


Figure 7: the 7 Use Dynamics Indicators from the perspective of the users of a building (G1-G7), joined together in Rearrange Flexibility, Extension Flexibility and Rejection Flexibility

G1. Redesign

This factor concerns the wishes/demands for changing the layout of the user units in a building and/or the functions of the user units in the building.



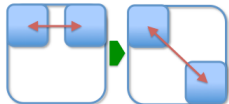
G2. Reallocate Internal

This factor concerns the wishes/demands for the changing the location of the user units in a building.



G3. Relation Internal

This factor concerns the wishes/demands for changing the internal relation with other users/stakeholders in the building.



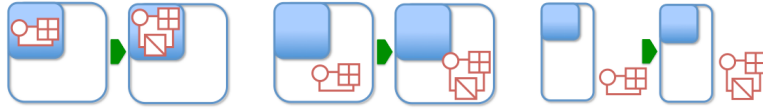
G4. Quality

This factor concerns the wishes/demands for changing the layout and finishing (look and feel) of the user unit in a building.



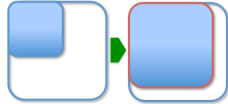
G5. Facilities

This factor concerns the wishes/demands for changing the facilities in the user units, in the building and/or at location level.



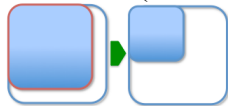
G6. Expansion

This factor considers to which extent the use surface of a user unit in a building should be extendable in the future (horizontal and/or vertical).



G7. Rejection

This factor considers to which extent the use surface of a user unit should be contractible in the future (horizontal and/or vertical).



ASSESSMENT VALUES

In the AC method a value is given for each assessment aspect of the spatial/functional flexibility characteristics and the constructional/technical flexibility characteristics when formulating the demand for flexibility or assessing the supply of flexibility. There are four possible values: 1=Bad, 2=Business As Usual (BAU), 3=Better, 4=Good (see figure 8).

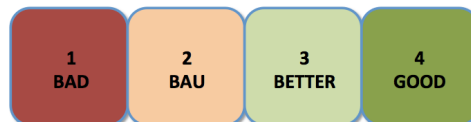


Figure 8: *the 4 possible assessment values of the spatial/functional flexibility characteristics and the constructional/technical flexibility characteristics*

Example assessment of spatial/functional flexibility - owner (A)

Figure 9 shows an example of some of the assessment values of the spatial/functional flexibility characteristics. For the owner of a building in total 36 different indicators (A) have been formulated with associated values for assessing this type of adaptive capacity.


A1. Division Support - Infill To which degree deals the design or building with the division between support (components with long life cycle) and infill (components with short life cycle; easy to demount, replace)?	Assessment values in % of infill 1. < 10% 2. 10 - 30% 3. 30 - 50% 4. > 50% 	Remark The more construction components belong to the infill domain, the more easily a building can be rearranged.	Source Values: Geraedts 2013; Adapted from: Beadle 2008 (Kendall, S. in (Beadle 2008) Flexis 1996 Habraken 1961
A2. Shape of the layout How is the shape of the layout (ratio length and width, straight, circular, irregular)?	Assessment values layout 1. Circular or irregular. 2. - 3. Shallow and oblong, and/or irregular. 4. Equilateral and/or regular.	Remark The more the layout of a building is equilateral and regular, the more easily a building can be rearranged.	Source Geraedts en Van der Voordt, 2007; Remøy 2010; Wilkinson, 2009 Adapted from: SBR 1981
A3. Building entrance, location of elevators, stairs, cores To what extent a centralized and/or decentralized building entrance (location entrance, cores, stairs, elevators) has been implemented?	Assessment values building entrance 1. Decentralized and separated building entrance and core. 2. Decentralized and combined building entrance and core. 3. Building divided in different wings, each with a centralized and combined entrance and core. 4. Building with one centralized entrance, divided in different wings, each with a centralized and combined entrance and core.	Remark The more a building entrance system can be used for a more independent use by different user groups the more easily a building can be rearranged.	Source Values: Geraedts 2013 Adapted from: REN 1992
A9. Oversized building space/surface Is the building oversized concerning the needed space or usable surface?	Assessment values oversized building space in % of oversized 1. No oversized. 2. 10-30% oversized. 3. 30-50% oversized. 4. > 50% oversized.	Remark The more the building space/surface is oversized (for instance by the use of a zoning system with margin space), the more easily a building can be rearranged or transformed to other functions.	Source Values: Geraedts 2013 Hermans, van Rijn, 2013
A10. Multifunctional location Is the location capable to support more different functions, like offices, living, care, offices and shops?	Assessment values multifunctional location 1. One function (suited for offices or living or care or shops). 2. Two functions. 3. Three functions. 4. > Three functions (suited for offices and living and care and shops as well).	Remark The more a location around a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.	Source Values Geraedts 2013 Hermans, van Rijn, 2013 SBR 82, 1981
A11. Multifunctional building Is the building capable to support more different functions, like offices, living, care, offices and shops?	Assessment values multifunctional building 1. One function (suited for offices or living or care or shops). 2. Two functions. 3. Three functions. 4. > Three functions (suited for offices and living and care and shops as well).	Remark The more a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.	Source Values Geraedts 2013 Hermans, van Rijn, 2013 SBR 82, 1981
A12. Multifunctional units Are the user units capable to support more different functions, like offices, living, care, offices and shops?	Assessment values multifunctional units 1. One function (suited for offices or living or care or shops). 2. Two functions. 3. Three functions. 4. > Three functions (suited for offices and living and care and shops as well).	Remark The more user units can support more different functions, the better can be responded to changing demands concerning facilities and quality.	Source Values: Geraedts 2013 Adapted from: Schneider, Till, 2007

