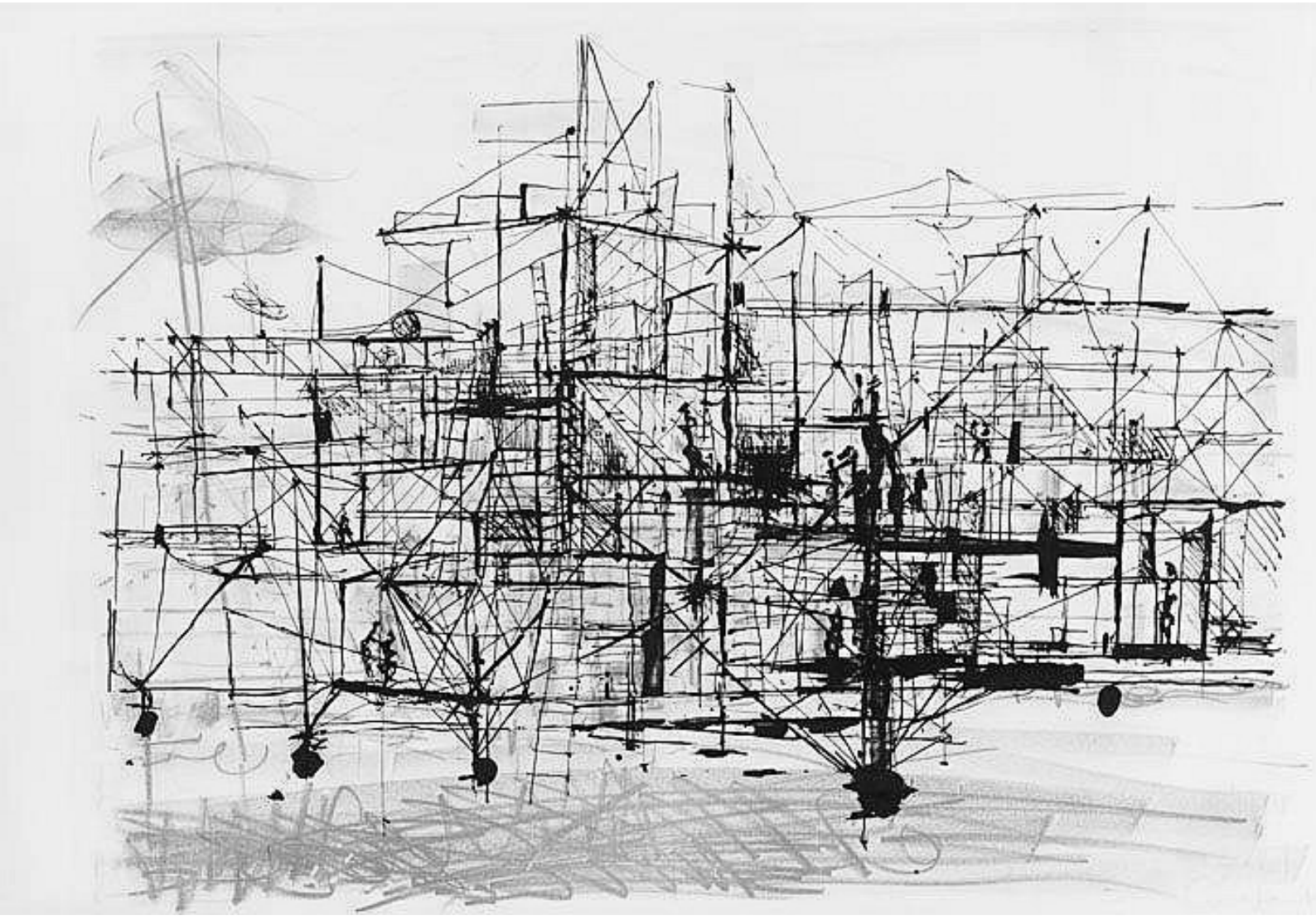
Degrees of Adaptability

A design Framework for Adaptable Real Estate Transformation Projects



New Babylon

P5 Report

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Management in the Built Environment

TU Delft

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Foreword

Architecture is everywhere, we use architecture to find a shelter, we use architecture to work, we see architecture to be amused, we use architecture… and then we stop using it. Buildings, as a result of architecture, are the objects that form our living environment and enrapture our history and memories, they the places which retain our memories. Although, at some point they stop being valuable to us, not because we do not like them but mainly because they cannot serve us anymore, and we cannot use them. Living in Athens, a city with great history and really beautiful buildings I was always wondering how it is possible to exist so many abandoned, vacant, obsolete buildings in the city Centre. Buildings that some decades ago were landmarks for the city, objects that the passengers and the pedestrians were admiring. My love for buildings and my internal faith that my city can be re-generated I studied architecture and, four years ago, I chose the redevelopment oh a historic Athenian train station and the square that enclose it to be my graduation topic. Many years after, I am still trying to deal with the obsolete building stock but now, from a different more strategical perspective.

Vision

After the Paris agreement in 2015 the regulations for energy consumption and material use started being in a high importance. Concerning that the built environment is responsible for the "*30% of global final energy consumption in 2014, and 55% of final electricity demand* [1]" the need for a more sustainable real estate environment is crucial. Moreover, new regulations about the energy labels of the existing buildings stock create big uncertainty about how the future built environment would look like. All these are happening while major accommodation problems area raised, the high densification of the big cities led the rents to be increased in an affordable range and people of my age phase great difficulties to find a home. O, once again we cannot use architecture. My vision is to try to use architecture in order to reverse the existing complex situation while confronting buildings potential obsolescence.

This can happen through re-development or re-design of buildings that are already vacant or becoming obsolete in order to cover the new, current demands. A demand that is quite possible to change again in ten or twenty years as we live in a constantly changing world while living in the most static form of architecture, buildings. So, my idea is to re-design the obsolete buildings but transform them in dynamic forms that can be adapted to our changing demands.

Acknowledgements

This thesis would have never been actualized in the extend that is presented in this report without the support of some people. First of my team, MOR, and Peter de Jong who alongside with Hilde Remoy proposed me to join the team to help with the feasibility. Of course, many thanks for the warm acceptance, respect and support to my best Indian friend Khushboo, with whom together made all of these feasible. Special thanks to Hanna, who was always checking my presentations and to Panagiotis who was coming with me to the interviews. To my parents, Yiannis and Angeliki, I owe an honorable mention as they were always supportive without being tired to hear me complaining.

I hope that you can share my enthusiasm and you will enjoy further reading

Charitini Kougea, Delft 2019

[1] IPEEC. 2017. *"Existing Building Energy Efficiency Renovation; International Review of Regulatory Policies".* OECD/IPEEC 2017. Retrieved on 15/12/2018, by: https://ipeec.org/upload/publication_related_language/pdf/651.pdf

Abstract

Context: The majority of buildings are designed as static objects, in order to serve a specific goal, a specific function. Although, this does not match to the contemporary and constantly changing way of living and working. Moreover, it does not match with the evolving technology, economy and culture. Thus, buildings that cannot respond to the changing demand can easily get obsolete by being outdated, inefficient, unable to be reformed accordingly. Buildings' obsolescence and vacancy is a quite common problem globally, that creates a lot of externalities in the built environment and in the quality of the daily life. A way to phase it, is be transforming the existing obsolete building stock to dynamic real estate objects that can adjust to the current and future demand. Thus, to enhance their future-proofness. This can happen by enabling design strategies which have the capacity to create adaptable transformation project. The aim of this research is to generate a framework that can be used in order to support the decision making and designing process of adaptability in real estate transformation projects.

Problem Statement: The main problem to be confronted is the real estate obsolescence as a result of buildings' inefficiency. Usually the functional life-cycle of an asset is smaller that the structural and/or technical. Thus, when the building is not able to adjust to the changing demand it becomes obsolete, a situation that can create a variety of other problems. The research is focused on transformation projects.

Methodology: The research aims at defining a solution for the problem and provide a practical tool to support this decision. So, as the objectives are hybrid the same happens with the methodology, Main pillars are the literature study and the empirical research, which consists of the Delphi research method and semi-structured interviews. These work as the backbones of the research while in the second part design and analytical tools, like SWOT and scenario planning, are used to illustrate the implementation of the proposed solution.

Results: After the conduction of the empirical and scientific research a design framework was developed based on the analyzed data. The framework consists of three degrees of adaptability which are additive to each other and can endorse specific type of accommodation supply alternatives. The way that the framework should be implemented and the steps for decision making are described via a set of tools and illustrations.

Conclusions: The author proposes a design framework for adaptable transformation projects. This can be adjusted and used based on each project's demands in order to offer a balanced outcome for a future proof building. Although the framework was developed for transformation projects of a specific typology, its general principles can be implemented into all the buildings, transformation or not. The final outcome is a result of deep understanding on the values and aspects of adaptability with respect to each projects uniqueness.

Keywords: obsolete buildings, adaptability, transformations, future-proof, design framework

Management Summary

Introduction

Obsolescence is a real estate phenomenon that is globally evident. It can be caused by various reasons like functional, political, technical and legal and describes a situation that a building cannot be in use as it does not further comply with the current demand (JLL, 2013). Some typologies of obsolescence are caused by external factors while other are related to the building itself (Blakstad, 2001). A way to confront or at least minimize the "symptoms" of obsolescence is to develop assets that can be adjusted to the constantly changing demand. These buildings, which can expand their life-cycle and serve multiple accommodation demands through the years, can be characterized as future proof. (Geraedts, 2008)

The buildings which present higher numbers of vacancy and obsolescence are the commercial buildings (Savills, 2018; Bouwinvest, 2016; Remoy & van der Voordt, 2014), which accordng to Kincaid are the ones that present the higher potential to be changed into a different function (49%) in comparison with other uses (Kincaid, 2002).So, considering the percentage of obsolete buildings and the amount of, mainly commercial, buildings that should be renovated due to environmental regulations, the need for their transformation to future proof buildings seems to be urgent (van Eerden, 2018; Remoy, 2010). Moreover, adaptive reuse of the existing obsolete buildings stock is characterized as the most sustainable solution for vacant, outdated and/or underperforming buildings but cannot guarantee future-proofness without the development of adaptive capacity into the re-used buildings (Aytac, et al., 2016; Manewa, 2012; Nakib, n.d.; Geraedts, 2008).

Scientific and Social Relevance

The ability of a building to retain its functionality and extend its life-cycle is vital for a future-proof built environment (Aytac, et al., 2016; Manewa, 2012; Nakib, n.d.; Geraedts, 2008; Remoy & De Jong, 2011; Schenk, et al., 2009). In scientific literature there are many papers on adaptability, tools and indicators for designing adaptable buildings (Blakstad, 2001; Kelly, et al., 2011; Schmidt III, 2014; Gosling, et al., 2008). Although the topic of adaptability is quite common in the scientific literature there is almost nothing specifically developed on the design of adaptive capacity in transformation projects. Additive to this, only little things have been written about the perspective of real estate practitioners on the topic of adaptable transformation project, a gap that this research is aiming to cover. Therefore, the following thesis is focused on future transformation projects and trying to fill in the existing scientific gap on how to deal with obsolescence and develop future proof transformation projects.

Concerning the societal perspective of the obsolete building stock and its transformation potential, adaptive re-use can be a solution for another big issue of the Netherlands, housing shortage. So, while many commercial buildings are vacant the housing problem is increased, and many people are unable to find a proper home, mainly in Randstad. Conversions of inefficient commercial buildings to mixed use or residential assets is a way to minimize the residential problem and at the same time mitigate with the un-sustainable building stock. Moreover, through adaptability buildings can adjust to the changing demand of their users and market and avoid future inefficiency (Bullen, 2007; Wilkinson & Remoy , 2011; Capital Value, 2018).

Problem statement

The problem stated in this research is the obsolete building's stock and its probable transformation to a non-dynamic object. Considering the variety of factors that can cause obsolescence, the chances of a non-adaptable reused (transformed) building to be obsolete again can be quite high based on the context of each case. Thus, the problem is that the buildings can be multiple times obsolete, even

though adaptive re-use strategies have been implemented (transformation projects). This is due to the static nature of the real estate sector and the parallel existence of many uncertainties and risks. The problem of **RE-obsolescence** is the problem that this researched is focused on

Research Question

Continuing to the rationale of the problem description and problem statement about the existing obsolete building stock, the need for transformation and the goal of future proofness (confrontation of re-obsolescence), the research question of this research was formed as follows:

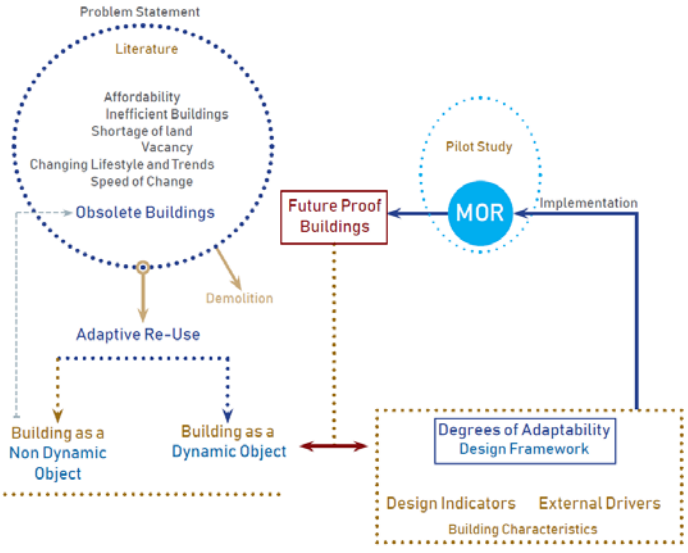
"Which are (design framework) and how can adaptability design strategies be applied in order to develop a future-proof transformation project?"

Looking at the research question and the before-mentioned research background, the importance of adaptability for a future proof project is obvious. What is crucial to understand here is that there is not only one path to follow for adaptable real estate. As each project is unique and highly dependent on its actual characteristics and environment, each final strategy should be an outcome of internal and external factors' analysis. That is why the question is referred to strategies and not a strategy. Thus, strict guidance on how to design a future-proof building via adaptability would be a utopia.

Research Sub-questions:

1. Which is the theoretical background of adaptability?
2. Which are the main design indicators of an adaptable transformation project?
3. How can a holistic Framework of adaptability (Degrees of adaptability) be developed?
4. What is the impact of the Degrees of adaptability on the future potentials of the building (pilot study)?

Figure 3: Conceptual Model, own illustration



The conceptual model

The conceptual model of the research's design reveals the sequence of the concepts and topics that constitute the reason, the process and the outcome of this master thesis. It shows the author's rationale regarding the stated problem of buildings' obsolescence, the two possible confrontation options and the selected tool to deal with it. Starting from the problem description, derived by literature, the obsolete buildings are an important problem caused by many factors. As adaptive re-use is characterized as a more sustainable technique, the author followed this path. To deal with re-obsolescence the author chose the transformation to a dynamic object and created a design Framework that can lead a building to be future proof.

In total, the objectives of this research are the following:

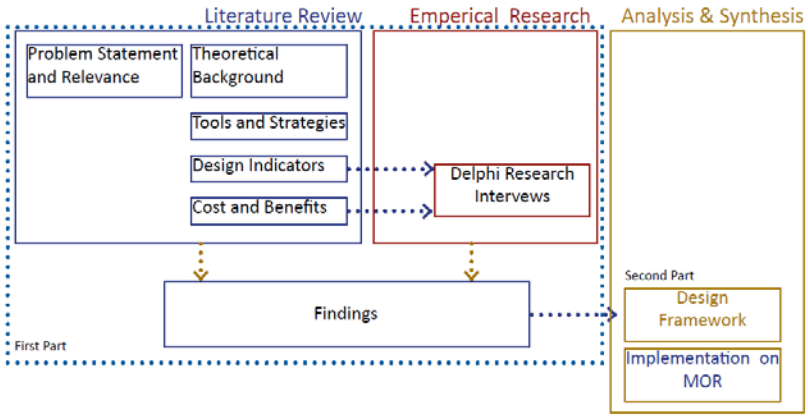
- Identification of the design Indicators for adaptable buildings
- Adjustment of the indicators for use in transformation projects

- Development and implementation of a design Framework which can be used by real estate professionals
- Barriers and benefits of the framework in the long term and buildings' future-proofness

Research Design and Methodology

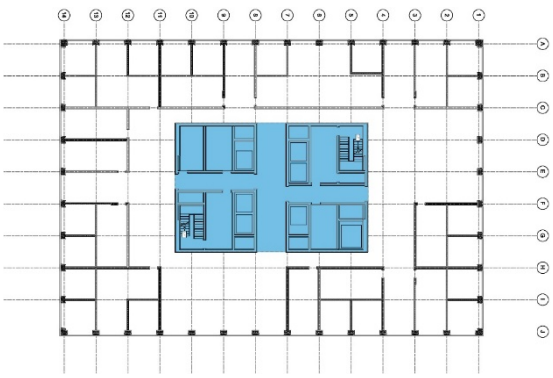
This thesis consists of two main parts, the research and the synthesis, thus can be characterized as hybrid (Barendse, et al., 2012). The first part includes the first two sub-questions and it is about the theoretical background and the gathering of data. The second part, which is related to the two last sub-questions, is about the analysis of the derived data towards criteria for the development of the solution that can respond to the problem statement and the posed research question. The research design follows this structure. The first three chapters includes the introduction and the research while the last three the analysis, synthesis and conclusions.

Figure 4: Research Methodology, own illustration



Similar to the research, the methodology can be described as hybrid. Literature review and empirical research are used to gather the data that will be further analysed and tested through Scenario Planning, SWOT, and Kendall W score. Moreover, vital for the conduction of this thesis is the use of a case study. The necessity of it was derived from the research objective of a tool/method that can be used by practitioners. So, in order to explain the formation and the alternatives that can be created by the framework it was important to use and test the framework on a real case scenario.

The typology & the pilot study



To make the final framework less generic, the scope of this research was narrowed down to one, specific typology of office buildings. The typology for which the Degrees of adaptability framework is made for, is the one constructed in the 70's and 80's on the American style typology (figure 15). More precisely, the office blocks with the core, the load bearing façade and the open layout.

Figure 16: Conceptual Model, own illustration

One reason why this group of buildings was selected is the high density of this type of buildings globally, fact that makes the value of the framework higher as it can be implemented in a higher percentage of obsolete buildings (Remoy, 2010). Moreover, as there is not a framework specifically for transformation projects the author chose to start researching the topic based on an typology which can be easily transformed and adapted to other uses due to its open layout, organized core and the efficient floor-to-ceiling height.

Named MOR, the chosen pilot study is a typical example of this building typology. The study is the MOR project of the TU Delft Team for the Solar Decathlon Competition 2019 in Hungary. MOR originates from the shortening of Modular Office Renovation. The project is about the transformation of a vacant office block under the principles of circularity, net-positivity and adaptability. The overall purpose is to re-design a **future proof** building block that could be easily be repetitive to other existing, vacant office blocks. The pilot study is known as the Marconi Towers project, which is the Europoint Complex which marks the entrance to the district of M4H (RotterdamMakersDistrict, 2018). The transformation design includes in total three, 90 meters high, towers designed by SOM in the '70s under the principle of the classical American building typology style; typology that can be recognized in many other buildings in The Netherlands, but also worldwide (MOR, 2019).

Figure 42: Commercial buildings in U.S.A., the Netherlands and Greece. The middle one is the case study (Marconi Towers)

Chapter 2

Theoretical Framework

Two are the main concepts that constitute the basis of the following thesis, obsolescence and adaptability. One has the role of the problem while the other one is the solution. So, the first step was to interpret their meaning, their principles and the parameters that they consist from. The clarifications and definitions are based on the existing scientific knowledge which also cover relevant to them concepts.

The related to problem concepts

Starting from Obsolescence is described and the situation when a building is "'*no longer used or practised; outmoded, out of date*" (Thomsen & van der Flier, 2011). Langston (2007) divided building obsolescence into seven (7) categories which are the **physical, the economic, the functional, the technological, the social, the legal, and the political** factors (Aytac, et al., 2016). One more categorization, based on the importance of factors, was made by JLL. In this perspective legislation, technology and corporate requirements are the main drivers for obsolescence (JLL, 2013). Especially, the corporate requirements and technology are drivers for the office vacancy (and/or inefficiency) (JLL, 2013), which constitutes one of the main concerns posed in this thesis. Obsolescence is followed by a variety of other concepts like vacancy and depreciation of the building stock. The non-dynamic nature of the buildings and the inelasticity in real estate market drive buildings to be after some years, depending on the building and its use, inefficient, then they are depreciated, and, in the end, they are obsolete and vacant (JLL, 2013). **Depreciation** can be defined as the loss of value of an asset due to both, external and internal indicators (Wofford, 1983). Additive to this is the real estate concept of **vacancy**. Considering property vacancy there are two main categories, the physical vacancy which is about assets that *"efficiently clear respective property markets-part of stock that can immediately*

respond to the demand" and structural vacancy which is about "vacant properties that no longer have a relationship with occupier demand in their present use" (Muldoon-Smith, 2017). The structural vacancy is linked to the obsolescence and to the location of the vacant building (Muldoon-Smith, 2017).

The related to solution concepts

Adaptability is the core concept that was defined, analysed and synthesized as solution in this research. According to literature, adaptability consists of four main values (Figure 6). The first one is "the capacity for change", which can be translated in many things like change of the size, function, location. The second one, is the ability to remain "fit" or "reduce in mismatches", which is about the connection and the relation between the user and the building. Thirdly comes the value; which is one of the main concerns of this thesis. Many researchers wrote about the value, this meaning range from "maximizing the productive use", "to fit both the context of a system's user and its stakeholders' desires", "at minimum costs". The last one is time. Time indicates the speed of change and the life cycle commitment; long term changes and "extension of use" (Schmidt, et al., 2010) (Estaji, 2017).

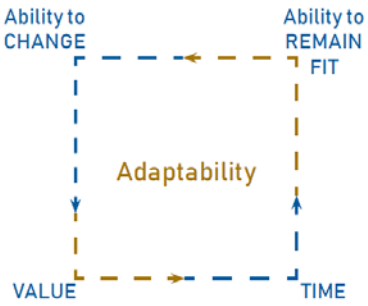


Figure 6: The components of adaptability, own illustration based on Schmidt et al. 2014

On the other hand, there is a quite similar to adaptability concept, flexibility. In the literature for adaptability and flexibility is observed that these two topics are overlapping. What is happening is that some researchers present flexibility as a part of adaptability while others use a reverse definition (Estaji, 2017; Pinder, et al., 2017). Therefore, for the sake of internal consistency it is crucial to define the exact meaning of adaptability and flexibility; this meaning is based on literature research and was confirmed during the empirical research (Gosling, et al., 2008; Geraedts & Prins, 2016; Pinder, et al., 2017; Schneider & Till, 2005; Groak, 1992).

Finally, two definitions derived from the literature were chosen to clarify the consistency and meaning of adaptability and flexibility. **Adaptability** is: *"The capacity to change the building's built-environment in order to respond and fit to the evolving demands of its users/ environment maximizing value throughout its lifecycle."* (Schmidt III, 2014), while **Flexibility** is: "*an adaptive response to environmental uncertainty as a reflection of the ability of a system to change or react with little penalty in time, effort, cost or performance".* (Upton 1994 in (Gijsbers & Lichtenberg, 2012)

Moreover, other concepts, related to adaptability, which are relevant to this research are the adaptive capacity, the adaptable buildings, adaptive architecture, sustainability and future-proofness. Namely **Adaptive Capacity** is "a building's *ability to maintain its functionality during its natural life on a sustainable and economically viable manner*" and measures the grade at which a building can be adapted to the changing demands (Brink Groep, 2014). **Adaptive Architecture** is describing the buildings that are designed "*to adapt to their environments, their inhabitants and objects as well as those buildings that are entirely driven by internal data"* (Schnädelbach, 2010) while **Adaptable (or adaptive) buildings** are "*dynamic systems that carry the capacity to accommodate a set of evolving demands regarding space, function, and components' thus maximizing the through life value*" (Manewa, et al., 2013) (Estaji, 2017) (Geraedts, et al., 2014).

Moreover, sustainable real estate can be less affected by financial downturns and obsolescence through adaptability (Schenk, et al., 2009 (Remoy, 2010)). Looking at the adopted definition of

sustainable buildings we can observe the relation with the before-mentioned definition of adaptability.

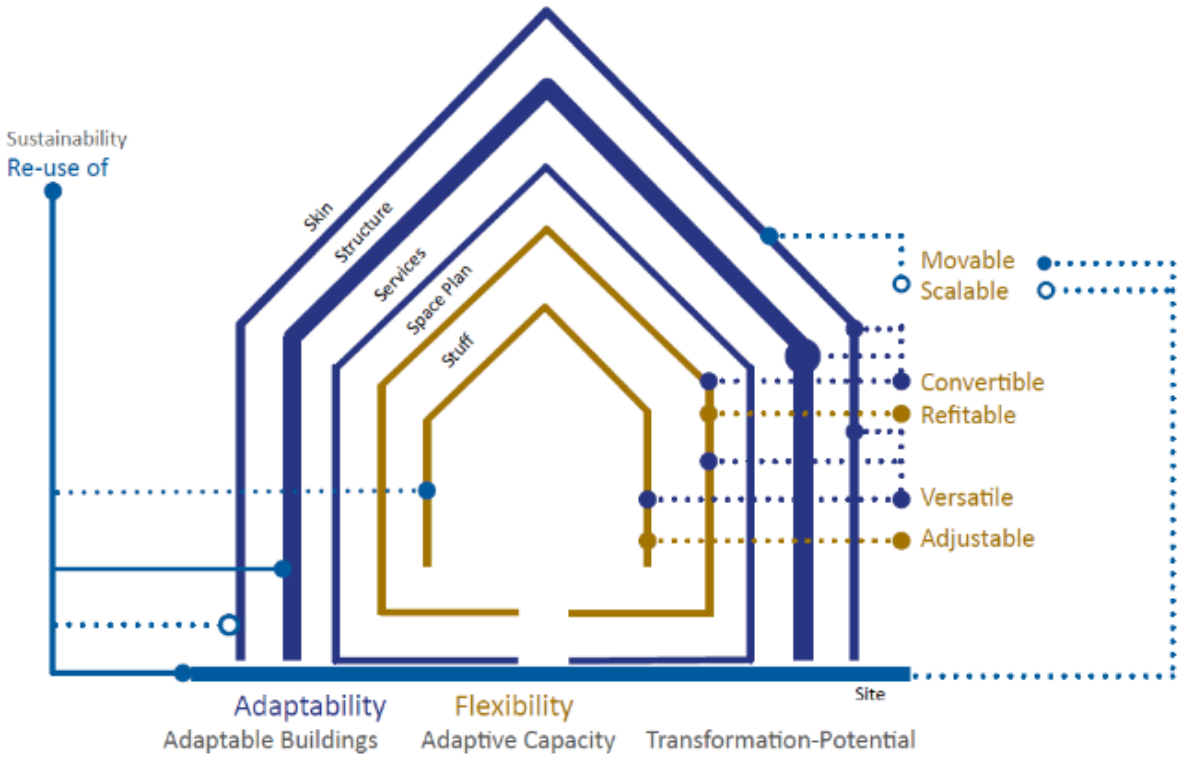
*"**Sustainable buildings** have an in-built ability to adjust to changing circumstances and technologies, without excessive waste and conflict."* (Manewa, et al., 2013) while the relation with **future-proofness** can be recognised in the following quotation: "*without adaptability buildings will reach the limit of their functionality or efficiency much sooner that their expected life cycle*" (Geraedts, 2008).

Theories, strategies and tools for designing adaptability

The research about the "core" of adaptable buildings was find out to be the theory of Brand's about Levels or Layers. Originated by Duffy in 1974[8] and re-formed by Brand in 1994 [9], the main element of these "levels" is that a building should not be measured as a whole – in material terms- but should be divided into parts according to the components' estimated technical, functional and economic life-cycle (Geraedts & Prins, 2015; Nakib, n.d.; Aytac, et al., 2016).

Brand expanded Duffy's theory to the "Ss". He defined six levels, all starting with an S. These are the Stuff, Space Plan, Services, Skin, Structure and Site. These levels have a different expected life span and could be changed at different time. Stuff represents the furniture or the smaller objects, the space plan is about the spatial organisation, the services are about the installation, skin in about the façade components, the structure is about the structural elements and finally the site is about the location and the legal boundaries of the building. In this thesis the "S" of surroundings will be also added in order to include the societal integration and feasibility for the MOR project (Schmidt III, 2014; Blakstad, 2001; Kelly, et al., 2011; Remoy, 2010).

"An adaptive building allows slippage between the differently-paced systems of S's." (Brand, 1994)



Based on the existing literature of adaptability (Robert Schmidt and the Adaptable Futures team proposed a theoretical framework which includes in total six adaptability strategies (figure 38). These are the Adjustable, Versatile, Refitable, Convertible, Scalable and Movable. The "ables" are positioned

in the “Framecycle”, which also reflects the levels of Steward Brand, as the proposed six strategies go from the smaller to the bigger scale (Schmidt, et al., 2009; Schmidt III, 2014).

Figure 38: The Layers (Brand,1994) and the Adaptable strategies (Schmist III, 2014), own illustration

Design indicators

Except of the strategies there are many research papers about parameters for adaptability. Starting from the literature regarding abilities, Geraedts proposed four key performance indicators for flexibility (Geraedts, 2008). These are partitionability, adaptability, extendibility and Multifunctionality. In these four categories are included several indicators towards flexibility like modularity, rearrangeability, zoning and demountability. Another list of 17 indicators is provided by Flex 2.0 (Geraedts & Prins, 2015), the AC model (Geraedts, et al., 2014), by Brink Groep (Brink Groep, 2014) and by Remoy (Remoy, 2010). The majority of them require a standard grid based on which the different perspectives of flexibility can take place. Nevertheless, these are not direct design indicators but indicators that describe a desirable type of change like extendibility, rearrangeability etc. (see Figure 14). Furthermore, there are plenty of other researches about real estate strategies and design parameters for adaptability. Nakib developed a series of guidelines towards adaptable design. Starting from socio-proffesonal, economic, spatial, functional, structural, technical and façade, he creates a pattern of solutions that can be implemented in order to create an adaptable building (Nakib, n.d.).

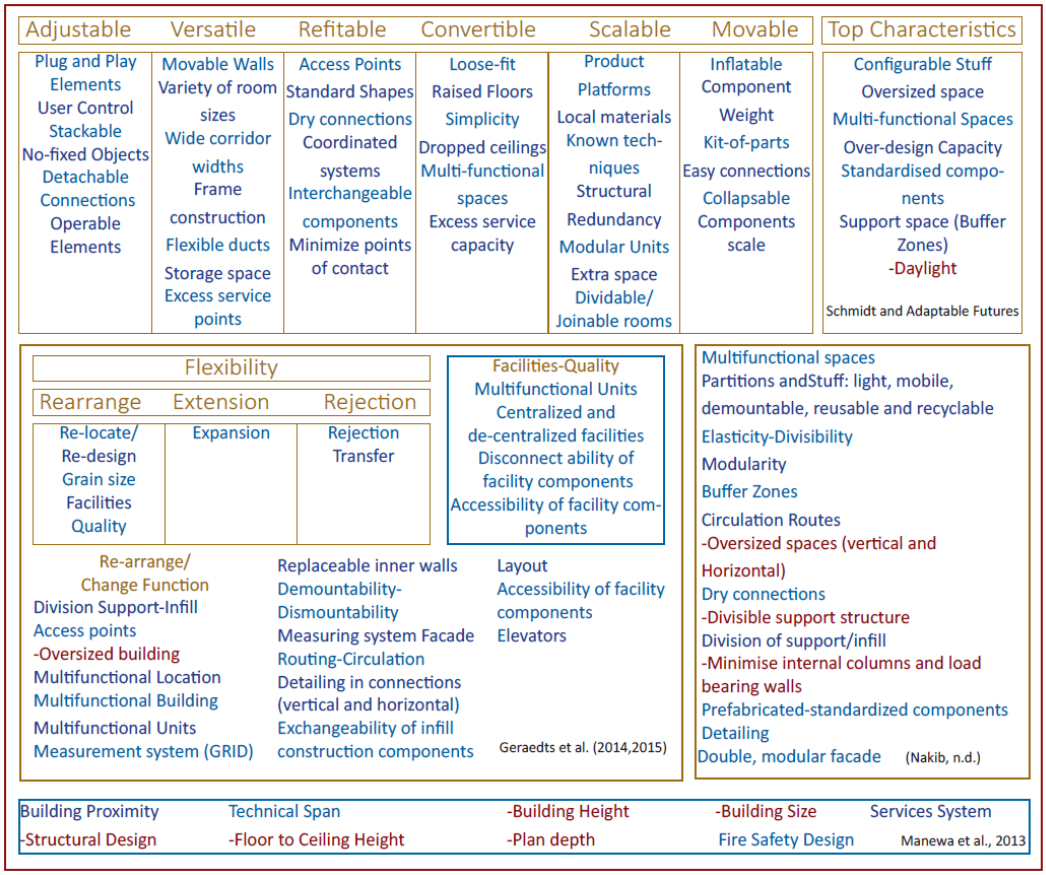


Table 2: Design indicators for adaptability, own illustration

The final design indicators and their descriptions

This research is focused on transformation projects of a specific typology. The selection of indicators and the final design of the adaptable real estate strategy is highly dependent on the existing building layout. There are numerous of things that change when designing a new adaptable building in comparison with an adaptable transformation project. The most important thing is the existing structure which, in the case of transformation projects, is difficult or quite costly to be changed. In Table 2 is presented a summary of design parameters for adaptability; in red are highlighted the ones that should be applied in new buildings or in different transformation typologies than the selected one. Although these are not relevant for the current research, they point out important principles for designing adaptability.

Modular & Dividable System (Blakstad, 2001; Nakib, n.d.; Sadafi, et al., 2014; Geraedts, et al., 2014; Beadle, et al., 2008; Schnadelbach , 2010; Moffat et al., 2001; Geraedts, 2001; Schmidt III, et al., 2010; Eguchi, et al., 2011). **Abilities:** Spatial flexibility (extendibility-rejectability), rearrangeability, modularity, divisibility

Loose-fit (& dry) connections (Nakib, n.d.; Sadafi, et al., 2014; Geraedts, 2008; Geldermans, et al., 2019; Moffat et al., 2001; Schmidt III, 2014). **Abilities:** Refitability, divisibility, speed of change

Multifunctionality (Nakib, n.d.; Sadafi, et al., 2014; Geraedts, 2008; Beadle, et al., 2008; Schnädelbach, 2010; Moffat et al., 2001). **Abilities:** refitability, convertibility.

Buffer Zones (Nakib, n.d.; De Paris & Lopes, 2018; Aytac, 2016 (Schmidt III, 2014)). **Abilities:** Change-ability, speed of transformation, absorption of tenses, scalability
Lightweight materials (Sadafi, et al., 2014; Estaji, 2017; Geldermans, et al., 2019) **Abilities:** Portability, speed of transformation, scalability (increased volume capacity)
Over-supply of services, over- dimension of structure (Nakib, n.d.; Geraedts & Prins, 2015; Geraedts, 2001; Sadafi, et al., 2014; Moffat et al., 2001; Schmidt III, et al., 2010; Brink Groep, 2014). **Abilities:** Technical and functional flexibility, scalability

Zoning (Nakib, n.d.; Geraedts & Prins, 2015; Geraedts, 2001; Sadafi, et al., 2014; Moffat et al., 2001; De Paris & Lopes, 2018). **Abilities:** Polyvalency, Divisibility, Versatility, Operational Efficiency

Accessibility (Nakib, n.d.; Geraedts & Prins, 2015; Geraedts, 2001; Sadafi, et al., 2014; Moffat et al., 2001; Eguchi, et al., 2011; Brink Groep, 2014). **Abilities:** Durability, maintainability, technical flexibility
Raised floors – Openings (Geraedts & Prins, 2015; Beadle, et al., 2008; Schmidt III, et al., 2010; Moffat et al., 2001; Brink Groep, 2014) **Abilities:** Vertical flexibility, versatility, convertibility

Demountable components: (Geldermans, et al., 2019; Estaji, 2017; Geraedts & Prins, 2015; Sadafi, et al., 2014). **Abilities:** Vertical flexibility, versatility, convertibility

Movable and Portable components: (De Paris & Lopes, 2018; Geldermans, et al., 2019; Geraedts & Prins, 2015; Schnädelbach, 2010; Eguchi, et al., 2011; Brink Groep, 2014). **Abilities:** Adjustability, movability, partitionability, spatial and functional flexibility.

Re-usable components: (Geldermans, et al., 2019; Sadafi, et al., 2014; Manewa, et al., 2013). **Abilities:** circularity, reusability, sustainability, movability.

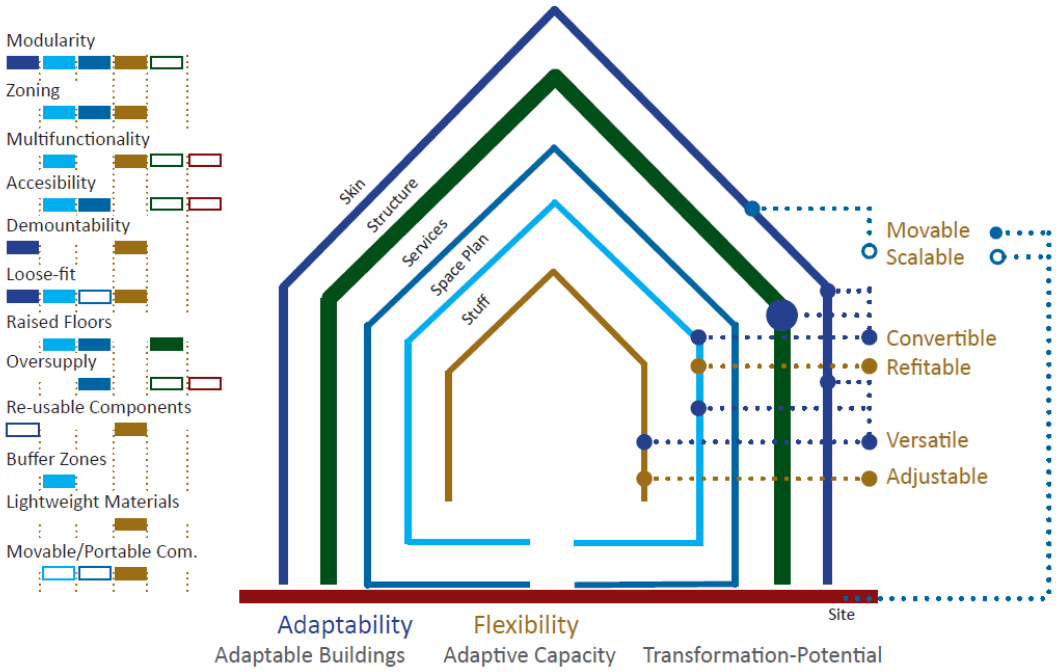


Figure 18: The design indicators for adaptability, own illustration

Chapter 3

Empirical research

Having in mind the existence of a set of indicators and the missing part of their value-meaning for the professionals, the author decided to conduct a Delphi research in combination with semi-structured interviews. The former method was used to give an order to the different design indicators while the second to increase the understanding, causes, risks and opportunities of adaptability. Moreover, the one-to-one talks were a tool to validate the "correctness" of the gathered data and identify possible gaps in the literature review. To increase the comprehensiveness of the findings and enhance the creation of a general accepted design Framework the author tried to gather participants who represent most of the real estate expertise. The expectations of these tow empirical research methods were to confirm the design indicators gathered by the literature, elaborate on them and on the importance, threats and consideration of adaptability. Fortunately, a variety of professionals accepted the invitation and many qualitative and quantitative data gathered to enhance the validity of the research.

The **Delphi method** is used in order to aggregate the responses of a group in order to improve the decision-making process (Delbecq, 1975). Moreover, it is considered to be a way to capture individual perspectives on topics that the literature review cannot cover completely or wherever there is failure of consensus (Delbecq, 1975; Remoy, et al., 2007). Usually, a Delphi Method consists of two to four rounds dependent on the characteristics of the research and the existing knowledge on the topic. According to Skulmoski et al. (2002), the two or three rounds of Delphi are efficient when the goal of the research is to qualify different opinions and understand the different perspectives among the interviewees (G. J. Skulmoski, F. T. Hartman, 2002). In this thesis, two rounds were conducted as there has been a lot of research on this specific topic alongside with the time limitation, the pre-determined indicators and the objectives of the research (Remoy, et al., 2007). The number of the participants and their expertise on the topic are crucial for the success of the research. In the current research seventeen people accepted the invitation, all of them highly related with the real estate sector.

As required by the Delphi methodology, the research took place in one-by-one meetings. So, after the conduction of the first Delphi round, the interview part started. In **semi-structured interviews** both open and closed questions are included. According to Bryman, a semi-structured interview is a flexible way to interview participants based on an interview guide (Bryman, 2012). In comparison with the Delphi part, the interviews session was more interactive while the scope was to understand how the participants ranked specific factors, based on what beliefs and which is their general understanding and strategies on the topic.

Chapter 4

Research Findings

A variety of data were gathered from the different methods used. These data cover all the aspects of adaptability, starting from the definition to limitations, layers, abilities and risks. Starting from the latter, one of the main research objectives is the importance of adaptability; what makes adaptability valuable. Based on the definition of adaptability adopted by Schmidt there are four things that adaptability consists of (Schmidt III, 2014). During the semi-structured interviews section, the interviewees were asked to elaborate on these four aspects, and an outcome created was that the most important is the ability of a building to remain fit[2]. This seems to be rational, at least in comparison with the ability to change (function) as the latter is a more expensive activity during a building's operation phase (Schleurholts, 2019).

Secondly, the research about the costs and benefits of adaptability adduced a pattern of pros and cons. Regarding the drawbacks of adaptability and the data gathered from the hybrid methods a main shortcut seems to be the incapacity of the existing real estate industry and the financial models to captures the value of adaptability. In addition to this, adaptability is usually related to higher investment costs and uncertainty of payback time, which create a negative atmosphere when deciding about the re-design of a(n) (adaptable) project. Of course, these shortcomings can be recognized in new projects. The information gathered during the empirical research was valuable as confirmed the literature study and added the personal perspective of the practitioners. That was helpful as some "solutions" to overcome these drawbacks were indicated.

Main Findings			
Costs	Benefits	Adapt-Abilities	Lessons Learned
Uncertainty of "payback time"	Improved investment value	Adjustable	Uniqueness of each Project
Timelapse between the costs and benefits of flexibility	Increased building's longevity	Versatile	Importance of Layers
Higher Risk and higher investment	Reduced change impact	Refitable	Ability to remain Fit
Absence of financial models that can measure adaptability	Improved oper. efficiency	Convertible	Detailing
Education	Sustainability, durability etc	Scalable Movable	Multifunctionality
Industry conventions	Higher re-sale value	Future Proof	Adaptable Structure
Convencional mindsets	Freedom of choice	Durable	Design Principles
	Reduction of uncertainty due to technology, trends etc	Feasible	
	Higher users' satisfaction		

Table 12: Main research findings on adaptability

The benefits of adaptability, the most-wanted abilities and the tools to create the required level of adaptive capacity is the third set of input by the research. Concerning the tools, fortunately the empirical research confirmed the design indicators that were adopted by literature (see section 2.5-2.7). The most wanted "abilities" is an input based on the scientific knowledge, as the existing research

[2] Almost all the interviewees agreed that the ability to remain fit is the most valuable aspect of adaptability.

is comprehensive and well developed (Geraedts, et al., 2014; Nakib, n.d.; Schmidt III, 2014). Lastly, the list of benefits was created having as backbone the literature and as finishing the interviews and the Delphi elaboration (the value creation grading part). Additive to this, come the "lessons learned". This part is mostly created by the interviews section (see 3.2.2).