Figure 9: an example of some of the (36) assessment values of the spatial/functional flexibility characteristics for the owner of a building (A-indicators).

Example assessment of construction/technical flexibility - owner (B)

Figure 10 shows an example of some of the assessment values of the construction/technical flexibility characteristics. For the owner of a building in total 49 different indicators (B) have been formulated with associated values for assessing this type of adaptive capacity.


<p>B2. Measurement system Has positioning and measurement conventions for construction components been used, like modular co-ordination (for instance 10-20-30 grid or multiples), for the implementation of project independent, demountable and replaceable components?</p>	<p>Assessment values implementation modular co-ordination in % of implementation 1. Not implemented. 2. <50% implemented. 3. >50% implemented. 4. > 90% implemented.</p> 	<p>Remark The more project independent, demountable and replaceable construction components has been implemented, the more easily a building can be rearranged or transformed to other functions. The implementation of the rules for modular co-ordination is absolutely conditional.</p>	<p>Source Values: Geraedts 2013, Geraedts, 2006</p>
<p>B3. Replaceable inner walls To what extend are inner walls easily replaceable ?</p>	<p>Assessment values replaceable inner walls 1. Inner walls are not replaceable without radical/expensive constructional interventions. 2. Inner walls are not replaceable, but good destructible. 3. Inner walls are replaceable by dismantle them and rebuild them at another location. 4. Inner walls are easily replaceable without radical/expensive constructional interventions (for instance system walls).</p>	<p>Remark The more inner walls are easily to be replaced the more easily a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts, Van Rijn 2013 Adapted from: DGBC 2012 Geraedts 2006</p>
<p>B4. Horizontal measurement grid What is the size of the horizontal measurement grid?</p>	<p>Assessment values horizontal measurement grid 1. > 3.60 m. 2. Between 2.40 - 3.60 m. and incidental between 1.20 - 2.40 m. 3. Between 1.20 - 2.40 m. 4. < 1.20 m.</p>	<p>Remark The smaller the size of the horizontal measurement grid the more easily a building can be rearranged or transformed to other functions. For instance a horizontal grid based on 1.80m. gives great opportunities for a layout for living/care and larger common rooms as well.</p>	<p>Source Values: Geraedts 2013 REN 1992 Remoy 2013</p>
<p>B5. Measurement grid facade What is the size of the measurement grid of the facade (for instance for the connection possibilities of inner walls)?</p>	<p>Assessment values facade measurement grid 1. > 3.60 m. 2. Between 2.40 - 3.60 m. and incidental between 1.20 - 2.40 m. 3. Between 1.20 - 2.40 m. 4. < 1.20 m.</p>	<p>Remark The smaller the size of the horizontal measurement grid the more easily a building can be rearranged or transformed to other functions. For instance a horizontal grid based on 1.80m. gives great opportunities for a layout for living/care and larger common rooms as well.</p>	<p>Source Values: Geraedts 2013 REN 1992 Remoy 2013</p>
<p>B6. Dismountable facade To what extend can facade components be dismantled in case of transformation of the building?</p>	<p>Assessment values dismountable facade in % of dismountable. 1. Facade components are not or hardly dismountable and have to be fully demolished and removed (<20%). 2. A small part of the facade components is dismountable (between 20 en 50%). 3. A large part of the facade components is dismountable (between 50 en 90%). 4. All facade components are easily dismountable (> 90%).</p>	<p>Remark The more facade components are easily dismountable the more easily a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Remoy 2013</p>
<p>B8. Self-supporting facade To what extend is the facade self-supporting (load bearing)?</p>	<p>Assessment values self-supporting facade 1. The complete facade is part of the load bearing structure of the building. 2. A major part of the facade is part of the load bearing structure of the building (>50%). 3. A small part of the facade is part of the load bearing structure of the building (<25%). 4. De facade is fully self-supporting and is no part of the load bearing structure of the building.</p>	<p>Remark The more a facade is self-supporting and is not taken part of the load bearing structure of the building the more easily a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Remoy 2013</p>