The criteria for the Framework's development are based on the findings (Table 13). The first thing to be mentioned is the "Layers". Afterwards, the solutions that are focused on short-term values are not that important for the practitioners. This means that flexibility is welcome, especially if not extreme costs are required, but will not add that much end value to the project (this is an outcome of the two parts of the empirical research). The second "criterion" comes is parallel with the first one, as both describe the importance of the layering and the long-term value of adaptability, which as described in Chapter two, is deferent from flexibility. Finally, there are design tools/indicators that do not add extra costs, and these are the most desirable ones.Nevertheless, in some cases more indicators need to be used to make a future proof project. "solutions" to overcome these drawbacks were indicated.

Criteria
• Balance between cost-value • Analysis of the project a. Transformation potential b. Building's and environment's characteristics • Basic Principles of Adaptability • Desirable Accommodation Opportunities • Definition of existing risks and threats • Impact on Layers

Table 13: Criteria for the Framework development, own illustration

Chapter 5

The Framework

Concerning the different requirements that each project may state; the proposed design framework consists of three degrees (grades). These were created based on the Delphi results regarding the cost impact, value and importance in order to give solutions that fit to different circumstances. The existence of these three grades can be translated to extra values (accommodation opportunities) of a transformation project. The one degree does not negate the other, but they work as three steps. The first, is the most basic one which can guarantee the creation of an adaptable basis and convey to the project the pillars of adaptive capacity without adding extra costs on the initial investment. Then, dependent on the specific demands and analysis, more abilities may be needed. In that case the decision makers or the designers can use design tools from the next degrees.

The word "degree" underlines an order based on which an adaptable strategy should be developed.

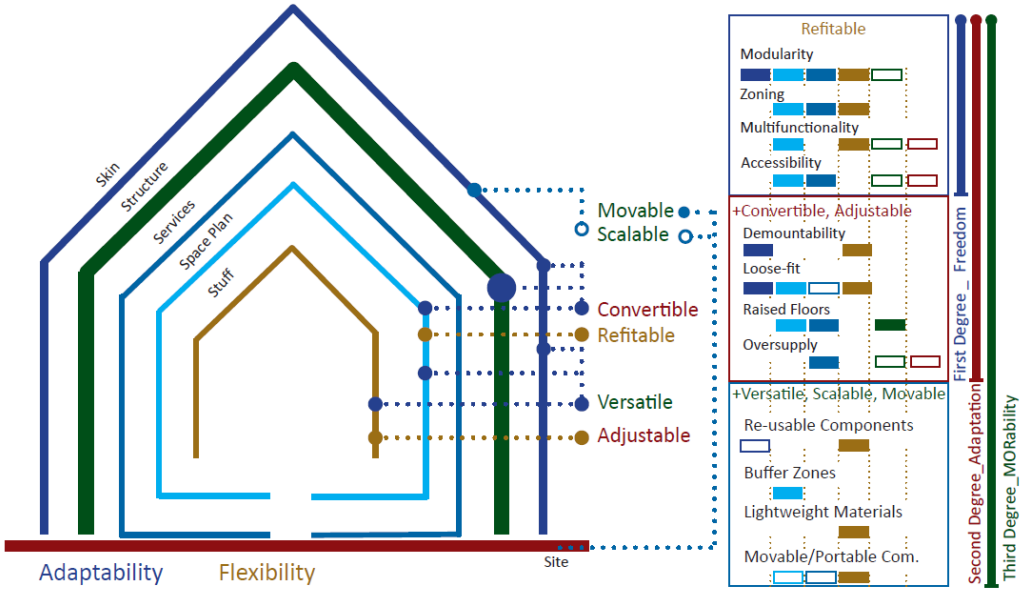


Figure 23: Degrees od Adaptability, the Framecycle and the Building's Layers, own illustration

The First Degree – "Freedom"

The first degree is the most generic one, developed on design techniques that have high value independent on the project. These are the ones that should be applied not only in transformation project but in the majority of projects as they increase the buildings' efficiency. It consists of the first four design parameters of Framework. The "modular and dividable system", "zoning" and "accessibility" can be considered as indicators for high qualitative buildings or as was stated during the interviews "must have a good zoning, a good grid and the ability to maintain and access properly your systems" (Hobma, 2019; van Rijn, 2019). So, the **first degree** can be considered as the basis or the **"backbone" for an adaptable project**. Extra initial costs are not considered in this degree, as the design indicators do not include any extra material costs while they only need a more detailed and proper design. Therefore the first degree can be assumed that only includes increased architects' fees, because of the extra detailing in design (6% instead of 4%) (Geraedts, 2001) (Moiseenko, 2017). Moreover, the assumption of low-cost impact is supported by the conducted Delphi research, where these four parameters had a low-or zero- cost impact on the initial investment.

The Second Degree – "Adaptation"

The second degree consists of the first eight first design parameters of the Framework. In comparison with the previous, low-cost degree, the second one includes two design parameters that can be quite costly for the project, the oversupply of services and the raised floors. In this degree these parameters will be used in their "less expensive" version. On the other hand, the context of "modularity", "zoning", "multifunctionality" and "accessibility" of the first degree is extended. Therefore the second degree will have 5% additional costs in the initial investment phase and increased (6% instead of 4%) architects' fees due to the high need for detailing (Moiseenko, 2017; Schmidt III, 2014; Geraedts, 2001; Schenk, et al., 2009; van Eerden, 2018). The combination of the first basic parameters and the four extra ones creates a more adaptable project. The advantages of it is the vertical flexibility and connectibility, the easy and quick in change construction details and the technical flexibility for different uses. The most important types of adaptability that can expressed by this Degree are the

rearrange-ability[3] (Geraedts, et al., 2014), the space convertibility (Schmidt III, 2014), the visitability (Estaji, 2017), the divisibility-partitionability (Geraedts, 2001), the lifetime compatibility in the services and skin layer (Estaji, 2017), vertical and horizontal scalability, the durability and maintainability (Estaji, 2017). Moreover, expandability in the quantity-density of spaces (Estaji, 2017) and refitability are added (Schmidt III, 2014). Although, considering the Framecycle by Schmidt III (2014) the ability gained with the first Degree is **Refitability**, **Convertibility** and some aspects of versatility (table 16).

The Third Degree - MORadaptability

In the third degree, all the (12) design indicators are included. In this stage, all the design indicators can be used in their maximum capacity, while the final strategy design should be formed based on the project and the market. The four new ones are namely "buffer zones", lightweight materials", "movable and portable components" and "reusable components". This degree is graded with the highest grade of adaptive capacity, as it includes elements and capacities in each layer (Table 17). Of course, this adaptability generates extra investment costs. The difficulty at this stage is to calculate the actual amount of extra money due to the diversity of building costs and the lack of data. Even though, the characteristics of the third degree can be easily recognized in the MOR case, the project is still in the process of making and no final cost estimations can be made.

	Site	Structure	Skin	Services	Space	Stuff	
Modular an dividable system							Refitability
Zoning							
Multifunctionality							
Accessibility							
Demountable units and modules							Versatility & Convertibility
Loose fit connections							
Raised floors, openings							
Oversupply of services, systems, facilities							
Reusable components							**Adjustability & Scalability,** Movability
Buffer zones							
Lightweight materials							
Movable an portable components							

Table 17: Degrees of Adaptability, the Framecycle and the Building's Layers, own illustration

The Case -study

To illustrate the process of the framework's implementation a case study was used, the MOR project (section 5.3). What comes before the implementation of a real estate strategy is the market analysis, the scenario planning and a SWOT analysis that will help the developers, or architects to define the project specific requirements. Based on the scenario planning, tow extreme accommodation scenarios are developed, and the final strategy should be evaluated on these in order to assess the capacity of the building to be future proof (de Jonge, et al., 2009). The final decision making for most appropriate strategy will be based on the "Perspectives of Adaptability" which are the Space, Function, Componentry and Time (Schmidt III, 2014).

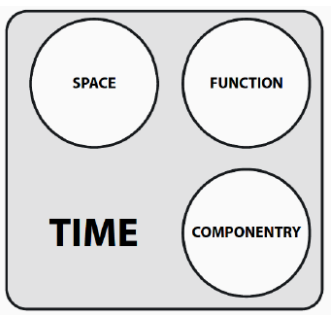


Figure 28: Perspectives of adaptability, Schmidt III, 2014

[3] or according to Geraedts et al., 2014, the transformation Dynamics

The analysis of the three probable adaptable real state strategies (that can be developed with the implementation of the Framework) and of one non-adaptable strategy is conducted based on a mis-match table, derived by the scenario planning, and on a risks-timeline developed based on the literature and empirical research (section 5.3.4).

Main Conclusion

According to literature, adaptability is relevant when talking about sustainability and future proofness (Aytac, et al., 2016). By following the definition of adaptability, we can find the characteristics of the concept which lead to the extension of a building's life and its more efficient operation. The ability to remain fit, the capacity to change functions and forms, the increased value and the extended lifecycle alongside with the speed of adaptation, are components that constitute a future proof real estate object (Schmidt III, 2014; Geraedts, 2008). Into this context the building is not perceived as a finished product (non-dynamic) but as a dynamic asset that has the capacity to be adjusted to external parameters that can cause obsolescence.

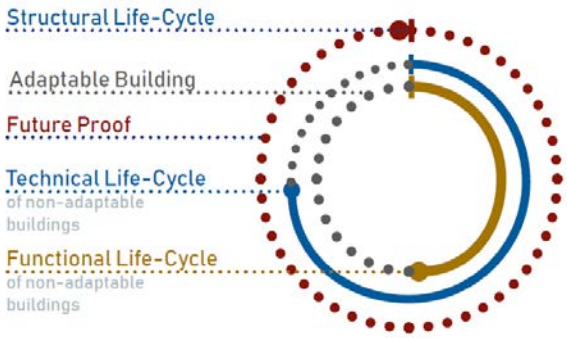


Figure 1: The circle of a building's potential lifecycle, own illustration

To propose a scientific way for real estate developments of future proof transformation objects the author conducted a research and created a design framework which supports the development of adaptable transformation projects. This is called "Degrees of adaptability" and consist of a set of twelve design indicators. Each indicator and each degree contain certain advantages and characteristics. The "Degrees" describe a sequence of steps that should be followed for the development of an efficient, adaptable project. The reason for these three grades is not related with a better or worst building but it is about the most appropriate real estate strategy. A balanced use of the Framework based on each case's requirements and characteristics should be made to develop a feasible, future proof project which has the needed adaptive capacity based on its context.

The Design Framework called "Degrees of Adaptability" was created in order to give a solution to commercial buildings' (re) obsolescence. It describes a set of design techniques to develop future proof buildings that can confront future risks and uncertainties, be adjusted to the changing real estate demand and serve satisfied users. This can be achieved by using the proposed framework in the extend (degree) that is more valuable for each specific case. The Framework was made to be used in transformation projects, which were created under the typology of the commercial core buildings. Nevertheless, the Framework is not a strict guideline. It includes some flexibility on its implementation to fit in all cases of obsolete office buildings (core) regardless their location and market specificities.

In the following diagram are presented the accommodation alternatives through the indicators implemented in each Degree (figure 43).

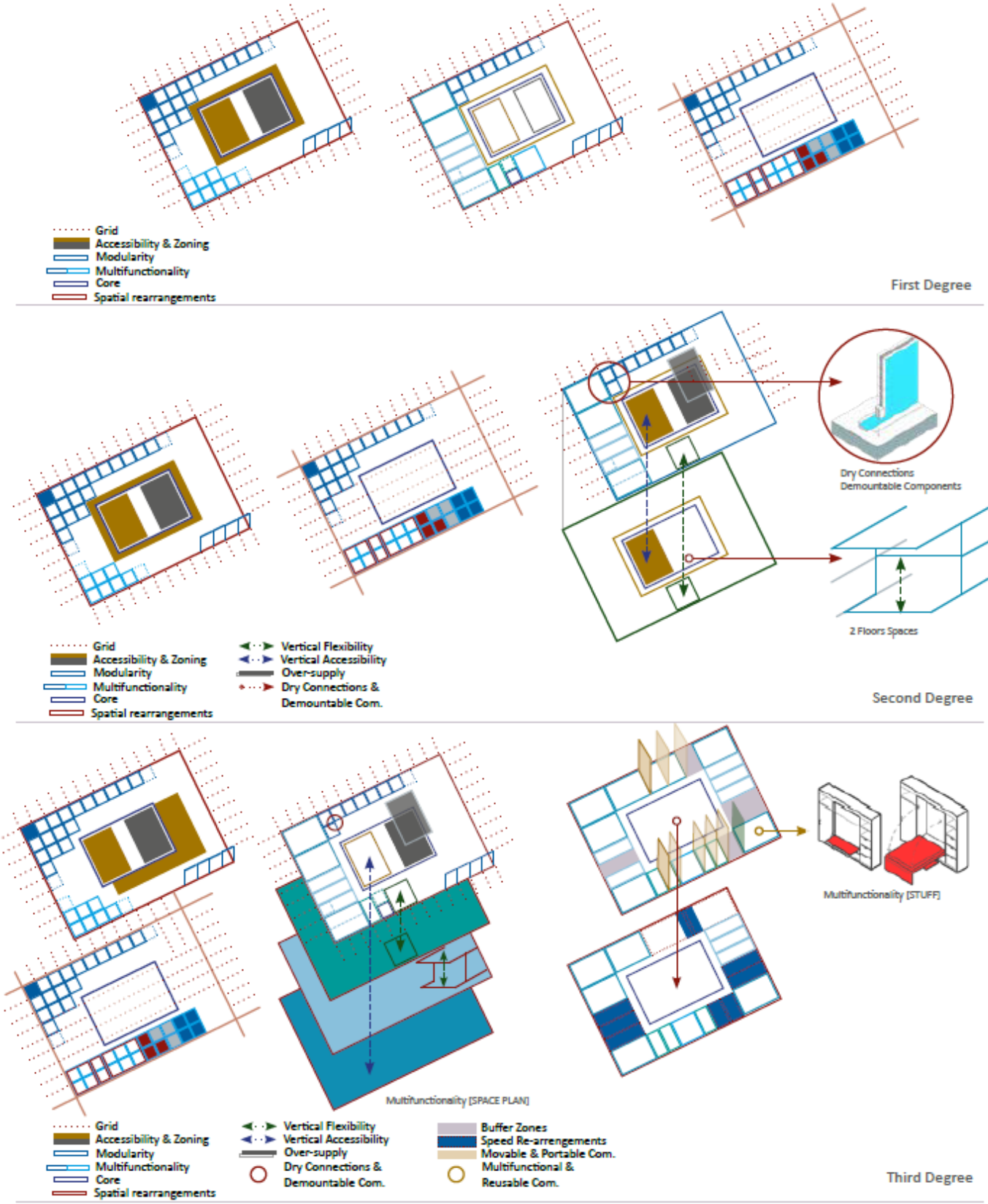


Figure 43: All the accommodation opportunities

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Discussion

The findings of this research indicate that the use of adaptable design strategies can generate a future proof transformation project (Manewa, 2012; Blakstad, 2001; Schmidt III, 2014). These strategies can be based on the "Degrees of adaptability" which is the deisgn outcome of this thesis. This was a result based on both literature and empirical research. The author was quite skeptical on the Framework's designing process and undertook many experiments in order to reach the best outcome. The data used were mainly qualitative as it was not easy to indicate specific quantitative data for the pilot study, as it is yet in process

Concerning the methodology

Starting from the existing research, the expectations from the literature study were met in an acceptable grade. However, what was missing was the actual, qualitative data for designing adaptability. What was surprising is that even though there are many research papers and publications for adaptability, adaptive capacity and transformations it was really hard to find quantitative data, but assumptions and percentage bandwidths. That was a big hardship for this research, this is why empirical research was also conducted. This time the expectations were met, as the author gained the information that was looking for. Through the Delphi method certain quantitative data were gathered, alongside with qualitative ones, that helped the author to interpret on the literature and existing theories. Nevertheless, a drawback was that not all the participants wanted to share real case data due to confidential issues while at some points it was evident that they presented the principles of the company they work and not their personal beliefs. The latter was confronted by asking them more in-depth questions and by conducting a second Delphi round.

Recommendation for Further research

A probable next scientific step would be to create a bank of information about transformation projects. Information about specific difficulties, uncertainties, costs, strategies and revenues is important for the creation of a holistic design framework which can be directly applied in all the typologies of obsolete buildings.

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Figures and Tables

Glossary

In this report some words are used constantly. These describe context that is important for the consistency of the research, thus they are also presented in this glossary in order to avoid mis-understandings.

Dynamic & Non-Dynamic: These words are used to describe the ability (and inability) of a building to be adjusted to the needs of its environment. Dynamic, in this research, is called an adaptable building.

A Non-Dynamic building is one which has a static nature, thus not adaptable.

Design Framework: Design framework is a set of proposed design strategies, tools and/or techniques. In this research is a set of design indicators which are grouped in a specific order.

Future proof: The Collins Dictionary describes the noun future proof as "*If something is future-proof, it will continue to be useful or successful in future if the situation changes*", while google proposes the definition as "*an object unlikely to become obsolete*". The same meaning is followed in this research

Degrees of adaptability (referenced in section 2.3.1): The degrees describe a grade, in this case a grade of adaptability/adaptive capacity.

"Degrees of Adaptability" is called the proposed by the author design framework to underline the importance of steps towards a feasible and balanced strategy.

Adapt-Abilities are called a building's different acquired abilities by the implementation of adaptable design strategies.

Holistic framework is defined in this research as a comprehensive framework that includes all the different perspective of a topic, in this case adaptability.

The definitions of **adaptability**, **flexibility**, **adaptive capacity**, **adaptive reuse**, **obsolescence** and **depreciation** are given in the main text of the research.

Chapter 1 Introduction & Research Design

1. Introduction

Change, for architecture is the biggest fear, as it includes the dimension of cultural-technical progress and time, principles that have been rarely counted in mono-functional architecture. Nevertheless, the world is changing; time and progress are parameters that matter. The way the society reacts, the innovations and the economics are getting reformed so radically and a building -as a finished product (NON-DYNAMIC)- cannot accommodate anymore the new demand (Schmidt III, et al., 2010). Buildings, due to their static nature are getting old, depreciated and inefficient, expressing their failure to absorb the new requirements and integrate new technologies and different life and working styles (JLL, 2013).

Inspired by the Form-follows-function of Louis Sullivan and the Function-reforms-form of Steward Brand (Brand, 1994), the problem of buildings' static nature in the era of sustainability and circularity became a trigger for this research. The reason is the in-ability of the building stock to react to its environment which is contradictory to the increasing awareness of both societal and environmental sustainability. Thus, what is frequently observed is the mismatch between the technical and the functional lifespan of buildings (Figure 1). This perspective of vacant buildings introduces the incapacity of a building to accommodate a new function (functional lifespan) does not match to the technical lifespan of a building (Remoy, 2010). These create the phenomenon of buildings' obsolescence which highly influences the third pillar of sustainability, the economic feasibility.

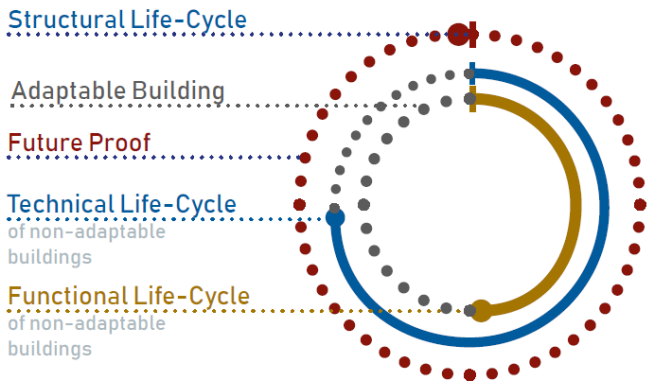


Figure 1: The circle of a building's potential lifecycle, own illustration

1.1 Problem Description and Research Background

Buildings Obsolescence and the risk of Re-Obsolescence

1.1.a Buildings Obsolescence

According to JLL building obsolescence is defined as "*The process or condition of going out of date or being no longer in use/of utility"* while depreciation which is the path towards obsolescence is defined as *"The rate of decline in rental (capital) value of an asset (or group of assets) over time relative to the asset (or group of assets) valued as new with contemporary specification"* (JLL, 2013).

Regarding property vacancy there are two main categories, the physical vacancy which is about assets that *"efficiently clear respective property markets-part of stock that can immediately respond to the demand" and structural vacancy which is about "vacant properties that no longer have a relationship with occupier demand in their present use"* (Muldoon-Smith, 2017). The structural vacancy is linked to the obsolescence and to the location of the vacant building (Muldoon-Smith, 2017).

Obsolescence has many different typologies. According to Baum (1993), these are "*(1)* ***Aesthetic*** *(or visual) obsolescence, resulting from outdated appearance, (2)* ***Functional*** *obsolescence, changes in occupiers' requirements due to new ways of working or new technology, (3)****Legal*** *obsolescence, resulting from the introduction of new standards, (4)* ***Social*** *obsolescence, resulting from increasing demands by occupiers, or by society in general, for better work environments and improved facilities - Tenure obsolescence, where regulatory arrangements become increasingly, (5) inappropriate to meet organizational requirements, (6)* ***Structural/physical*** *obsolescence, resulting from technical deterioration that will make the facility increasingly inadequate. (7)* ***Financial*** *obsolescence, when costs are not balanced by returns and benefits, (8)* ***Environmental*** *obsolescence, when the conditions in a neighborhood render it increasingly unfit for its present usage patterns, (9)****Locational*** *obsolescence, where the resources and image of a location are increasingly detrimental to organizational and staff expectations, (10)* ***Site*** *obsolescence, where site value becomes greater than the facility asset"* (Blakstad, 2001).

Langston (2007) divided building obsolescence into seven (7) categories which are the **physical, the economic, the functional, the technological, the social, the legal, and the political** factors (Aytac, et al., 2016). One more categorization, based on the importance of factors, was made by JLL. In this perspective legislation, technology and corporate requirements are the main drivers for obsolescence (JLL, 2013). Especially, the corporate requirements and technology are drivers for the office vacancy (and/or inefficiency) (JLL, 2013), which constitutes the main problem stated in this thesis.