Figure 10: an example of some of the (49) assessment values of the construction/technical flexibility characteristics for the owner of a building (B-indicators).

Example assessment of spatial/functional flexibility - user (C)

Figure 11 shows an example of some of the assessment values of the spatial/functional flexibility characteristics. For the user of a building in total 29 different indicators (C) have been formulated with associated values for assessing this type of adaptive capacity.


<p>C1. Multifunctional units To what extent can user units be used for more functions, like living and/or care functions, different office functions or commercial functions?</p>	<p>Assessment values multifunctional units 1. One function (living, care, office, or commercial). 2. Two - Three functions. 3. Three - four functions. 4. > Four functions (living, care, office, and commercial).</p> 	<p>Remark The more user units in a building can support more different functions the more easily a unit can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from Schneider, Till, 2007</p>
<p>C2. Size floor What is the size of the usable floor surface?</p>	<p>Assessment values size floor 1. < 400 m² 2. 400 - 600 m² 3. 600 - 1000 m² 4. > 1000 m²</p>	<p>Remark The larger the size of the usable floor surface the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013, Remoy 2013.</p>
<p>C3. Size user units What is the size of the smallest functional independent unit (to be rented)?</p>	<p>Assessment values size units 1. > 150 m². 2. 150 m² (workspace and family housing). 3. 50 m² (office space- and single housing). 4. 35 m² (care units).</p>	<p>Remark The smaller the size of the smallest functional independent unit the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013, Remoy 2013.</p>
<p>C4. Oversized unit surface To what extent are the user units oversized for the demanded function(s)?</p>	<p>Assessment values oversized unit surface 1. Not oversized. 2. 10-30% oversized. 3. 30-50% oversized. 4. > 50% oversized.</p>	<p>Remark The more the surface of user units are oversized the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Geraedts, Hermans, van Rijn, 2013</p>
<p>C6. Unit entrance To what extent has the unit a centralized and/or decentralized entrance?</p>	<p>Assessment values unit entrance 1. The unit has only one limited entrance possibility at only one side of the unit. 2. The unit has several entrance possibilities at one side of the unit. 3. The unit has entrance possibilities at two sides of the unit. 4. The unit has several different entrance possibilities at more than two sides.</p>	<p>Remark The more the user unit has more several entrance possibilities on more sides of the unit the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from REN 1992</p>
<p>C7. Relocation unit entrance To what extent can unit entrances be horizontally relocated (for instance from the inside of a building towards outside near the facade)?</p>	<p>Assessment values relocation unit entrance 1. It is not possible to relocate the unit entrance. 2. The unit entrance can be limited relocated towards one direction. 3. The unit entrance can be limited relocated towards more directions 4. The unit entrance can be easily relocated towards more directions</p>	<p>Remark The more easily the entrance of a unit can be relocated the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Geraedts 2013</p>
<p>C8. Horizontal routing, corridors units In which way is the horizontal disclosure of the units in the building accomplished (for instance by internal corridors)?</p>	<p>Assessment values horizontal routing 1. Disclosure by only single internal corridor. 2. Disclosure by a double internal corridor. 3. All disclosures directly by a central core in the building with a surrounding corridor. 4. All disclosures directly by a central core in the building.</p>	<p>Remark The more the horizontal disclosure of the units is limited by a central core the more easily units in a building can be rearranged or transformed to other functions. <i>Single corridor: suited for offices and living/care. Orientation reasons cause a preference for a corridor outside near the facade instead of inside the building.</i> <i>Central core: a corridor surrounding a central core meets the demands of offices, living/care and housing.</i> <i>The location of stairs has great influence on the adaptability of a building.</i></p>	<p>Source Geraedts, Hermans, van Rijn, Remoy 2013</p>