1.1.b Real Estate Cycles

Vacancy and obsolescence are highly affected by the real estate market, locally and globally, as we can understand after the financial crisis of 2008. The property markets, or real estate markets, are cyclical (Winters, 25.10.2016; Pyhrr, et al., 1999). This is because they are sensitive to exogenous factors and macro-economic figures (Pyhrr, et al., 1999) like demographics, trends and employment growth. This cyclicality is evident for the economic factors, cashflow variables and real estate performance; in global, national and regional level (Pyhrr, et al., 1999). The cycles of economy (Muldoon-Smith, 2017) are factors of high importance that determine, and affect, the success of real estate investments, the returns, the risks and the values of buildings; this is way the cycle theory and analysis has a great position in the decision making process of investors and portfolio managers (Pyhrr, et al., 1999). The inelasticity of real estate markets, as a result of land's scarcity and the time needed for a project to be finished (Muldoon-Smith, 2017). This makes the risk higher for the investors, especially in eras that we are in the top of the cycle. Thus, based on the cycle or the market's standards building obsolescence or vacancy are more than probable to happen when the supply does not much with the demand.

Real Estate Risks and Uncertainties

"A risk is the probable negative impact on the expected value of a real estate development project caused by uncertainty about an event or events that might occur and/or the reduced ability to influence the events, after an actor has irrevocably allocated his scarce resources to that project". (Gehner , 2008, p. 43)

The risks and uncertainties that occur in the real estate market are interdependent with the factors that create obsolescence, endogenous and exogenous (Aytac, et al., 2016). Starting from the latter, exogenous factors are non-steerable, by the investor or the stakeholders of a transformation project, parameters while their predictability can vary. On the other hand, the endogenous parameters are more steerable. Examples are the functional and technical obsolescence which can also be predictable as they are highly dependent on the chosen real estate strategies and the stakeholders of a project. The risks that occur due to the endogenous factors are easier to be confronted by real estate strategies

while for the exogenous risks, the less steerable ones, long term thinking and adaptability in management and strategy design is needed (Gehner , 2008).

"*Risk response is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives*". (Gehner , 2008)

1.1.c Depreciation

Depreciation can be defined as the loss of value of an asset due to both, external and internal indicators (Wofford, 1983). The depreciation, or the decrease of a real estate asset, is another variable of the DCF model that determines the end value. The depreciation rate is crucial for the estimation of the exit capitalization rates and the estimation of the market rental values. Looking at the following formula (1) we can see that the expected return is highly connected with the depreciation rate as it is a result of the sum of the initial yield, the depreciation and the expected income growth (Baum & McElhinney, 2002).

Formula 1: RFR + r = k + g - d

RFR= Risk Free Rate
r=risk premium
k= initial yield
g= expected income growth
d= annual depreciation rate

According to literature, one of the main causes of Depreciation is buildings obsolescence. According to Baum (2002), the main types of obsolescence that affect the depreciation is the physical, functional and aesthetics deterioration (Baum & McElhinney, 2002). Moreover, what has a high impact on the depreciation is the buildings' quality. This consists of the physical deterioration and the obsolescence factors. Moreover, the factors that indicate higher quality, according the research of Baum, are the external appearance, the internal specifications, the space configurations and the deterioration. The most significant one was voted to be the space configuration which can cause incurable depreciation (Baum & McElhinney, 2002). Except of the endogenous factors (internal or external configurations), there are other exogenous parameters that may affect the depreciation rate of a property. As discussed above, the rental values are highly dependent on the demand and supply. These can be affected by macro-economic parameters like the real estate and business cycles, the policy and political changes (Johnstone, 2004). Although there can be some exceptions, the value of the building tends to decrease (depreciated) in line with obsolescence (Baum, 1988). Thus, while confronting the phenomenon of buildings' obsolescence it is expected that the value of a building can be retained high through the years.

1.1.d Adaptive re-use

The phenomenon of buildings obsolescence can be observed globally, and it creates an urban pattern that cannot respond to the changing demographics, on the social and market demand (Bullen, 2007). Low-performing, outdated and insufficient vacant buildings are concerned not only as a financial loss for the owners, but they also affect the general image and safety plan of cities[4] (Remøy, 2010; Remøy & van der Voordt, 2014b; Koppels, Remøy, & El Messlaki, 2011). This makes the need for re-birth of this building-areas (usually the office building-blocks are located as clusters in the business districts of cities) in order to minimize the negative impacts of buildings obsolescence (Manewa, et al., 2013).

[4] Broken window theory

Two probable strategies to confront the negative externalities and obsolescence is the adaptive re-use of the existing stock or the demolition and development of new buildings (Bullen & Love, 2010; Bullen, 2007; Schmidt III, 2014; Shishavan, 2013; Remoy & van der Voordt , 2014). According to Bullen et al. (2010), the adaptive re-use approach to mitigate the changing financial, social and environmental demands is a more sustainable option (Bullen & Love, 2010).

According to Schmidt, the concept of **adaptive reuse** can be described as a **"trajectory of adaptability"**. It is quite related with the transformation of insufficient, semi-used or vacant buildings in order to "revive" them (Schmidt III, 2014). Adaptability and adaptive reuse are not new concepts in the field of architecture and real estate as conversions to other function was a common tactic since Renaissance (Shishavan, 2013). Although, nowadays is gaining more importance as we strive for a more sustainable and environmentally friendly future (Aytac, et al., 2016).

Considering the long structural life of building and the continuous change in market and users' demand, adaptive reuse is a re-birth strategy that could be applied on the scale of a whole city, neighborhood or building. Moreover, it supports the concept of environmental and social sustainability as it reduces the waste of demolition and new construction while, from the societal perspective, it can give a second chance to neighborhoods with criminality or low identity. Usually, the tactic of adaptive reuse is used in office buildings in order to convert them for residential or commercial use (Schmidt III, 2014; Remoy & van der Voordt , 2014). Adaptive reuse is also broadly used in monumental buildings as a conservation strategy (Shishavan, 2013).

Appeared as a challenge for the built environment, raised issues like the environmental problem, the carbon emissions, the social and technological sustainability, seem that can be handled by designing adaptable buildings. All these external factors that affect directly the performance and the efficiency of buildings and consequently its vacancy (Manewa, et al., 2013). Adaptive re-use can be used as the most proper way to deal with the existing, inefficient or obsolete building stock (when the principles and the circumstances allow a transformation) in comparison with demolition which is a waste generating strategy (Manewa, 2012).

1.1.e The Netherlands

During the global financial crisis that started in 2008 in The Netherlands, the real estate sector was affected dramatically (ABN AMRO, 2015). The commercial real estate was one of the sectors that presented the biggest downturn, fact that was obvious through the high vacancy rates of the period 2008-2014 (Bouwinvest, 2016). This led to financial depreciation of the existing, vacant building stock. This existing stock was an opportunity for re-development by real estate developers and investor. The opportunity was reflected to the low cost of buying real estate in central locations while minimizing the construction time and acquiring easier building permits. The idea was to transform these assets to less risky (more stable) functions (Lockhorst, 2019; Mackay, 2019). The number of square meters of office buildings that were redeveloped was around 200.000 sqm in 2012 and ended to be almost 800.000 square meters in 2016 (Dynamis, 2018; Savills, 2018), expressing the big need for another use or the over-supply of offices. Thus, many offices were transformed into residential, because of the increasing demand for housing and the low-risky residential real estate sector (Savills, 2018).

"*Commercial buildings are forever metamorphic, pp.7*" (Brand, 1994)

But is a transformation strategy enough to create a future proof-built environment?

Adaptive re-use and adaptable buildings are theories that can lead the real estate sector to be future proof, as an extension in buildings' life cycle is created. In order to fulfil this purpose a building should

be able to act as a **dynamic** object that can be converted and re-designed through its lifecycle. This need for change during time can be caused by external or internal factors. Buildings should be able to be converted and be adjusted to the future needs over the time (Aytac, et al., 2016; Geraedts, 2008). Although adaptive re-use is a regeneration strategy to revive obsolete buildings, cannot guarantee future proofness due to the big amount of risks and future uncertainties. An adaptive re-use towards a non-dynamic asset is sensitive to aforementioned obsolescence parameters and the need for more dynamic assets is increased.

1.2.1 Societal Relevance of the Problem

An outcome of buildings' obsolescence is an abandoned, underperforming urban system that is not efficient for the urban life. It can cause a series of other problems like criminality in the areas where exists density of empty buildings (Koppels, Remøy, & El Messlaki, 2011) as it is an easy target for vandalism and illegal occupancy, elements that could drive to the undervaluation of a whole area (Remoy, 2010). This is also underlined in the "Broken window theory"; the emptier a building seems to be the more criminal activities will enhance. Such actions is probable to transform a whole area to be unattractive for inhabitation or work, an area of vandalism and criminality (Keizer, 2008). This could be quite obvious in highly urbanized cities with strict zoning plans (Remoy, 2010). By adapting and reviving existing stock we can reverse these circumstances and upgrade a whole district while creating living and working opportunities (Bullen, 2007; Wilkinson & Remoy , 2011).

According to Bullen (2007), adaptation is a way for a more sustainable built environment. While demolition, as a solution to in-efficient or vacant buildings, can cause an extreme use of energy and raw materials, adaptive reuse of the existing stock can drive to less resource consumption, energy use and emissions (Bullen, 2007). **Sustainability via adaptability is achieved in three main pillars which are financial, societal and environmental**. Firstly, the majority of adaptive transformations are cheaper than demolishing and rebuilding (Bullen, 2007). Secondly, adaptability has less environmental footprint and thirdly it can sustain the urban fabric (Aytac, et al., 2016). Moreover, according to literature the problem of sustainability has a global presence and the need of adaptive capacity grows stronger over the years for less CO2 emissions globally (Geraedts & Prins, 2015).

Adaptive re-use, or re-design, of existing stock except of the already mentioned societal problems can solve another major social problem. While many office buildings are vacant another accommodation issue is rising in The Netherlands, the lack of affordable housing (Capital Value, 2016; Czischke & van Bortel, 2018; Boelhouwer & Schiffer, 2016). The residential market is booming, and the rental growth is impressive. These lead to an increasing housing demand, especially for the middle-income households (Boelhouwer & Schiffer, 2016). Moreover, based on the demographic changes and the expected population growth, the shortage of this type of supply will be much bigger in the coming years (PWC, 2018). Also, the type of households changed. Single, two people and elderly households are dominant while families tend to live in the suburbs instead of the city centers. So, the increasing accommodation demand can be specified to small-medium size affordable dwellings for one or two people (PWC, 2018; Capital Value, 2018).

1.2.2 Scientific relevance of the Problem

The issues of office obsolescence and underperforming, inefficient buildings have been under research for many years now. To mitigate this problem, many papers have been already published on the adaptive capacity, on adaptability and on transformation strategies and techniques for vacant office buildings (Pinder, et al., 2017). Except of the scientific research there are also many transformation projects that were developed in The Netherlands during the previous years and drive the vacant stock and the office supply to lower numbers (Remoy & De Jong, 2011; Remoy & Van der Voordt, 2007;

Dynamis, 2018). In all these, academic or practical projects, the main goal is to convert an empty building of an oversupply market (offices) to another that is more aligned to the current market demand (housing sector) or to keep alive from demolition a (cultural - landmark) building (Geraedts & Van der Voordt, 2007). What is observed is that we can find literature on how to transform a building of type A to a building of type B.

The existing literature and practice are mostly based on the perspective of a linear process (design, construct, operate) or a single function direction. What is not common is transformations with a flexibility to be converted from type A to type B and from type B to type A. But, concerning the cycles that economy does (Muldoon-Smith, 2017) the importance of the adaptive capacity of buildings seems to be high. Moreover, there are a lot of research that present design techniques for adaptability, but nor specified to conversions and transformation. Thus, the scientific gap that this research aims to fill in is about the adaptable real estate strategies in transformation projects. Considering the high percentages of transformation projects that take place in the Netherlands, but also the existing obsolete stock worldwide, the need for adaptable strategies specified on transformation seems to be vital.

1.2 Research Design

1.2.1 Problem Statement

The problem stated in this research is the obsolete building's stock and its probable transformation to a non-dynamic object. That rises from the fact that even though many policies and developments are implemented in order to reduce vacancy and upgrade the efficiency of buildings they are focused only on the current demand and context. That enhances the possibility where obsolescence is re-generated. Considering the variety of factors that can cause obsolescence, the chances of a non-adaptable reused (transformed) building to be obsolete again can be quite high based on the context of each case. To conclude, the problem is that the buildings can be multiple times obsolete, even though adaptive re-use strategies have been implemented (transformation projects). This is due to the static nature of the real estate sector and the parallel existence of many uncertainties and risks. Thus, the problem of RE-obsolescence is the problem that this researched is focused on. Although, due to time limitations and the need of a deeper analysis and description of a final design proposal the researched is developed on a specific building category, which presents the higher percentages of vacancy and high potentials for adaptive reuse.

1.2.2 Research Question

Continuing to the rationale of the problem description and problem statement about the existing Obsolete building stock, the need for transformation and the goal of future proofness (confrontation of re-obsolescence), the research question of this research was formed as follows:

"Which are (design framework) and how can adaptability design strategies be applied in order to develop a future-proof transformation project?"

Looking at the research question and the before-mentioned research background, the importance of adaptability for a future proof project is obvious. What is crucial to understand here is that there is not only one path to follow for adaptable real estate. As each project is unique and highly dependent on its actual characteristics and environment, each final strategy should be an outcome of internal and external factors' analysis. That is why the question is referred to strategies and not a strategy. Thus, strict guidance on how to design a future-proof building via adaptability would be a utopia.

Research Sub-questions:

1.Which is the theoretical background of adaptability?

2.Which are the main design indicators of an adaptable transformation project?

3.How can a holistic Framework of adaptability (Degrees of adaptability) be developed?

4.What is the impact of the Degrees of adaptability on the future potentials of the building (pilot study)?

1.2.3 Research Output and Research Objectives

This research is dealing with the obsolete building's stock and is focused on real estate transformation projects. The process of how to design adaptability and the description of the obstacles, the required analysis and the final design parameters will be described in detail in the coming chapters. The main goal is the development of a framework, called "Degrees of Adaptability", which can be applied in office transformation projects in order to convert obsolete offices to dynamic objects. The level of the desirable adaptive capacity will be adopted after the selection of a "Degree". This can be decided based by the stakeholders of a project that want to use the framework based on building, location and market characteristics of each case.

To explain the decision-making process and the use of the framework, a pilot study is developed. This is the MOR case, which is an excellent example of the targeted typology of buildings to be transformed under the principles of the "Degrees of Adaptability". The implementation will happen based on four scenarios, three for each degree of adaptability and one that will represent a non-adaptable building. The reason of this experimentation is to evaluate the impact of the design indicators on the life-cycle (30 years) of the building.

Objectives:

- Identification of the design Indicators for adaptable buildings
- Adjustment of the indicators for use in transformation projects
- Development of the Framework
- Barriers and benefits of the framework in the long term and future-proofness

Relevance with a bigger scale objective

The proposed design Framework is focused only on a specific category and layout typology of buildings, due to time limitations. The researched typology was selected because of its global presence in commercial buildings; which are the ones with high potential of being obsolete or outdated (Dynamis, 2018; JLL, 2013; Remoy, 2010). Moreover, by choosing such an international target the research outcome can be useful in a bigger than the Dutch-specific scale. Nevertheless, except of the researched buildings typology, the principles of the designed framework can be used in a wider variety of buildings, transformations or new projects, as it includes general accepted design parameters. To implement the framework in other cases (different society and typology of building) adjustments and additions should be made. This is mainly due to important design factors and parameters that were excluded from the final framework as being already part of the researched typology. Some of these are the "daylight", the distance for exit and fire protection, the internal floor-to-ceiling-height which

are crucial when designing adaptability[5]. To conclude, the principles of the Framework can be widely implemented and can lead to a synthesis of adaptable, future proof buildings.

1.2.2 Pilot Project- MOR

In order to make the design framework more tangible, it will be implemented and analysed based on a pilot project. The description of the framework and the design outcomes are presented on the floor-plan and floor-plan's alternatives of a specific building to illustrated and explain the different versions and accommodation opportunities created by the proposed framework. Moreover, the project will be analyzed based on its adaptive capacity, environment and context to create a real case scenario in which the implementation of the Framework will be "tested".

The pilot study is the MOR project of the TU Delft Team for the Solar Decathlon Competition 2019 in Hungary. MOR originates from the shortening of Modular Office Renovation, which underlines the purpose of the final design. The project is about the transformation of a vacant office block under the principles of circularity, net-positivity and adaptability. The overall purpose is to re-design a **future proof** building block that could be easily be repetitive to other existing, vacant office blocks. The project is located in M4H area in Rotterdam. This is the Rotterdam's Makers District where Pioneering, craft manufacturing companies, creative entrepreneurs are creating their innovation hub (RotterdamMakersDistrict, 2018). The pilot study is known as the Marconi Towers project, which is the Europoint Complex which marks the entrance to the district of M4H. The transformation design includes in total three, 90 meters high, towers designed by SOM in the '70s under the principle of the classical American building typology style; typology that can be recognized in many other buildings in The Netherlands, but also worldwide.

Figure 2: The MOR project, team's illustration

1.2.4 The Conceptual Model

The conceptual model of the research design reveals the sequence of the concepts and topics that constitute the reason, the process and the final outcome of this master thesis. It shows the rationale of the author's regarding the stated problem of buildings' obsolescence, the two possible

[5] Important design indicators for adaptability that gathered from the interviews and literature study.

confrontation options and the selected tool to deal with it. So, starting from the problem description, derived by literature, the obsolete buildings are an important problem caused by changing lifestyle and accommodation demand while creates inefficient-vacant buildings in an era of materials', homes' and land's scarcity. There are two main alternatives to deal with it, adaptive re-use and demolition and re-built. At the model is evident which is the preference of the author and which is her way of implementing this idea which are based on scientific literature.

Based on the existing scientific knowledge (see Chapter 2) a transformation of an obsolete building into a dynamic object, can lead to an extended life cycle and future proofness. The way that this transformation should be designed, is expressed through the "Degrees of Adaptability", a design framework developed by the author for the purpose of this research. The framework is an outcome of combined research methods and it is designed based on a buildings' specific layout. The implementation and the resulting values of the framework will be illustrated through the MOR case study. This aims at giving directions and advice of how to use the model (framework) in order to achieve the most beneficial result towards Future Proofness.

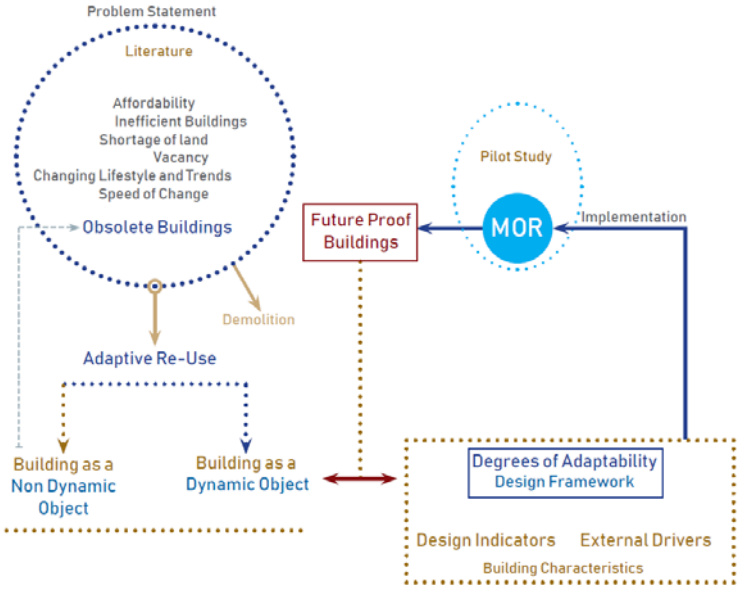


Figure 3: Conceptual Model, own illustration

1.2.5 Research Methodology

The objectives set by the author are multidimensional and necessitate a variety of different findings and data to achieve a final design result that can provide a comprehensive design solution. To fulfil the purpose of this, the author uses Hybrid research methods and the study can be characterized as empirical and formal (operational). Starting from the first part of the research, the empirical, it includes literature review, empirical research and a variety of analysis tools (Barendse, et al., 2012). Thus, the collected data are both, qualitative and quantitative. The operational part, which consists of the final design and the evaluation of it, mainly consists of qualitative data gathered from the empirical and scientific results.

The main methodological tools that used for the Empirical (informal) part of this research is the scientific literature study, the Delphi and the Interviews. Literature review was the starting research point used to create the theoretical framework and background related to adaptability, design indicators and evaluation tools of adaptability. Nevertheless, one of the main objectives of the research is the implementation of the framework from practitioners. Thus, the deep understanding of

their perspective, opinion and interests were crucial for the author resulting a big empirical research. This consist of two methods, the Delphi research method and the semi-structured interviews part (see Chapter Three). The Delphi was used to gather quantitative (grading the indicators based on their importance, cost and value impact) and qualitative data (elaboration on the grading). Through the semi-structured interviews, with real estate experts and professionals, more in-depth qualitative data regarding practitioners' tools, evaluation and designed methods data were collected.

Considering the operational part of the research, which is the answer to the "How?" set by the main research question, a variety of analysis methods were used. The result is the design of the framework which was based on the empirical part's results and constitutes the answer on the main question. So, the final Framework is a synthesis based on the literature, the experts' perspective, the market and economical considerations. The latter is briefly presented in the introduction and in the Appendix related to the Discounted Cash flow methodology but also explained through the SWOT and Scenario Planning analysis. All these analysis, implementation and evaluation of the Framework were developed based on the MOR case study through a variety of floorplan sketches and mis-match comparison tables. The sequence of the methodology formation is illustrated in Figure 4.

1.2.6 Research Design

The research is structured in three main phases (Figure 4). The first one is the theoretical framework, which was the basis of the research. In this first phase various information was gather by literature review on topics related to adaptability.

The second phase was the empirical research. This stage consists of two parts, the Delphi research and the semi-structured interviews. During this period quantitative and qualitative data were gathered. This was also, the last analysis part of the research as it is one step before the synthesis of the Framework.

The third, was the Analysis and Synthesis phase. At this stage, was gathered all the analysis of literature and empirical study findings. These were used for the design of the Degrees of Adaptability Framework, which constitutes the main research objective of this thesis. The last phase is the implementation of the Framework on the pilot study. This process was created in order to illustrate and explain how the Framework should be use, which are the potentials, the benefits and the costs of adaptability.

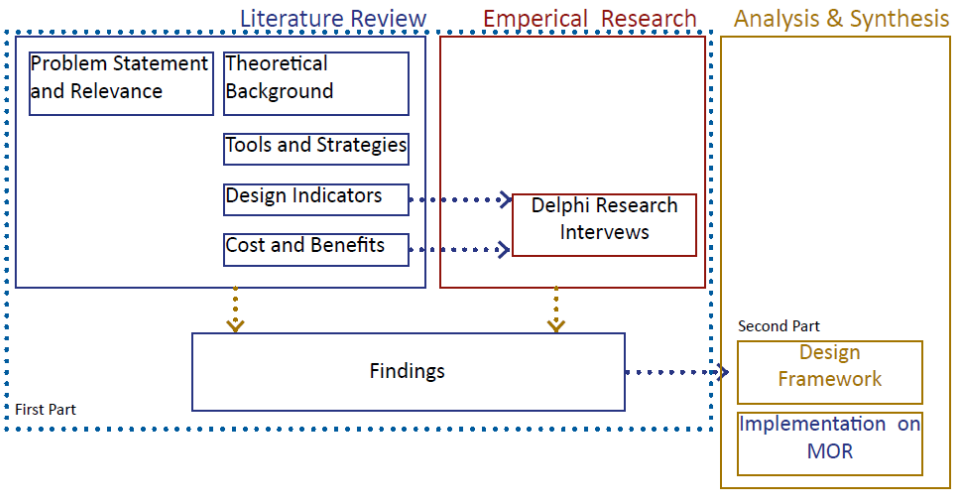


Figure 4: Research Methodology, own illustration

Chapter 2

Theoretical Framework

2.1 Theoretical Framework: The definitions

Many literature studies have been already conducted in the field of adaptability and flexibility. Both are describing the future potential of a building to be changed, adjusted or converted based on different requirements (Estaji, 2017). Even though these topics are not contemporary phenomena, as they have been under discussion since the movement of Modernism, there are still many contradictory definitions and perspectives provided by the literature (Pinder, et al., 2017). Nevertheless, to develop a generally accepted design model for future proof transformation projects it is important that the concepts that are described to be fully identified and consistent. So, the understanding of the differences, the overlapping and the common ground of these two concepts is crucial for this thesis due to the importance of clear definitions for the creation of an efficient framework. To overcome the obstacle of mis-communication an extensive literature study was conducted.

In the literature for adaptability and flexibility is observed that these two topics are overlapping. What is happening is that some researchers present flexibility as a part of adaptability while others use a reverse definition. This gap of a clear definition is possible to create confusion to the understanding, implementation or functioning of a design strategy or design parameters from practitioners. Far from the academic perspective and inconsistency, practitioners seem not to refer at adaptability and flexibility as different concepts but as similar words that describe the ability of an object to change (Pinder, et al., 2017).

Based on what Estaji (2007) explained "Usually, researchers and architects use "flexible" for physical changes and "adaptable" for non-physical changes. Adaptability as capable of different social uses and flexibility as capable of different physical arrangements" (Estaji, 2017). This one is referred to the first part of these broad concepts, the use and functionality. Functionality is also linked to adaptation and the type of change which can be physical, technical, social (Pinder, et al., 2017). Schneider and Till describe adaptability to be more relevant to social changes while flexibility to be about the physical arrangements (Schneider & Till, 2005; Blakstad, 2001). In architecture and the Built Environment there are also other core parts that need to be addressed and described like Time. Time is one of the most important aspects and has a high impact on how to describe it in the process of defining our concepts. What we can see in the literature is that flexibility is described as the shot-term change while adaptability represents the long-term, more dramatic changes (Pinder, et al., 2017; Schmidt III, 2014).

Robert Geraedts distinguish adaptability and flexibility in a qualitative way. He claims that adaptability can be described as a value, like sustainability. Adaptability includes all the characteristics that can create a dynamic building in order to keep its functional value during the technical life cycle. On the other hand, flexibility is considered as a tool of possible measures that enable the adaptability, or the adaptive capacity, of a building (Geraedts & Prins, 2015). In align with the above comes the classification by Swafford (2006)[6] where adaptability is described as a "capability" while flexibility as a "competence" (Gosling, et al., 2008). By this we can understand, that adaptability seems to be a decision in a big scale that includes the smaller scale decisions of flexibility. Consequently, adaptability is a top approach, it creates the constraints and the possibilities. Flexibility is about providing solutions and could be a bottom-up approach (Blakstad, 2001).

Groak (1992), distinguishes adaptability from flexibility based on the type of arrangements that they represent. For him adaptability is referring to capacity to respond to social uses while flexibility is

[6] Swafford, P M, Ghosh, S and Nagash, N M (2006) A framework for assessing value chain agility. *International Journal of Operations and Production Management*, **26** (2), 118- 140

about the ability to change the physical arrangements (Groak, 1992). Another distinction between adaptability and flexibility is presented in the work of Pinder et al. (2017) where they included a table of the existing literature on this context. They referred to the work of Blyth and Worthinghton (2010)[7], Schneider and Till (2005), Leamen and Bordass (2004)[8] and Groak (1992). Following the sequence of names, adaptability is defined as "larger scale changes over a bigger period of time", is about different social uses, infrequent and high magnitude differentiations and territorial changes. On the other hand, flexibility is about "quick, not expensive, low effort changes", "capable of physical arrangements", "frequent and low magnitude changes" and technological adjustments" (Pinder, et al., 2017).

2.1.1 Adaptability

The first step to understand the meaning of adaptability are the components of it; what does adaptability consist of. Schmidt et al. (2010) stated that there are four main characteristics of adaptability (Figure 6). The first one is "the capacity for change", which can be translated in many things like change of the size, function, location. Another one is the ability to remain "fit" or "reduce in mismatches", which is about the connection and the relation between the user and the building. Thirdly comes the value; which is one of the main concerns of this thesis. Many researchers wrote about the value, this meaning range from "maximizing the productive use", "to fit both the context of a system's user and its stakeholders' desires", "at minimum costs". The last characteristic is time; which is another main concept for this thesis. Time indicates the speed of change and the life cycle commitment; long term changes and "extension of use" (Schmidt, et al., 2010; Estaji, 2017).

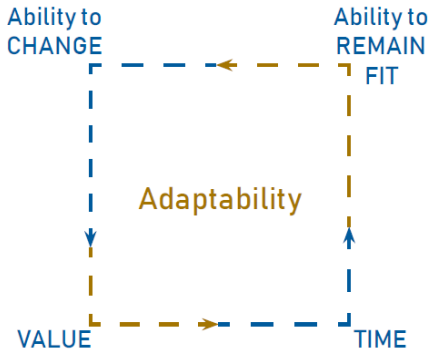


Figure 5: The components of adaptability, own illustration based on Schmidt et al. 2014

"*Adaptability" has become a "buzzword"* (Carthey et al., 2011, p. 89; at Pinder, Schmidt, Austin, Gibb, & Saker, 2017).

The moajority of definitions derived from literature could be classified in two main categories, the users' satisfaction and the extension of life cycle. Starting from the first, adaptability is a concept that contains change in order to meet the future demand or the uncertain user's requirments. This can be defined as a "*probability of changing construction and installation systems in a simple way-easily to* ***meet the modified users' demand***" (Geraedts, 2008; Geraedts & Prins, 2016). This is of course linked to the technical and spatial ability of a building to undergo, in a simple manner, convertions with the less effects on the buildings use and operation (Gijsbers & Lichtenberg, 2012). Same definition and description for adaptability was given by Nakid, who described it as "t*he built-in ability to adapt and adjust to change by meeting different uses, allowing various spatial and functional configurations, and updating technologies without requiring significant disruption of the building, the ongoing activities and the environment"* (Nakib, n.d.). There are also other definitions that conncts adaptability more to the technical capacity to enhance and support flexibility-in-use[9] (Gijsbers & Lichtenberg, 2012).

[7] Blyth, A. and Worthington, J. (2010), *Managing the Brief for Better Design*, 2nd ed., Spon Press, Abingdon.

[8] Leaman, A. and Bordass, B. (2004), "Flexibility and adaptability", in Macmillan, S. (Ed.), *Designing Better Buildings*, Taylor & Francis, Abingdon, pp. 145-156.

[9] *"The ability of a building part to continuously undergo physical changes to the benefit of flexibility-in-use, with no or only minor effects on other building parts" (Gijsbers, 2011; in* (Gijsbers & Lichtenberg, 2012)*)*

Concerning the extension of a building's life cycle, there are quite a lot of descriptions. Some of them are: "*Adaptability is the capacity to change the building's built-environment in order to respond and fit to the evolving demands of its users/ environment maximizing value throughout its lifecycle"* (Schmidt, et al., 2009)*; "The capacity of a building to accommodate effectively the evolving demands of its context"* (Schmidt III, 2014)*; "Adaptability refers to the capacity of buildings to accommodate substantial change. Over the course of a building's lifetime, change is inevitable, both in the social, economic and physical surroundings, and in the needs and expectations of occupants"* (By Sebastian Moffatt, Peter Russell at (Estaji, 2017); *"A building's ability to accommodate change throughout time, fundamentally extending its life"* (Kelly, et al., 2011). In the same concept of *Time*, there is another definition provided by Schuetze where Adaptability describes the ability to easily change form or function, by using circular[10] materials or components, in a way that requires the less effort (Geraedts & Prins, 2015).

The selected definition to be followed and used in this research is the one provided by Schmidt, as it consists of all the main characteristics af adaptability described also by other researchers. So adaptability is:

"The capacity to change the building's built-environment in order to respond and fit to the evolving demands of its users/ environment maximizing value throughout its lifecycle." (Schmidt III, 2014)

2.1.2 Flexibility

Like adaptability, many researchers have already explained and analyzed the topic of flexibility in the Built environment. For the majority of them this topic refers to the "*adaptive response to environmental uncertainty*" or the capacity or the systems included in a building to adjust to the changing demand. What is always present when talking about flexibility is the speed of change, the low energy consumption, the less money and effort needed. Generally, what we can observe is that the term flexibility responds more to the smaller changes that can occur during the life-cycle of a building, changes that can follow a bottom-up perspective. In this type of changes the single user (tenant or employee in the case of offices) has a high influence and power (Gosling, et al., 2008; Till & Schneider, 2005). Thus, flexibility can be described as a proactive capacity for change during the operating life of a building, as a part of a general plan for adaptation (Gosling, et al., 2008; Schneider & Till, 2005; Schmidt III, 2014).

Another aspect of flexibility is the technicalities. Flexibility is deeply connected with the technical capacity of a building to change spatially or adapt new uses and functions (Gijsbers & Lichtenberg, 2012). In contrast with adaptability, as has been described in this Thesis, *Flexibility* is more about physical arrangements and short-term changes as the idea is that a flexible building can answer to a number of prevailing conditions in the Built Environment (Schneider & Till, 2005). Concerning both the spatial and the technological notion of flexibility we can find quite many sub-categories of flexibility. These are the layout flexibility, the re-format flexibility, the spatial/functional flexibility and Technical flexibility. All of the above describe flexibility as "*flexible, supple and easily adaptable to changing conditions"* (Brink Groep, 2014).

The definition of flexibility adopted in this research is:

"Flexibility is generally perceived as an adaptive response to environmental uncertainty as a reflection of the ability of a system to change or react with little penalty in time, effort, cost or performance." (Upton 1994 in Gijsbers & Lichtenberg, 2012)

[10] Materials that can be reused or recycled (Geraedts & Prins, 2015)

2.1.3 Adaptive Capacity

The Adaptive Capacity of a building is its "*ability to maintain its functionality during its natural life on a sustainable and economically viable manner*" and measures the grade at which a building can be adapted to the changing demands (Brink Groep, 2014) while for Aytac et al. (2016), adaptive capacity through an adaptable design is the solution for depreciated, obsolete buildings (Aytac, et al., 2016). According to Geraedts (2014), the adaptive capacity of a building consists of three main parts. These are the *Organizational flexibility*, the *Process Flexibility* and the *Product Flexibility* (Geraedts, et al., 2014). These types represent three different levels of adaptation. The first one expresses the way an institution or organization can use and adapt to its internal changing needs in the building that they are accommodated. The Process Flexibility, is about the capacity to change, rearrange or adapt to the changing demand during the process of initiating, designing and constructing the building. Last but not least, the Product Flexibility is object specific and it is related to the adaptive capacity of the constructed project (Geraedts & Prins, 2015).

The term of *Process Flexibility* has been also discussed by Gosling et.al, 2008, with a quite same meaning but in a different framework. In that case, the authors designed a building adaptation system in which the "*Process flexibility*" is "collaborating" with "*Building Flexibility"* and "*Design for flexibility*" to create the Building Adaptability. In this case, P.F. refers to the ability of a system to "adjust and accommodate changes and disruptions"; of course, in the construction industry is a project specific process meaning that it can accommodate late changes (Gosling, et al., 2008).

2.1.4 Adaptable buildings

Adaptive or adaptable buildings are the ones that were strategically designed in order to be able to adapt to the changing circumstances and needs (Schnädelbach, 2010). In the same direction comes the definition other researchers where adaptable buildings are "***dynamic systems that carry the capacity to accommodate a set of evolving demands regarding space, function, and components' thus maximizing the through life value***" (Manewa, et al., 2013; Estaji, 2017; Geraedts, et al., 2014). The ability to accommodate new uses or being easily altered to prolong its life according to the changing market demand through the way they were designed and constructed is another characteristic of adaptable buildings. (Beadle, et al., 2008; Gijsbers & Lichtenberg, 2012).

2.1.5 Sustainability

Considering the importance of adaptable buildings in the built environment, the most important one is the link with sustainability and future proofness (Nakib, n.d.). One of the concepts that seem to become more and more important in the built environment is **Sustainability.** The term of Sustainability is mainly referred to the environmental perspective, the materials and the energy use for the construction, maintenance and operation phase of the buildings. Although, sustainability incorporates more aspects and can be translated in four main levels, including the environmental perspective (Nakib, n.d.; Manewa, et al., 2013). Sustainability is a concept that is quite interrelated with adaptability and flexibility (Aytac, et al., 2016; Bullen, 2007; Kelly, et al., 2011; Manewa, et al., 2013; Nakib, n.d.; Schnädelbach, 2010; Lansgston, 2012; Nakib, n.d.) that can be easily recognises in the following phrase:

"Sustainable buildings have an in-built ability to adjust to changing circumstances and technologies, without excessive waste and conflict." (Manewa, et al., 2013)

Adaptable design and adaptable buildings enhance the creation of a sustainable real estate environment. Aspects that can be highly promoted by adaptability is durability and recyclability as they are core concepts for a more sustainable design (Geraedts, 2008; Schneider & Till, 2005; Bullen,

2007). Moreover, sustainable real estate can be less affected by financial downturns and obsolescence (Schenk, et al., 2009).

The adaptive reuse of the existing building is a "revitalization" strategy that facilitates sustainable developments in three stages: it requires less energy, it has lower resource consumption and in the majority of times it is less expensive than demolishing and rebuilding (Aytac, et al., 2016). Also, another aspect is the lower CO_2 emissions in the case of adaptive reuse instead of demolition, fact that brings closer Sustainability with the adaptive capacity of the buildings (Wilkinson & Remoy , 2011). According to Bullen (2007), adaptation is an effective strategy to improve the sustainability of existing buildings, particularly as a performance upgrading strategy (Bullen, 2007; Russel & Moffat, 2001).

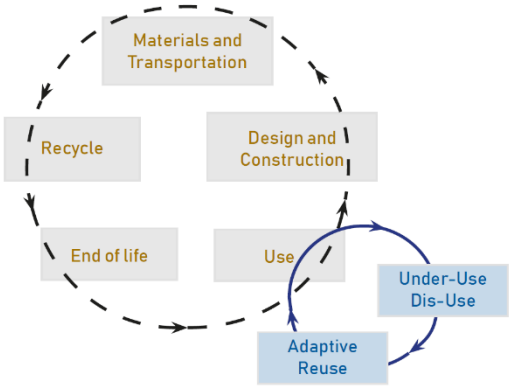


Figure 6: Adaptive reuse approach integrated with sustainable building life cycle approach; adapted from Building Information Modeling (own illustration based on Aytac et al., 2016)

Figure 7 represents the connections between a sustainable building and adaptability. What we can see in the drawing is that in the bottom is designed the *"End of life".* In that stage the building is demolished and the materials that can be reused are recycled. What can be added to this cycle via adaptive capacity in the extension of the buildings' life. In that case, when a building becomes obsolete (the stage before "End of life), adaptability can "put in effect", which by the author is called renewal stage (Aytac, et al., 2016). In the end what we can say is that "Sustainability depends on the long-term utility value of buildings" (Geraedts & Prins, 2015)

In the paper of Schmidt et al. (2010), is stated that "*If a building does not support change and reuse, you have only an illusion of sustainability*". That connects immediately sustainability to adaptability and time; time -and capacity to change during the life of a building- is expressed by adaptability (Schmidt, et al., 2010). The same perspective is promoted by Kelly et al. (2011). They stated that adaptable design strategies which allow changes to happen and add malleability in the building, this enhances the development of a more sustainable environment (Kelly, et al., 2011; Nakib, n.d.).

"A sustainable building is not one that must last forever, but one that can easily adapt to change."
- Peter Graham, Environment Design Guide, 2006, Royal Institute of Australian Architects in Schmidt, et al., 2009.

"The capability to adapt to change or accommodate change is a basic and fundamental premise for the future of society, which is to do with buildings having a long-term future, being capable of modification, for changing aspirations as well as needs." (Schneider & Till, 2005)

Definitions of adaptability and circularity could be also found in the literature. According to Schuetze, adaptability (adaptive capacity) means to be easily adaptable to different functions, "*constructed with components and products, which allow re-use and recycle with a minimum effort and loss of quality"* (Geraedts & Prins, 2015).

Another general concept which is highly connected with Sustainability and Adaptability is the **Future Proofness**. It is about buildings that can be efficient in long term, buildings that can give an answer to the future needs. And this is how adaptability/flexibility are coming in the framework. According to R.

Geraedts, "***without adaptability buildings will reach the limit of their functionality or efficiency much sooner that their expected life cycle***". This means that the depreciation and the obsolescence of the property will come earlier, fact that affects directly the value of the building, its owners and its users (Geraedts, 2008). Except of the environmental perspective of Future profess we have the perspective of social and economic feasibility. In the adaptability definitions we can find terms as social and financially feasible. Future proof in these means is that even though the time passes the building is able to respond to changing human or social needs without losing its value and without being extremely costly (Schneider & Till, 2005).

2.2 Theoretical Framework: The Layers and the Abilities

One of the core frameworks about adaptability, and how buildings change, was firstly designed by Duffy in 1974[11] and formed by Brand in 1994 [12]. The main element of these "levels" is that a building should not be measured as a whole – in material terms but should be divided into parts according to their estimated technical, functional and economic life-cycle (Geraedts & Prins, 2015; Nakib, n.d.; Aytac, et al., 2016). Duffy correlates these sets of different components – levels- by simply looking at the initial costs of a building's development and at the "reoccurring capital" on a time frame of 70 years (Schmidt III, 2014).

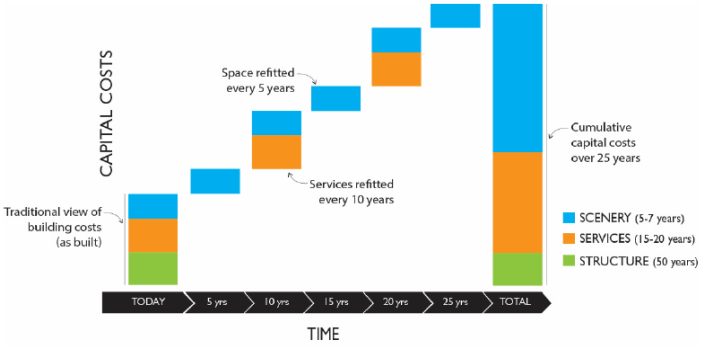


Figure 7: Cumulative Capital Costs over time (Duffy and Henney, 1989 in Schmidt III, 2014)

Brand expanded Duffy's theory to the "Ss". As shown on the following Figure (9) he defined six levels, all starting with an S. These are the Stuff, Space Plan, Services, Skin, Structure and Site. These levels have a different expected life span and could be changed at different time. Of course, the more the overlapping between different levels the more complicated and expensive the adaptation is. More researchers worked[13] on what Brand proposed and a final- holistic brief explanation of what these levels mean is following. Stuff represents the furniture or the smaller objects- fixtures- included in the building, the space plan is about the spatial organisation, the ceiling etc., the services are about the installation (piping etc.), skin in about the façade components, the structure is about the structural elements like the columns and the beams and finally the site is about the location and legal boundaries where the building is placed. In this thesis the "S" of surroundings will be also added in order to include

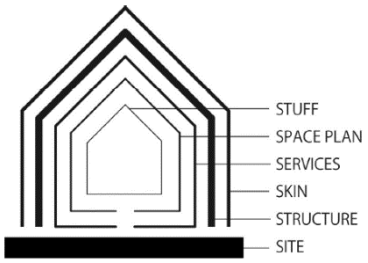


Figure 8: The S's (Brandt, 1994)

[11] Duffy, F. 1974. Office Interiors and Organizations. PhD Dissertation, Princeton University
[12] Brand, S. (1994) *How buildings learn: what happens after they're built*. Penguin, New York
[13] Blyth and Worthington (2000); Blakstad (2001)

the societal integration and feasibility for the MOR project (Schmidt III, 2014; Blakstad, 2001; Kelly, et al., 2011; Remoy, 2010).

"An adaptive building allows slippage between the differently-paced systems of S's."
(Brand, 1994 in Schmidt III, 2014*)*

2.2.1 Types of change

Following the paradigm of Brand's (1994) the building can be separated in six different levels, the six Ss. The layers which change slower dominate the ones who are probable to change more frequent. This means, that site dominates structure and the structure dominates skin etc. The changes that will occur to the layers can be allocated in three main categories, the function, the capacity and the flow (Sadafi, et al., 2014). **The changes in function require adaptability, the changes in capacity require structural (and material) transformation, while the changes in flow could require both spatial and structural transformation**. These types of changes create the interactions among the different levels between the different components of a building (Sadafi, et al., 2014).