Figure 11: an example of some of the (29) assessment values of the spatial/functional flexibility characteristics for the users of a building (C-indicators).

Example assessment of construction/technical flexibility - user (D)

Figure 12 shows an example of some of the assessment values of the construction/technical flexibility characteristics. For the users of a building in total 33 different indicators (D) have been formulated with associated values for assessing this type of adaptive capacity.


<p>D13. Detailing joints inner walls - horizontal Which detailing is applied with the joints between inner walls, load bearing walls, columns and facades?</p>	<p>Assessment values horizontal joints 1. Penetrating joints. 2. Joints of grout or sealants. 3. Unique specific project bound joint components. 4. Common project unbound demountable joint components.</p> 	<p>Remark The more the horizontal joints of inner walls are easily demountable, the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from van SBR 1981</p>
<p>D14. Detailing joints inner walls - vertical Which detailing is applied to the joints between inner walls, floors and ceilings?</p>	<p>Assessment values vertical joints 1. Penetrating joints. 2. Joints of grout or sealants. 3. Unique specific project bound joint components. 4. Common project unbound demountable joint components.</p>	<p>Remark The more the vertical joints of inner walls are easily demountable, the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from van SBR 1981</p>
<p>D15. Exchangeability (infill) construction components To what extend is it possible to apply inner walls, doors, ceilings, floors, etc. elsewhere in the unit or in other units?</p>	<p>Assessment values exchangeability construction components 1. No possibilities to exchange infill construction components. 2. < 50% of components is exchangeable. 3. 50 - 80% of components is exchangeable. 4. >80% of the infill construction components are easily replaceable and exchangeable.</p>	<p>Remark The higher the exchangeability of the infill construction components, the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Geraedts 2013, adapted from REN 1992</p>
<p>D16. Measurement and control of facilities Is it possible to control and measure the facilities as well on building level (centralized) as on user unit level (decentralized)?</p>	<p>Assessment values measurement and control 1. Only on central building level. 2. On central level and occasionally on unit level. 3. On central level and limited on unit level. 4. As well central on building level as well completely on unit level.</p>	<p>Remark The more possibilities for measurement and control of the facilities on unit level, the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Flexis 1996</p>
<p>D18. Disconnect ability of facility components To what extend can facility components be disconnected?</p>	<p>Assessment values disconnect ability of facility components 1. No disconnect ability, not demountable. 2. Bad disconnect ability, demountable. 3. Partly disconnect ability, demountable. 4. Excellent disconnect ability, completely demountable/able to unplug.</p>	<p>Remark The higher the ability to disconnect of facility components, the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from ISSO/SBR, Flexis, 1996</p>
<p>D19. Accessibility of facility components To what extend are facility components good accessible?</p>	<p>Assessment values accessibility of facility components 1. Hardly or not accessible (components on support level; concreted in). 2. Limited accessible (partly on support and infill level). 3. Good accessible (a lot of components on infill level). 4. Very good accessible (most components on infill level and completely demountable; able to unplug).</p>	<p>Remark The higher the accessibility of facilities components, the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from ISSO/SBR, Flexis, 1996</p>
<p>D20. Level of use of universal facility components To what extend has been made use of common universal project unbound facility components?</p>	<p>Assessment values use of universal facility components 1. Hardly/no use of common project unbound facility components (< 10%). 2. Limited use of project unbound components (<25%). 3. Partly use of project unbound components (<75%). 4. Extensive use of common project unbound facility components (>75%).</p>	<p>Remark The more facility components are universal and not specific project bound the more easily units in a building can be rearranged or transformed to other functions.</p>	<p>Source Values: Geraedts 2013 Adapted from ISSO/SBR, Flexis, 1996</p>