2.2.2 "Abilities"

The "layers" of Brand's is the first step to organize a building, to understand its capacities, interrelations and components. The next step is to define the types of changes that a building can accommodate and the strategies to be implemented to fulfil this purpose. An adaptable strategy is a plan of action that is implemented as a way to respond to a changing and dynamic environment (Manewa, 2012). According to Mintzberg, a strategy that can deal with the change towards the creation of a durable project can de reflected through the 5Ps framework. Namely these Ps are the **plan, ploy, pattern, position and perspective** (Mintzberg, 1987). The three first parameters (Ps) are dealing with the macro level of adaptability, position deals with the external environment of the project while the perspective is about the internal characteristics that affect the building, like the stakeholders and the internal interests (Mintzberg, 1987). Thus, an adaptable real estate strategy is influenced by the external and internal environment of the project. It is highly connected with the market, the area, the stakeholders and the building itself.

	Design strategies for adaptability																				
Author/s	Generality	Flexibility/Versatility	Elasticity/Extendable/ Expandable/Scalable	Convertible	Dismantable/ Separable/ Partitionable	Disaggregatable	Prefabrication/ Standardisation	Overcapacity	Movable	Rearrangeable	Reusable/Recyclable	Refitable	Multi-functional	Integratable	Universal	Modularity	Ejectable	Exchangeable
Gann and Barlow (1996)							•	•	•	•								
Blakstad (2001)		•	•		•								•					
Robertson and Sribar (2002)			•		•						•			•				
Arge (2005)	•	•	•													•		
Douglas (2006)		•	•	•	•	•												
Verweij and Poelman (2006)			•															
3DReid (2006)		•	•	•					•		•	•						
Geraedts (2008)		•	•		•				•	•					•		•	•
Pati *et al.* (2008)		•	•	•														
Gijsbers *et al.* (2009)		•			•		•		•									

Figure 9: Strategies on Adaptability (Schmidt III, 2014)

Based on the existing literature of adaptable strategies (Figure 10), Robert Schmidt and the Adaptable Futures team proposed a theoretical framework which includes in total six adaptability strategies (Figure 11). These are the Adjustable, Versatile, Refitable, Convertible, Scalable and Movable. The "ables" are positioned in the "Framecycle", which also reflects

the levels of Steward Brand, as the proposed three strategies go from the smaller to the bigger scale (Schmidt, et al., 2009; Schmidt III, 2014).

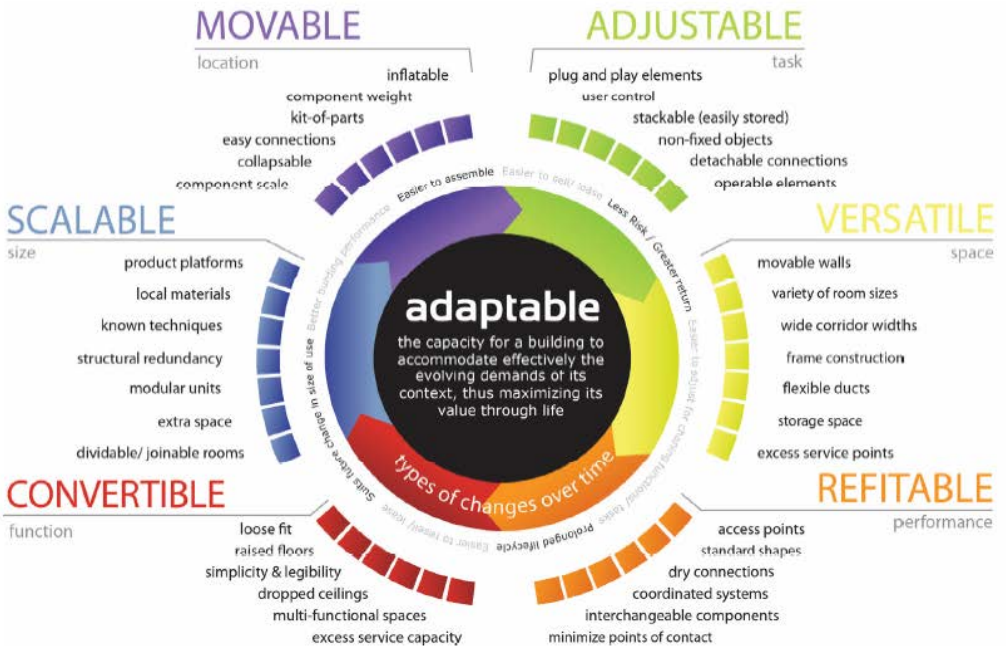


Figure 10: The Framecycle (Schmidt, 2014)

Adjustable indicates the change of task. It is about the furniture types, the coordinated connections, the modules, the systems and the easy interfaces. In this type of adaptability, the decision maker is the user and in comparison, with the layers of Brand's it is about the Stuff. What causes the need for adjustability is mainly the user, or a probable need for change in tasks. Versatile, is an ability mainly driven by the need of change in activities and operations. There is a direct connection with the layers of Stuff, Space, Skin and a probable connection with services and structure. It represents the change of space, an action that is also in the decision level of the user and, as the Adjustable type, has a life cycle that could be daily or monthly. Both are changes that can happen in the scale of the components. Versatility can be also expressed in the layer of skin, while it can be connected to services and structure but with a lower impact on them (Schmidt, et al., 2009; Schmidt III, 2014).

Refitable and Convertible represent different Brand levels. The first strategy, Refitable, is the "change of performance", while Convertible is the "change of function". Refitability, generally caused by the age of the building or technology, is more evident in the layer of space while can be also expressed through skin, but with a lower impact. On the other hand, convertibility is mainly caused by the change in ownership and it is about the function of a building. It is highly linked to the layers of Space, Skin and Structure while it has a probable impact on the layer of Services. Both of them are in the decision level of owner and user. Where we find differences is on the life cycle of the change and the scale that they represent. The change of performance is about the components of the building and represent a potential of change almost every 7 years. On the other hand, the change of function is about the building scale and it is possible to happen every 15 years (Schmidt, et al., 2009; Schmidt III, 2014).

The two last strategies which are completely in the decision level of the owner are the Movable and the Scalable. Starting from the one with the smaller cycle speed- 15 years, the Scale-ability, symbolizes the change of size and loads. Even If it is in the scale of building it also has an application to more than one Brand levels. Scalability can be implemented in Skin and Site and is mainly driven by the market changes; fact that proves that is a broad, multi sale type of adaptability. The last ability, Movable, has

30 years possibility for change, is mainly about the change of location. Although, according to Schmidt there is a probable connection with all the layers of Brandt's. (Schmidt, et al., 2009; Schmidt III, 2014).

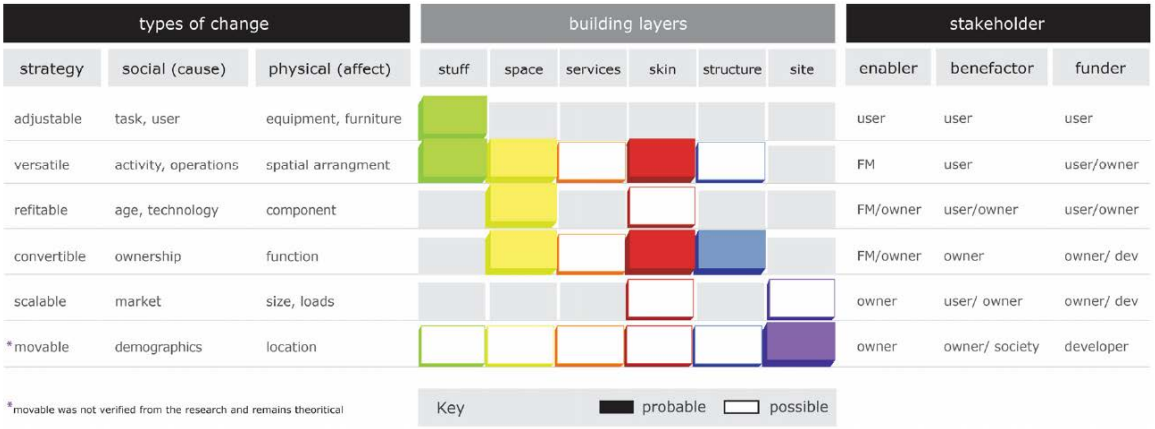


Figure 11: Linking Model (Schmidt III., 2014)

The framework proposed by the Adaptable Futures and Schmidt is the more comprehensive one, thus the one that give a more holistic understanding about the "abilities" that an adaptable building has. Although, there are more "abilities" described in the literature (Aytac, et al., 2016). Aytac selected numerous of these, which are presented in the following box (1). Looking at them, we can see a big overlap between meanings and abilities, but this can also give us a good understanding of the depth that this sector had been researched all these years. Moreover, some of the following abilities describe better the sub-components of the six abilities of Schmidt's, concerning the design strategies and the spatial arrangements of its ability. To conclude, these abilities give us the context based on which we can develop the Frameworks of the design Parameters. This is dependent on the type of abilities that we want our project to have. Of course, the final selection of the preferred abilities should be project specific. That is the reason that the Framework to be developed is not a guideline.

Transferability, Combinability, Recyclability, Scalability, Rearrangeability, Dismantlability, Convertibility, Demountability, Dissagretability, Visitability, Divisibility, Multifunctionality, Durability, Expandability

Box 1: Box of Abilities, based on Aytac, et al., 2016

2.3 How to assess and design adaptability

2.3.1 Evaluation of transformation potential

The benefits and the additive accommodation opportunities of a dynamic building can increase the willingness of real estate professionals to implement adaptable strategies on their projects. This can mainly happen in areas where the need of adjustability is higher or where the market is riskier. The importance of the **degree of adaptability**, so the required extra accommodation scenarios to be covered, can be defined through the area's and building's analysis. In the case of transformation projects there is an extra step, to define the "transformation potential" of them. In comparison with the new projects that can be designed from scratch, the existing buildings inherit many limitations at the transformation process and design. Thus, it is critical to first assess the capacity of a building to be transformed and then its capacity to be re-designed in an adaptable manner. The evaluation of the ability of an existing building to be transformed is not an objective of this research. Nevertheless, it is important to understand the way this assessment takes place, which are the important characteristics

that are graded, and which are the important components to pay attention at. So, for a better insight on the assessment of transformation potential of a building two scientific methods are described.

2.3.1.a Transformation potential of office buildings (Methods)

The ***Conversion Meter*** is one of the tools that can be used in order to measure the transformation potential of a building. It has in total six steps (Figure 13), which can help the user to define if a specific building has a transformation potential. The zero (0) step is to identify the vacant or to-be-vacant buildings exist in the area. Then, in step one (1) a quickscan based on veto criteria should be implemented (in area level) for a first appraisal on this vacant stock. In step two (2), another list of feasibility's criteria, named gradual criteria, are assessed to identify the feasibility of the transformation in the area and building level. In step three (3) the degree of transformability can be assessed while in step four (4) a more detailed financial appraisal is made. If the transformation evaluated to be financially feasible (in step 4), then the last step is the risk assessment analysis which includes a checklist of risk planning (Geraedts et al., 2017). This tool is including both the level of the building and the area. This helps to have a more holistic approach on the potential project to be transformed alongside with its surrounding and the dynamic of the area. Indeed, to transform a building into a successful residential or mixed-use asset it is more than important to analyze the market and the location. This tool is a nice start in order to understand the character and the probability of a project (de Ridder, 2018).

Step	Action	Level	Outcome
Step 0	Inventory market supply of unoccupied offices	Stock	Location of unoccupied offices
Step 1	Quick Scan: initial appraisal of unoccupied offices using veto criteria	Location Building	Selection or rejection of offices for further study; Go / No Go decision
Step 2	Feasibility scan: further appraisal using gradual criteria	Location Building	Judgement about transformation potential of office building
Step 3	Determination of transformation class	Location Building	Indicates transformation potential on 5-point scale from excellent to not transformable
Further analysis (optional, and may be performed in reverse order if so desired):			
Step 4	Financial feasibility scan using design	Building	Indicates financial/economic feasibility Sketch and cost-benefit analysis; Go / No Go decision
Step 5	Risk assessment checklist	Location Building	Highlights areas of concern in transformation plan; Go / No Go decision

Figure 12: Conversion meter (Geraedts et al., 2017)

A more technical approach is expressed through the ***ABT Quickscan***. This tool does not take into account the market characteristics of the object but its technical feasibility to be transformed in another function. The conditions that are evaluated in order to assess the transformation potential of a building are, as shown in Figure 14), the location, the exterior, the installations, the construction (supporting structure), the interior of the building and the entrances. All of these are divided in three predetermined assessment sub-categories of the "current state£, the "quality" and the "legislation". Through this tool both hard (legislation and current state) and soft (quality- cultural and emotional) approaches are taken into consideration (de Ridder, 2018).

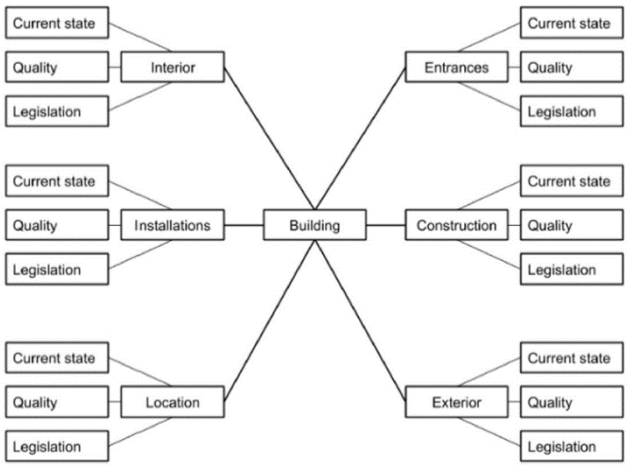


Figure 13: ABT Quickscan (de Ridder, 2018

2.3.2 Assessment of Adaptability and Adaptive capacity of buildings (Methods)

According to Gijsbers et al., the final assessment of flexibility/adaptability is made by the user. This is more than rational as in the definition of adaptability adopted by Schmidt III the user is one of the included parameters to extend the functional life of an object (building): "being able to adjust to the changing users' requirements" (Schmidt III, 2014). So, we can accept and adopt Gijsbers consideration about the users' power and importance in assessing adaptability/flexibility. Based on that, Gijsbers is concluding that the optimum goal is to achieve a balance between the (users') demand and the supply in order to maximize the functional and economical life span of the building (Gijsbers & Lichtenberg, 2012). Same considerations we can find in the work of Geraedts et al. (2014) as it is presented in Figure 8. He expanded the number of actors in the demand side and described three main players that are inked to the demand, the User, the Owner and the Society. All of them, in a higher or lower degree, according to the project and its environment, are important to create the final real estate supply (Geraedts, et al., 2014).

2.3.2.a The CSA method

The Comparative Selection Method (CSA) was made in order to fill the gap between the design selection and the users' demand in the future, based on scenarios. It was developed to accurately select and compare design parameters for the decision making on flexible and adaptable measures that can be used by the designers in the design phase of a project. The first step is to list the indicators for an effective design based on a scenario. These adaptive measures will be accessed on three main parts. The (1) "requires effort of adaptation", (2) environmental and (3) financial costs. Each adaptability measure will have a score of these three parts which will be evaluated individually. This is because the different measures represent different things and they cannot be directly compared. Moreover, each indicator expresses another need and affects differently the stakeholders. Generally, the CSA method offers an optimized solution based of the effects of every possible adaptive measure and helps in the final decision making (Gijsbers & Lichtenberg, 2012).

The model has ten steps that can be divided in two domains. The first part is about the user preferences (step 1-3). This includes the (1) "*Scenario description: change in user situation*", (2) *"Identification and prioritization of functional demands", (3) "Definition of required flexibility-in-use*". The second domain has the four final steps which include the building technology (steps 4-7) and the final quantification and comparison of the adaptability measures (step 8-10). The steps 4-10 in detail: (4) "*Identification of building components in the preliminary design and analysis of the technical and functional interrelations", (5) "Identification of building parts that are of great influence on the relevant functional demands using Quality Function Deployment", (6) "Selection of an appropriate adaptability measure for the identified building parts of step 5, followed by technical concepts for suitable solutions, (7) "Determination of the building technical cohesion and interrelations between the solution variants (of step 6) and the building parts in the preliminary design (step 4) using the Coupling Index; Definition of construction plan for each adaptability solution", (8) "Quantification of construction effort, costs and environmental costs for each adaptability solution", (9) Comparison of the efficiency of the adaptability solutions based on the scores in step 8; Selection of most appropriate solution based on stakeholders preferences", (10) "Verification of the suitability of the selected adaptability measure to the user demands from step 2*". (Gijsbers & Lichtenberg, 2012).

2.3.2.b The ADAPT STAR Model

The AdaptStar Model was developed in Australia as a means of evaluating design criteria based on a pilot project and the existing literature. The model was built on the seven obsolescence types to determine the weighted value; "*Physical (Long Life); Economic (Location); Functional (Loose Fit); Technological (Low Energy); Social (Sense of Place); Legal (Quality Standard) and Political (Context*)" .

Numerical grading will be used in order to assess the design criteria and produce the foundations for a new design. The grading varies from significant to not significant. To evaluate the final design criteria (maximum 100%) every sub-category of the obsolescence types has a value of 14.29 %, the final evaluation (score) provides the Star rating of the building; the higher the rating the best adaptive reuse opportunities (Conejos & Langston , 2010). The model is based on survey results and in experts' and clients' preferences, so it is project specific and quite sensitive to the client's preferences; the awareness of the importance of adaptive reuse is crucial (Conejos, 2013).

2.3.2.c FLEX 2.0 & AC

The ***Flex 2.0*** was the further developed method of the 143 indicators that were presented by Geraedts et al. in 2014[14]. It was made in order to fill the gap for a generally accepted way of accessing criteria for adaptability. In fact, Flex 2.0 is a practical instrument that can be used in construction practice and for me was the base to develop my own framework for adaptability indicators. Same as many other researchers, the Flex 2.0 method has clusters of indicators for assessment based on the layers first developed by Duffy and Brand (1994). The model comprises 83 flexibility performance indicators under 5 layers (in analogy with the ones of Brands). After the Flex 2.0 a smaller list of indicators were presented, the Flex 2.0 Light with the most important, 17, indicators (Geraedts & Prins, 2016).

The way that the model works is first by clustering each indicator into one of the following levels (1) Site/location, (2) Structure. (3) Skin, (4) Facilities (services) and (5) Space plan/finishing. Each indicator has a weighting factor (1-3, low-high importance) and is graded with one value (1=Bad, 4=Best) which multiplied give the score. In the end all the scores are summed up and according to the score there ae five possible adaptability classes, class 1is not adaptive while class 5 is excellent adaptive (Geraedts & Prins, 2015). Geraedts developed further the model by making two new versions, Flex 3.0 (44 indicators) and Flex 4.0 (44 indicators separated based on Habraken's (1992) support (12)-infill (32).

Another model by Geraedts et al. (2014) is the ***Adaptive Capacity method*** (AC) which consists of three modules. These are "*the determination of the adaptive capacity; formulating the demand for or assessing the supply of flexibility, "the determination of the financial-economic profitability and the "determination of the sustainability impact of the several measures*" (Geraedts, et al., 2014). Considering the first module, the adaptive capacity of buildings, a method that "*leads to … a definite judgement if a specific offered design or building fits a given demand for flexibility*" (Geraedts, et al., 2014). As was described in previous section on this thesis, adaptive capacity can be divided in three main parts, the organizational flexibility, the process flexibility and the product flexibility. Moreover, the demand which is the factor that determines the way that a building should be adjusted in the future to support the changing needs, can be splitted in two categories, transformation and use dynamics. The latter one represents the demand by the user while the first one is about the demand of the owner (Geraedts, et al., 2014).

Both of them can be expressed through seven indicator clusters in three categories, rearrange flexibility, extension flexibility and rejection flexibility in order to formulate the wishes and requirements of owners and users. The AC method includes assessment values (1-4, 1= bad, 4= good) based on which the evaluation of adaptive capacity can be made. What is assessed by these values is a list of indicators. By this we can evaluate the spatial/functional- constructional/technical characteristics (when formulating the demand) and in the end we make supply-demand tables (or profiles) to check the mis-match (Geraedts, et al., 2014).

[14] The paper was presented at the International Union of Architects World Congress UIA2014 in Durban SA, titled Adaptive Capacity of Buildings (Geraedts & Prins, 2015)

2.4 Indicators for adaptability

A way to start designing an adaptable strategy is by start listing the indicators that should be fulfilled in order to endorse at your building the abilities you want (Gijsbers & Lichtenberg, 2012). The design indicators for adaptability are the ones that create a proper background, so the building can be easily converted while retain a balance between the costs, benefits and time. The indicators need to be defined based on their functioning, impact and cause. An indicator is not a floor-plan suggestion but a tool that creates abilities alongside with costs, risks and opportunities (Geraedts, 2017).

In the literature there is plenty information about these design parameters while based on the tools described in the previous section, we can map what is important for developing feasible adaptable buildings. Starting from the literature regarding abilities, Geraedts proposed four key performance indicators for flexibility (Geraedts, 2008). These are partitionability, adaptability, extendibility and Multifunctionality. In these four categories are included several indicators towards flexibility like modularity, rearrangeability, zoning and demountability. In this theory, Geraedts use the world flexibility instead of adaptability as the umbrella concept for the future buildings adaptations. Another list of 17 indicators is provided by Flex 2.0 (Geraedts & Prins, 2015), the AC model (Geraedts, et al., 2014), by Brink Groep (Brink Groep, 2014) and by Remoy (Remoy, 2010). These 17 indicators (figure 12) are a compression of 143 indicators, and they are structured based on the Brand layers (Geraedts & Prins, 2015). The majority of them require a standard grid based on which the different perspectives of flexibility can take place. At this point it is important to say that these are not direct design indicators but indicators that describe a desirable type of change like extendibility, rearrangeability etc (see Figure 15).

FLEX LIGHT 2.0			
LAYER	**SUBLAYER**	**Nr.**	**Flexibility Performance Indicator**
1. SITE/LOCATION		01(2)	Surplus of site space
2. STRUCTURE	**2.1 Measurements**	02(5)	Surplus of building space / floor space
		03(11)	Surplus free of floor height
	2.2 Access	04(17)	Access to building: location of stairs, elevators, core
	2.3 Construction	05(21)	Surplus of load bearing capacity of floors
		06(29)	Extendible building / unit horizontal
		07(30)	Extendible building / unit vertical
3. SKIN	**3.1 Facade**	08(42)	Dismountable facade
4. FACILITIES	**4.1 Measurement & control**	09(53)	Customisability and controllability of facilities
	4.2 Dimensions	10(56)	Surplus facilities shafts and ducts
		11(57)	Surplus capacity of facilities
		12(65)	Disconnection of facilities components
5. SPACE PLAN/FINISHING	**5.1 Functional**	13(70)	Distinction between support - infill (fit-out)
	5.2 Access	14(73)	Access to building: horizontal routing, corridors, gallery
	5.3 Technical	15(77)	Removable, relocatable units in building
		16(78)	Removable, relocatable interior walls in building
		17(79)	Disconnecting/detailed connection interior walls; hor/vert.

Figure 14: Flex 2.0 (Geraedts & Prins, 2015)

Furthermore, there are plenty of other researches about real estate strategies and design parameters for adaptability. Nakib developed a series of guidelines towards adaptable design. Starting from socio-proffesonal, economic, spatial, functional, structural, technical and façade, he creates a pattern of solutions that can be implemented in order to create an adaptable building (Nakib, n.d.). Sadafi et al. summarized another set of strategies (figure 13) for adapability an flexibility (Appendix 2) based on the existing literature (Sadafi, et al., 2014). A set of design parameters derived from the literature was also presented in the research of Manewa (Figure 14), which includes parameters of structure, services, flows and floor plan (Manewa, et al., 2013).

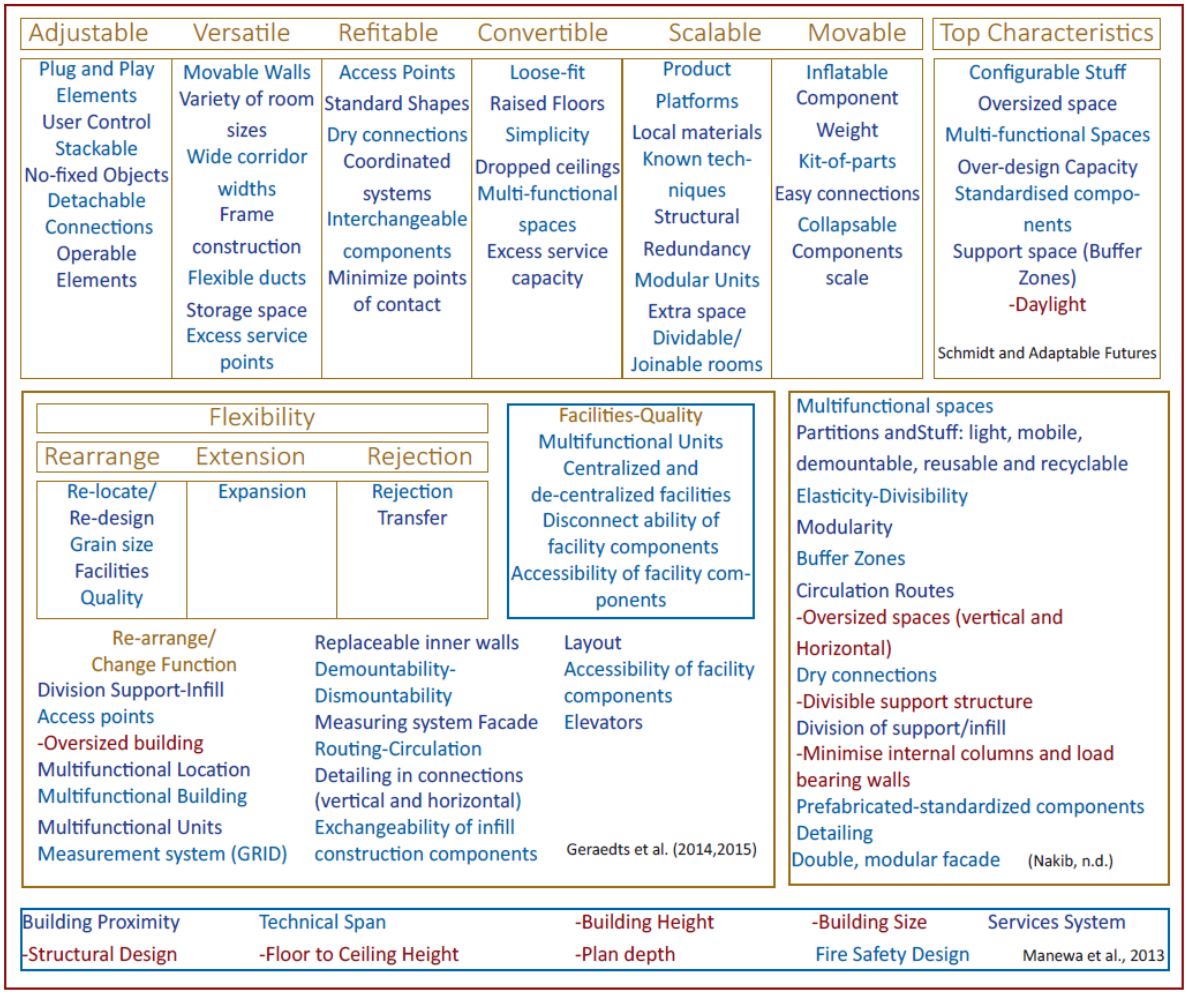


Table 2: Design indicators for adaptability

In Table 2 are presented design indicators for adaptability. These are design methods that can be used or should be under consideration when designing a new or a transformation project. If someone looks closer will observe overlapping among the different authors, while what is presented are only based on four scientific researches. The indicators in red are the ones that can be implemented only on new projects. This is due to the facts that these indicators cannot be re-designed (mainly the structural elements) or because they are highly dependent on the existing layout. Some of them, like the daylight or the floor-to-ceiling height are crucial for a successful transformation and this is why the transformation potential of a building should be investigated before starting a project.

2.5 Design Indicators for Adaptable Transformation Projects: The obsolete buildings' typology

The selection of indicators and the final design of the adaptable real estate strategy is highly dependent on the existing building. This is another reason that makes a framework for transformation project different than one for a new building. Another extend of this differentiation is that there are many differences among the various building typologies. It is obvious that a transformation of a detached home is different from a transformation of an apartment and extremely different from an office block. So, only one generic framework, or general principles of adaptability could be used as a basis for all the transformation project. Thus, the need for defining a **specific typology** of existing building stock was vital for this research in order to create a solid framework and not a repetition of ideas.

The first step for the typology's selections was the function. According to Kincaid the office buildings are the assets that present the higher potential to change to another use (49%) in comparison with other uses while residential is the most favorable function to change to (Kincaid, 2002). Moreover, the buildings which present higher numbers of vacancy and obsolescence are the office buildings (Savills, 2018; Bouwinvest, 2016; Remoy & van der Voordt, 2014). To make the final framework less generic, the scope of this research was narrowed down to one, specific typology of office buildings. The selection of the office typology was made because of multiple reasons. Remoy and de Jong, describe two types of office buildings which are the most common in commercial developments. The first one, which also fits to the MOR case study (sections 2.1.5, 5..1.1), is the central core tower type. What characterizes this typology is that there is one central core and the structure of the tower is based on a structural grid of columns. The second typology is the single corridor type (Schenk, et al., 2009). This a typology dominated by a horizontal, centrally located corridor while the offices are located in the perimeter. The structure of this typology is mainly based on bearing outer walls and hollow core floor slabs (Remoy & De Jong, 2011; Schenk, et al., 2009).

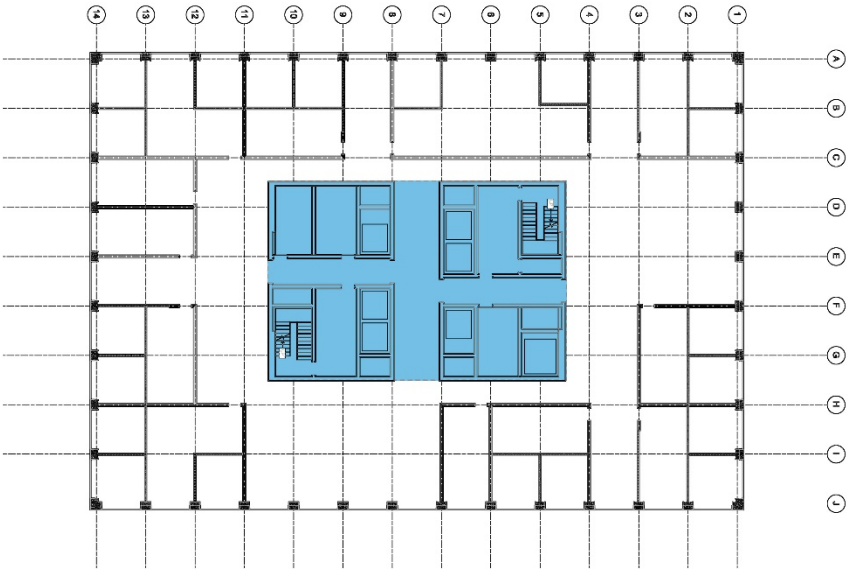


Figure 15: Typical floor plan of core office buildings, MOR case

Thus, the typology for which the Degrees of adaptability framework is made is the one constructed in the 70's and 80's on the American style typology (figure 16). More precisely, the office blocks with the core and the open layout. This decision was made as the selected type as the adaptive capacity and the impact on investment costs is estimated to be lower than the single corridor one (Schenk, et al., 2009). Another reason why this group of buildings was selected is the high density of this type of buildings globally, fact that makes the value of the framework higher as it can be implemented in a higher percentage of obsolete buildings.

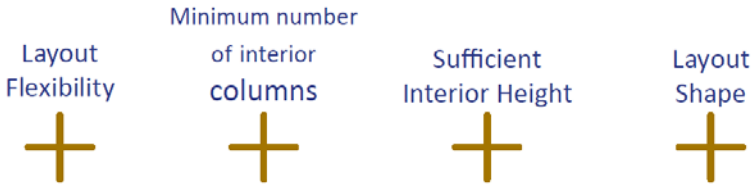


Figure 16: Beneficial characteristics of the selected typology, own illustration

2.6 Design indicators for Adaptability in transformation Projects

To create the final list of the most important and comprehensive adaptability design indicators many steps were made.Starting from understanding the meaning and the importance of adaptability to the creation of a framework of indicators the literature study was a millestone. The before-mentioned

evaluation and decision making tools were important to understand how adaptability can be measured while the indicators and the abilities are essential to develop a framework for future proof adaptable design.

There are numerous of things that change when designing a new adaptable building in comparison with an adaptable transformation project. The most important thing is the existing structure which, in the case of existing buildings, is difficult or quite costly to be changed. An example based on a "popular"[15] design parameter is that the free floor height can be easily designed in a new project while in an existing building the height must be taken as granted. Other design parameters are the zones and the access-points. Considering how to develop an adaptable building as a new construction the lifts and the staircases can be designed in a way that promotes spatial flexibility. Once again, in a transformation project these are things connected to an existing system, which make it more difficult to be adjusted. Thus, as a redevelopment process is unique for each building is important to check the transformation potential of the object

Considering the limitations and the restrictions that an existing building will oppose towards a transformation process, the author developed a framework of design parameters. These are mainly based on the layering of Brand's theory and on the adaptability strategies of Schmidt III and built of the selected researched typology. As there is no framework specified only on "designing adaptability in transformations", indicators proposed by Geraedts and other researchers used as the basis for the new model.

Looking at the literature there are numerous principles and approaches towards the creation of an adaptable building. Starting from the characteristics of adaptability (mentioned in section 2.1.1) an adaptable building should have the capacity to change, remain fit, maximizing its value and be easily and quickly convertible and durable (Aytac, et al., 2016; Schmidt III, et al., 2010). To fulfil these principles there are some "abilities" to be incorporated in the building. Some of the mentioned - abilities are proposed by other researchers like Geraedts and Schmidt III (Framecycle). The most dominant ones are the adjustability, versatility, refitability, convertibility, scalability, moveability, partitionability and multifunctionality (described in section 2.4; Schmidt III, 2014; Brink Groep, 2014; Geraedts, et al., 2014; Aytac, et al., 2016).

In Table 3 are presented the most important design indicators (76), or the principles of adaptability in transformation projects, derived from the literature. All these are referred directly to the layers of Brand's, site, structure, skin, services, space plan and stuff. Many of the are expressing general principles like "circularity" and "maintain-ability", while others represent more direct design directions, like the "removable, relocatable walls". This table is the basis of the main Framework developed in this thesis and illustrates one of the starting points. Even though it looks quite complete and gives a good understanding on how different principles can be allocated through the layers and abilities, it includes some shortcomings. The first one, is that not all the indicators have the same direction. Some are design parameters while others express a preferable outcome. The second shortcoming is that the list is way too long. The size creates to main problems. It does not fit the purpose and research methodology (Delphi panel) while it is too big and vague to be a handy framework.

The next step of this process was to group the indicators that would give back the same abilities, and the indicators that create overlapping. Some examples are the "Adaptability of elevators" which was

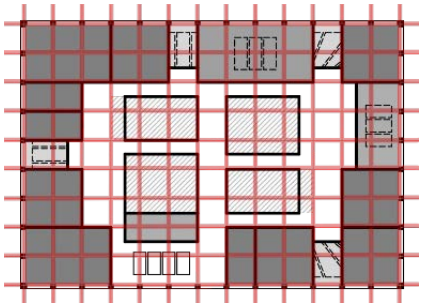
[15] In Remoy (2010) the free floor height was underlined as the only veto criterion at the building for a building to be able to be transformed (Remoy, 2010).

merged with “oversupply of services”, the “efficient lay-out” and the “routing” which were merged to the “zoning”. The scope of these groupings was to minimize the list of indicators to the shorten possible while retaining the abilities. In this case, the layering was extremely valuable as the same design indicators can be translated to multiple abilities when being implemented in different layers.

Table 3: List of indicators, first attempt, own illustration

Site Location	**Structure**	**Skin**	**Services/ facilities**	**Space Plan/Floor Plan**	**Stuff**
Eternal	30-300 years	20 years	7-15 years	3-30 years	Daily
Movable	**Scalable - Movable**	**Refitable - Convertible - Scalable**	**Refitable - Convertible - Scalable**	**Versatile - Refitable - Convertible - Scalable**	**Adjustable - Versatile**
Surplus of space	Access to Building	Dismountable Façade	Customizability and controllability of facilities	Distinction Between support-infill	Multifunctionality
Multi-functional Site	Surplus of Building/Floor space	Social Safety of main Entrance	Surplus Facilities shafts and ducts	Access to building	Re-usable
Multi-functionality	Surplus of load bearing capacity	Re-use Façade Windows	Surplus Capacity of Facilities	Removable relocate units in the building	Easily rearrangeable
Obstacles for daylight in surroundings	Horizontal Extendibility	Daylight Facilities	Disconnection of Facilities' components	Removable, relocatable walls	Modular
	Vertical Extendibility	Outdoor space on the roof	Measure and Control Techniques	Disconnected / detailed connections of the interior walls Horizontally	Easily moved and disassembled
	Surplus Free floor height	Own Identity of the roof	Adaptability of elevators	Disconnected / detailed connections of the interior walls Vertically	Circular
	Measurement System/Modular coordination	Partionability-Demountability	Control of Sun Screens	Multifunctional Building	Maintainability
	Measurement System Façade		Modularity of Facilities	Multifunctional Units	Interchangeability (in) building components
	Self -Supporting Façade		Independence of User Units	Size of Units	
	Positioning Obstacles/ Columns		Over-design capacity of Public Facilities	Horizontal and Vertical Routing	
	Positioning of facility Zones and Shafts		Location Sources of Facilities	Personal Access of User Units	
	Reject-ability Horizontal		Independence of User Units	Relocation of Building or Unit Access	
	Reject-ability Vertical		Partionability: centralized/ decentralized	Possibility of Raised Floors	
	Partionability: zoning		Multifunctionality	Dysconnectivity/Portability/ Movability of Components	
	Partionability: centralized/ decentralized		Bike PARKING	Multifunctionality	
	Multifunctionality			Entrance opening Relocated	

2. 7 The final list of design Indicators

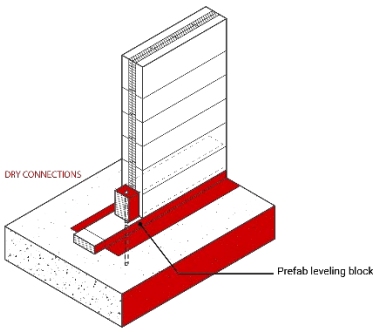


Modular & Dividable System: By working in a modular system you can replace, divide or expand components (module) without affecting the rest of the system, as everything is based on a standard system/module/grid. This is about working on a specific grid. In transformation projects, you can re-design the grid but in this case will not affect the layer of structure. Generally, is more efficient to respect the existing grid and work on that. The grid and the modularity are applied on the space plan and on the façade and structure, depending on the capacities of the existing asset (Blakstad, 2001; Nakib, n.d.; Sadafi, et al., 2014; Geraedts, et al., 2014; Beadle, et al., 2008; Schnadelbach , 2010; Moffat et al., 2001; Geraedts, 2001; Schmidt III, et al., 2010; Eguchi, et al., 2011).

This is the final version of the following sub-indicators: modular coordination, modularity of facilities, measurement system, grid.

Layers:	Site	Structure	Skin	Services	Space	Stuff
Modular and dividable system	No	Probable	Yes	Yes	Yes	Yes

Abilities: Spatial flexibility (extendibility-rejectability), rearrangeability, modularity, divisibility



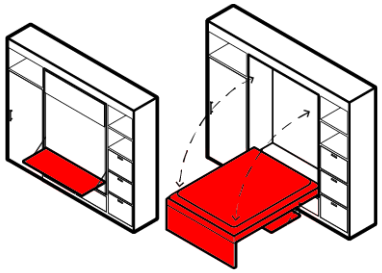
Loose-fit (& dry) connections: The support-infill elements to be easily separated. The connections of the "infill" components, like interior walls-ceiling-floors, are of a loose-fit type. In this type of constructions, we do not have wet or male-female connections. (Nakib, n.d.; Sadafi, et al., 2014; Geraedts, 2008; Geldermans, et al., 2019; Moffat et al., 2001; Schmidt III, 2014).

Moreover, "loose-fit" as a design technique in the layer of space plan is a "tailored to no specific use" tactic which can be used during the design phase of the project (Schmidt III, 2014).

This is the final version of the following sub-indicators: Independent systems, no secondary finishes, size, disconnected and detailed connections of interior partitions (Vertically/Horizontally), dry connections, detailed connection of internal and external components.

	Site	Structure	Skin	Services	Space	Stuff
Loose fit connections	No	No	Yes	Probable	Yes	Yes

Abilities: Refitability, divisibility, speed of change



Multifunctionality: This design parameter can be applied in more than one layers of Brand's. Multifunctionality is about a multi-use of space(s), or a multifunctional use on interior components (like the one shown in the image) (Nakib, n.d.; Sadafi, et al., 2014; Geraedts, 2008; Beadle, et al., 2008; Schnädelbach, 2010; Moffat et al., 2001)

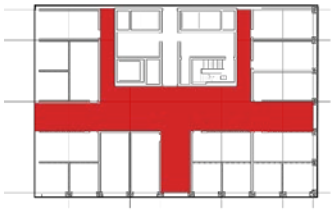
This is the final version of the following sub-indicators: Multifunctional units, multifunctionality of components, day and night cycles of use

	Site	Structure	Skin	Services	Space	Stuff
Multifunctionality	Probable	Probable	Probable	Probable	Yes	Yes

Abilities: refitability, convertibility.

Multifunctionality in an adaptable system can minimize the functional obsolescence.

Buffer Zones: The Buffer Zones can be used as supportive space in the case of horizontal – vertical extendibility or change of function. **A buffer zone does not mean automatically empty or unused space**. A common space for the tenants (secondary use in a building) can work as a buffer zone in case we need to add density in the building (Nakib, n.d.; De Paris & Lopes, 2018; Aytac, 2016). The Buffer zones (Schmidt III, 2014)can be considered as un-finished design.

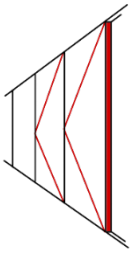


This is the final version of the following sub-indicators: Buffer zones, oversupply of space, horizontal and vertical extendibility

	Site	Structure	Skin	Services	Space	Stuff
Buffer zones	Probable	No	No	No	Yes	No

Abilities: Change-ability, speed of transformation, absorption of tenses, scalability

Lightweight materials: The lightweight materials are minimizing the construction time and the load of the structure. Are easily reject-able without affecting other parts of the building (Sadafi, et al., 2014; Estaji, 2017; Geldermans, et al., 2019).The lightweight materials are supportive to other indicators like movable and portable components, dry connections, demountability.



Example: Light-weight interior wall

This is the final version of the following sub-indicators: lightweight materials, prefabricated components, component weight (in movability section of the Framecycle)

	Site	Structure	Skin	Services	Space	Stuff
Lightweight materials	No	No	No	No	No	Yes

Abilities: Portability, speed of transformation, scalability (increased volume capacity)

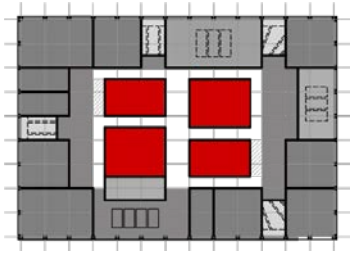
Over-supply of services, over- dimension of structure: Over capacity of systems, facilities and services in order to support more demanding uses or higher densities. This can also be applied in case for a higher load bearing structure, or the creation of shafts in order to support future installation needs (Nakib, n.d.; Geraedts & Prins, 2015; Geraedts, 2001; Sadafi, et al., 2014; Moffat et al., 2001; Schmidt III, et al., 2010; Brink Groep, 2014). The over-supply does not automatically mean a big overcapacity of services, but is also about the pre-design of future extension or additions of the systems.