Figure 12: an example of some of the (33) assessment values of the construction/technical flexibility characteristics for the users of a building (D-indicators).

ADAPTIVE CAPACITY: DEMAND AND SUPPLY PROFILES

It is obvious that the described AC method enables the users to make so-called demand or supply profiles. A demand profile can be made for a specific programme of a new adaptive building or a programme for an existing building that needs to be transformed into a new, alternative function. A supply profile can be made to map the adaptive capacity of an existing building. The profiles can be compared to each other to see if a match between the flexibility profiles is possible (see figure 13).

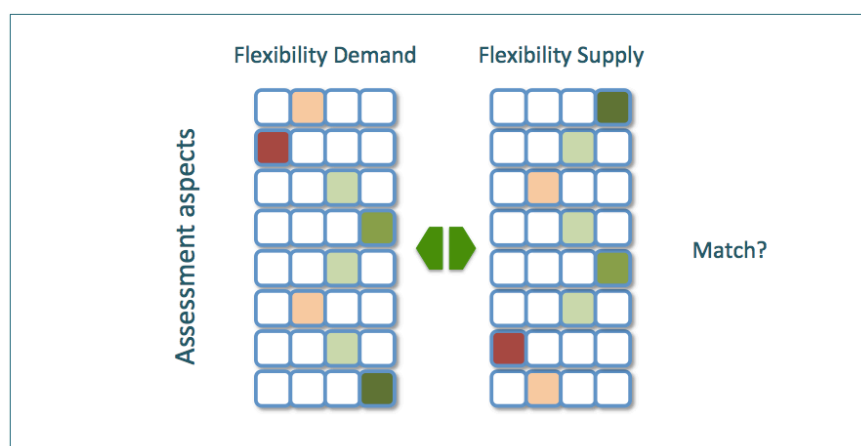


Figure 12: an example of a demand and supply profile to see if there could be a match between the wishes for future adaptability and the building supplied

RECOMMENDATIONS FOR THE NEXT STEPS

As shown in the previous examples, the Adaptive Capacity method is a first important step in the development of instruments to formulate adaptive demands and to assess adaptive supplies. In the next steps this method will be transferred to easy to use and implementable instruments.

Communication, verification, validation

The next step is discussing and evaluating the AC method with the owners and users of buildings and with the construction companies involved. The steering group behind this research project and the two already engaged expert panels - one with representatives of the clients (demand side) and one panel with representatives of construction companies and suppliers (supply side) - could play an important role in this next step.

Instruments for small and large projects

Further developments will also look into the implementation of the AC method for small and rather simple projects and large complex projects as well. For smaller projects it will be sufficient to define an assessment only on a limited number of crucial aspects, while large complex projects ask for a more detailed analysis of the capacity to change.

Instruments for different sectors of building types

The AC method can be specified for different sectors within construction. Different building types like hospitals, schools, office buildings or residential housing may lead to the use of a selected and specific group of assessment aspects.

To stretch the method to the urban context

The urban context is essential for the use value of buildings. The current method is limited to a small number of assessment aspects of the location of buildings. It would be very interesting to look into the urban context more in detail. The need and demand of changing buildings in a condensed urban context to changing circumstances is far higher than for buildings located in a suburban area.

Develop a standard for the adaptive capacity

Finally it is not unlikely that professional owners and clients in construction feel the urge for a standard describing the adaptive capacity of buildings. Such a default standard could be developed to change over time if developments concerning the flexibility of products evaluate further. Also non-professional owners and clients are potential users of such a standard with default values to use in practice. These standards could be developed per sector in construction.

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