This is the final version of the following sub-indicators: surplus facilities' shafts and ducts, surplus capacity of facilities, adaptability of elevators, surplus free floor height

	Site	Structure	Skin	Services	Space	Stuff
Oversupply of services, systems, facilities	Probable	Probable	Probable	Yes	Probable	No

Abilities: Technical and functional flexibility, scalability

Zoning: Zoning in a building scale by means of facility zones, routing, services, access points. This parameter enhances technical flexibility, circulation routes and efficient functioning. In the image below, you can see clear zoning, in the core are located all the installations and services while in grey we can see the residential function (Nakib, n.d.; Geraedts & Prins, 2015; Geraedts, 2001; Sadafi, et al., 2014; Moffat et al., 2001; De Paris & Lopes, 2018).

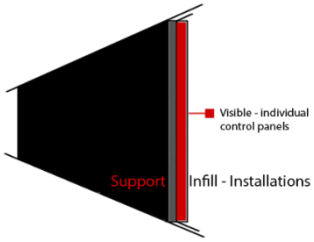


This is the final version of the following sub-indicators: location sources of facilities, horizontal and vertical routing, efficient layout, centralized facilities, circular routing, distributed and individual control facilities

	Site	Structure	Skin	Services	Space	Stuff
Zoning	No	Probable	No	Yes	Yes	No

Abilities: Polyvalency, Divisibility, Versatility, Operational Efficiency

Accessibility: Easy access to control panels, installations, stuff in order to minimize time of adaptation and maintenance. That is another dimension of the separation between support and in-fill components. This parameter enhances technical flexibility (Nakib, n.d.; Geraedts & Prins, 2015; Geraedts, 2001; Sadafi, et al., 2014; Moffat et al., 2001; Eguchi, et al., 2011; Brink Groep, 2014).

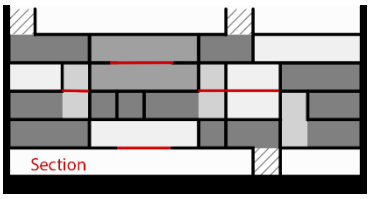


This is the final version of the following sub-indicators: location sources of facilities, distinction between support-infill, entrance opening relocation, Personal access of user units, Independence of user units, Disconnection of Facilities' components, customizability and controllability of facilities

	Site	Structure	Skin	Services	Space	Stuff
Accessibility	Probable	Probable	No	Yes	Yes	Probable

Abilities: Durability, maintainability, technical flexibility

Raised floors – Openings: Ability to increase the floor height, enhances the vertical flexibility through internal connections between different levels. (Geraedts & Prins, 2015; Beadle, et al., 2008; Schmidt III, et al., 2010; Moffat et al., 2001; Brink Groep, 2014) The "Raised floors" capacity can be translated into shafts for staircases or removal of a certain part of the slab/ceiling to create two floors height.

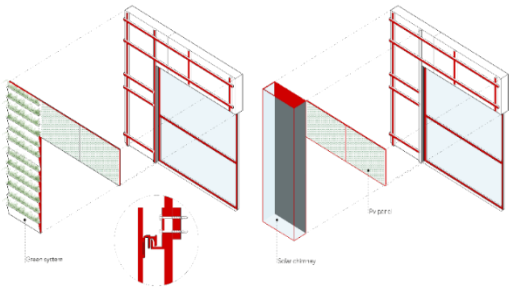


This is the final version of the following sub-indicators: positioning of facility zones and shafts, rejectability/extendibility vertical, raised floors, vertical routing

	Site	Structure	Skin	Services	Space	Stuff
Raised floors, openings	No	Probable	No	Yes	Yes	No

Abilities: Vertical flexibility, versatility, convertibility

Demountable components: Ability of stuff to be easily demountable. This presupposes detailed plans and detailed connections between components (Geldermans, et al., 2019; Estaji, 2017; Geraedts & Prins, 2015; Sadafi, et al., 2014). Demountability is an indicator that needs a certain basis in order to be adopted as a design strategy. This is the loose-fit connections and the accessibility to the systems. Moreover, demountable components can be related to the lightweight materials and the movable-portable components.

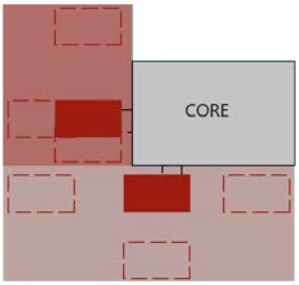


This is the final version of the following sub-indicators: disconnected components, demountable units and modules, dismountable façade, prefabricated components, partitionability-demountability (skin)

	Site	Structure	Skin	Services	Space	Stuff
Demountable units and modules	No	No	Yes	No	Probable	Yes

Abilities: Vertical flexibility, versatility, convertibility

Movable and Portable components: Interion components to be easily movable and portable. This enhances quick and low-cost adaptations. In the example, all the interior organization can change and plug-in/plug-out from the core which includes all the installations and services (De Paris & Lopes, 2018; Geldermans, et al., 2019; Geraedts & Prins, 2015; Schnädelbach, 2010; Eguchi, et al., 2011; Brink Groep, 2014). As some other indicators, movable and portable components is a tactic that needs some extra design basis in order to be adopted. Once again, there is a high need of loose-fit connection, efficient zoning and preferably some buffer zones and storage space.

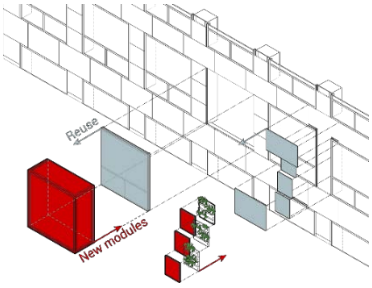


This is the final version of the following sub-indicators: inter-changeability in building components, dis-connectivity-portability-movability of components, removable-relocatable walls and units

	Site	Structure	Skin	Services	Space	Stuff
Movable and portable components	No	No	Probable	No	Probable	Yes

Abilities: Adjustability, movability, partitionability, spatial and functional flexibility

Re-usable components: Ability to reuse parts of the building as a whole, or materials of the building to enhance sustainability and quick adaptation to the new requirements. (Example: use the interior wall of an apartment as an interior wall for offices etc., circulation of materials in the same building) (Geldermans, et al., 2019; Sadafi, et al., 2014; Manewa, et al., 2013). As some other indicators, reusability is a tactic that needs some extra design basis in order to be adopted. So, there is a high need of loose-fit connection and demountable components.



This is the final version of the following sub-indicators: Multifunctionality of materials, re-use façade windows, reusable/multifunctional elements

	Site	Structure	Skin	Services	Space	Stuff
Reusable components	No	No	Probable	No	No	Yes

Abilities: circularity, reusability, sustainability, movability

2.8 Conclusion

In this section tools for designing and assessing adaptability were described. There are several inputs to be considered while developing the Framework of indicators for adaptability. Starting from the first step, before the projects starts the building should be assessment on its transformation potential. Without knowing the grade of this capacity, it is impossible to design the transformation strategy. Moreover, in the described tools we can be recognized plenty indicators which can upgrade the adaptive capacity of a building. This information is valuable for understanding what is important and what is not, while giving a good background for the development of the Framework. The most influencing tool for this research is the FLEX method, developed by Geraedts as it includes the abilities that a building should have alongside with a well-developed grading system. Moreover, the Adapt-star model was highly informative on the basis of scenarios and grading of adaptability, while the Adaptive Capacity model expressed also the perspective of the mis-match between demand and supply.

The final design indicators for adaptability is a list of twelve parameters (Figure 18). Each of them serves a different scope and adds extra qualities or value at an adaptable design strategy. Even though each one acts as a unique strategy, or tactic, there are some important things to be mentioned. Following the rationale of the Layers, the indicators that can be expressed in the layers that are higher in the hierarchy of change (the top one is the Site while the last one is the Stuff) dominate the ones which are only present in the bottom layers. That also means that the "higher ones" act independently while the "lowest ones" require the pre-existence of other indicators (Schmidt III, 2014). An example was given in the "demountable components" indicator where the need for loose-fit connections is vital. Thus, the dynamics among the indicators are not the same, and the final outcome of a real estate strategy is highly dependent on the combination of different indicators. A strategy that includes all the indicators expresses all the abilities of an adaptable building and can be characterized as highly adaptable.

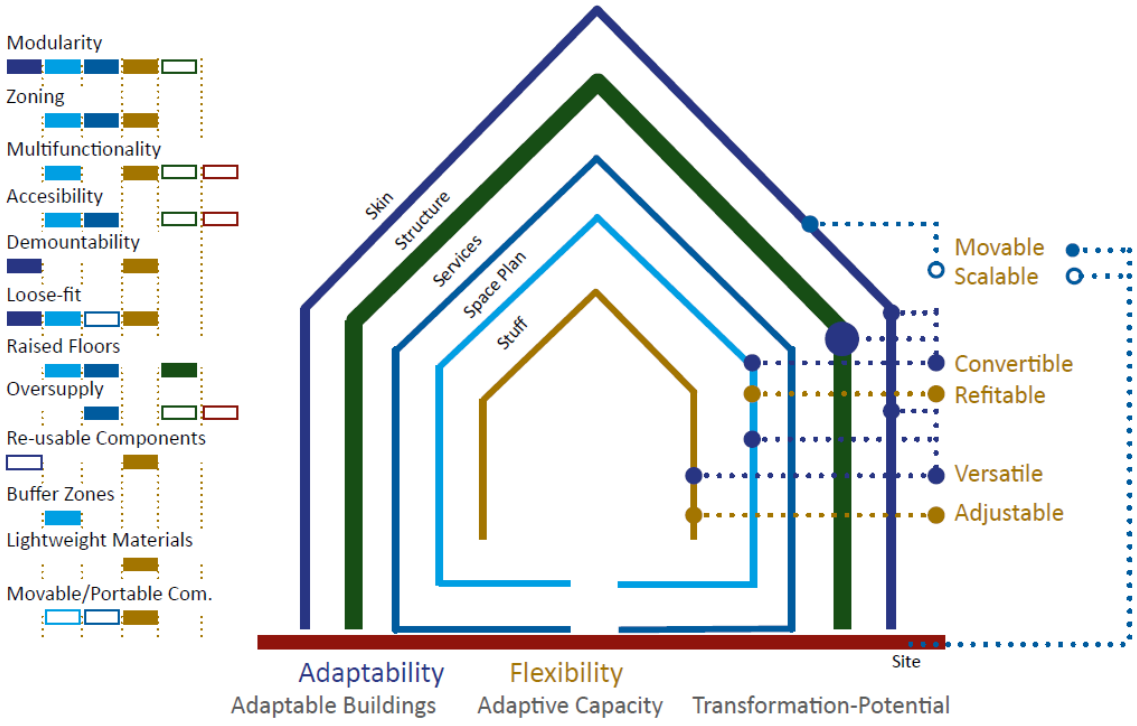


Figure 17: The design indicators for adaptability, own illustration

Chapter 3

Empirical Research

3. Empirical Research

The existing scientific literature of adaptability, and of the related to it concepts, function as the theoretical background and backbone of this research. Nevertheless, the scope of this thesis is to propose a tool that the practitioners can use to design future proof transformation projects. To be more realistic it was crucial to include the opinion and take into consideration the perspective of the professionals. Unfortunately, only a small part of the existing scientific research focus on this side resulting a necessity for empirical research to be conducted by the author.

Having in mind the existence of a set of indicators and the missing part of their value-meaning for the professionals, the author decided to conduct a Delphi research in combination with semi-structured interviews. The former method was used to give an order to the different design indicators while the second to increase the understanding, causes, risks and opportunities of adaptability. Moreover, the one-to-one talks were a tool to validate the "correctness" of the gathered data and identify possible gaps in the literature review. To increase the comprehensiveness of the findings and enhance the creation of a general accepted design Framework the author tried to gather participants who represent most of the real estate expertise. The way that the empirical research was organised and functioned is described in the following sections.

3.1 The Delphi method

One of the main methodological parts of this research is the Delphi Research method. A Delphi method is used in order to aggregate the responses of a group in order to improve the decision-making process (Delbecq, 1975). Moreover, it is considered to be a way to capture individual perspectives on topics that the literature review cannot cover completely or wherever there is failure of consensus (Delbecq, 1975; Remoy, et al., 2007).

This methodology has numerous benefits. The participation in a Delphi panel can be anonymous while it prevents manipulation by more "loud" or dominant experts (Delbecq, 1975). Another benefit is the panel of experts which can offer a more holistic approach on an issue in comparison with single interviews of experts, that helps to gain more valid results (Remoy, et al., 2007). A characteristic that was proven important in the current research is that during the elaboration of their grading, the participants gave extra information or views that were added to the vocabulary of the research and enhanced the better understanding on the topic (Remoy, et al., 2007). This is described in the literature as "flexibility", which was more than valuable as the author had the freedom to form a research question and a list of indicators based on the specific expected findings. Also, Delphi is a method through which differences among diverse groups can be clarified and be further analyzed (Delbecq, 1975).

On the other hand, in order to ensure the validity of the results some restrictions and considerations should be taken into account. According to literature, firstly the suitability of the method should be defined followed by clear guidelines on how to rank the different indicators to be assessed, predefined criteria of the grading, the number of rounds to be conducted and the organization of the feedback moments (Delbecq, 1975; Fink A., 1991; Schmidt, 1997). What is also important, an obstacle if cannot be met, is time. A Delphi research, according to Delbecq, needs at least 45 days to be conducted, so it cannot be applied in cases where the time is limited. Last but not least, it needs highly motivated participants with a capacity in written communication (Delbecq, 1975).

The Delphi method in this research

Delphi research presents some characteristics quite beneficial for this research. Considering the high importance of a holistic understanding about the drivers and the design parameters for adaptability,

the Delphi panel is more than appropriate for this goal. The interviewees participated in this research work in the real estate sector but in different positions. To enhance this multi-perspective dimension, except of practitioners (who are the biggest part of the interviewees) also researchers (2) with big experience on the topic took part in this activity. For this research the attendance of policy makers or civil servants was not considered as necessary as the legal-policy issues will not be taken into account. Another goal in the organization of the panel was to invite not only people with many years of experience, but also young professionals. Due to the increasing awareness about sustainability, it is more possible that the young professionals have a fresher view on the topic of adaptability or new ideas that they are trying to implement in their working environment. On the other hand, the more experienced ones have a clearer view of how the market works and can help to understand in depth the drivers and the obstacles of adaptability. The anonymity and the one-by-one interviews required by the Delhi method was useful in this sense, as the less sociable or shy interviewees had the freedom to express themselves openly (Delbecq, 1975).

3.1.2 Structure

Usually, a Delphi Method consists of two to four rounds dependent on the characteristics of the research and the existing knowledge on the topic. According to Skulmoski et al. (2002), the two or three rounds of Delphi are efficient when the goal of the research is to qualify different opinions and understand the different perspectives among the interviewees (G. J. Skulmoski, F. T. Hartman, 2002). In a research where the sample is almost homogenous (all the experts are operating in the real estate environment) and the time for the conduction of this research is restricted only two rounds of Delphi will be held (Remoy, et al., 2007). In this thesis, two rounds will be conducted as there has been a lot of research on this specific topic alongside with the time limitation, the pre-determined indicators and the objectives of the research (Remoy, et al., 2007).

The structure of this Delhi method was quite simple, as it included only two rounds. This number of iterations is considered to be enough as firstly, there is a lot of literature on the topic, secondly a clear ranking list was provided to the interviewees and thirdly, all of the participants had knowledge on the topic (Remoy, et al., 2007). Moreover, the aim of the panel was not to reach consensus but to analyze and share their knowledge based on the provided indicators. By having two rounds, the validity of the ranking is higher as the participants have the opportunity to re-think their grading and compare it with the average.

The first round was conducted via one-to-one meetings and lasted almost one month. On the other hand, the second round of the Delphi was conducted via email (Remoy, et al., 2007). What was sent to the participants was an extensive “vocabulary” document where all the meanings of the indicators were included alongside with the questions. Moreover, to help some of the interviewees who had problems in the decision making of ranking, the author sent them their original elaboration on the topic in addition with specific questions on what they did not understand or under/over rank. That was mainly happened because some interviewees wanted to express so directly the beliefs or the principles of their company that their elaboration did not match exactly with their ranking. Thus, these topics were underlined by the author and sent to each interviewee for further thinking before the round two ranking submission to upgrade the validity of the results.

3.1.3 The sample and the experts’ panel

According to Delbecq, when the group of participants is homogenous then ten to eighteen people considered to be enough (Delbecq, 1975). Other researches evaluate as a good sample, depending on the type of participants, from 10 to 1865 while others from 10 to 18 (Remoy, et al., 2007). What is also important to be considered regarding the panel is the selection of experts. A participant can be a “specialist” or someone who has specific knowledge on the topic (Remoy, et al., 2007). Thus, the

number of the participants and their qualities are crucial for the success of the research. In the current research seventeen people accepted the invitation, all of them highly related with the real estate sector. Their working environment was chosen to be various, from real estate investors to architects, in order to gather comprehensive quantitative and qualitative data.

The panel consists of seventeen (17) experts. The participants are four architects, four real estate developers, three investors, one who is both developer and investor, two people from academia, one contractor and two real estate consultants. The selection of the interviewees was based on the multiple criteria. For the architects the selection was based on their projects, the main concern was if they are experienced in transformation projects and if the design adaptable buildings. Quite same rationale was used for the developers and contractors, again based on the image of the company and the experience in transformation concepts. The investor's is a more complex group. In this case the choice was to have four different investors profile to gain a more holistic understanding. The participants from academia and the consultants were selected based on their publications on the topic and their experience on it.

Table 4: Panel's composition, own illustration

Type	Total number	>10 years of exp.	<10 years of exp.
Architects	4	-	4
Developers	4	2	2
Investors	4	3	1
Contractors	1	-	1
Academics	2	1	1
Consultants	2	2	-

3.1.4 Objectives of the Delphi research

The context of the Delphi research was more complex than its structure. The main aim was to ask the panel to rank, based on their importance, a set of twelve design indicators. So, the participants judged the importance (or not) of each given design indicator for developing adaptable transformation projects. As the expected outcome of the research is the creation of the "degrees of adaptability", two extra rounds were added to the ranking. The "cost" and the "added value" are important parameters during the decision-making process for a building's re-design. Although, what was different in comparison with the ranking of "importance" was that the participants had only to categorise the indicators into three categories. So, the cost impact (at t=0) and the added value of each indicator was graded into the categories of "low", "moderate" and "high", regarding their impact on the final product.

Another objective of the Delphi was to map the importance of the external drivers that create the necessity for adaptable buildings or adaptable transformations. This is not closely related to the design indicators but to the end-strategy of a design proposal. So, to understand why the practitioners believe that there is a need (or not) for adaptable buildings and If they include this concept in their agenda. This also works as supporting to the literature information and input for the scenario and risk analysis that will be presented in the next chapters. For this reason, eleven drivers for adaptability were derived from literature in order to be evaluated for their impact on the decision making for adaptability.

Objectives of the Delphi:

1 Ranking the twelve design indicators based on their importance on designing adaptable transformation projects

2 Understand and define their cost implication and their added value on the project
3 Understand and clarify which layers are most important ones in order to map the "degrees of adaptability framework"
4 Understand the drivers for the decision-making process towards an adaptable transformation
5 Gain a deeper understanding on how different professionals (real estate sectors) interpret the importance (or not) for adaptable real estate strategies

Delphi Questions:

The first question was about the drivers for adaptability. It was placed first in order to help the interviewees to start thinking immediately on the adaptability issue and be prepared for the next set of indicators.

1. Which of the following indicators are more important when deciding If the transformation will go into creating an adaptable building or If you will go for a standard transformation/conversion?

The rest questions are about the design indicators for adaptable transformation projects.

1. Importance for adaptability
   Q: Which of the following DESIGN PARAMETERS are more important when designing an adaptable building. Please, prioritize from 1-12 considering transformation projects and explain
2. Cost (Three categories, 1=Low-3=High)
   Q: Which of the following parameters add cost, have a high cost impact on the initial investment (at t=0), to your building as a real estate transformation project?
3. Value (Three categories, 1=Low-3=High)
   Q: Which of the following parameters add value to your building as a real estate transformation project?

Delphi Cards

The ranking of the indicators was made by the use of cards. This method was selected after the recommendation of my mentor and achieved big acceptance among the participants. The use of hand-made cards was assessed to be a handier way of putting things in an order and a tool that enhances brainstorming. The other option was to have a printed version of the list of indicators, but the random positioning of the parameters could have influenced the participants' ranking. Each card was representing one indicator and its meaning. In the case of the design indicators (see section 2.7) a small sketch was also added. Thus, the participants were playing with the cards, reading the meanings and in the end ranking the indicators (Figure 19).

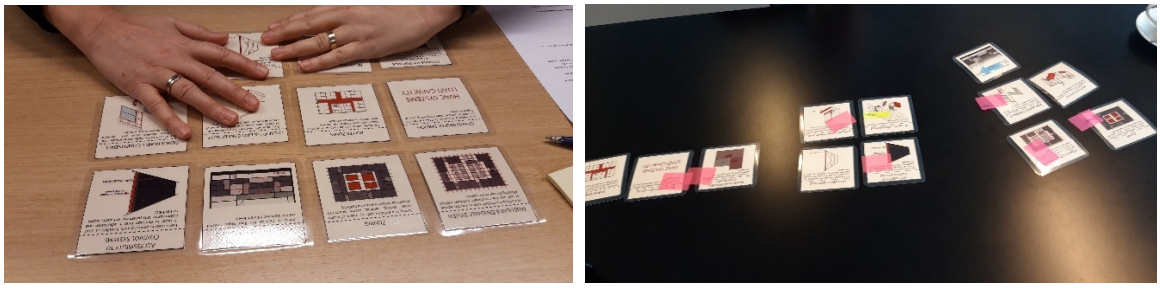


Figure 18: Photos taken during the Delphi Research

3.1.5 Analysis of the Delphi Results- Findings

By the Delphi research some quantitative data acquired. These express the ranking of different drivers and design indicators derived from the literature. This process enhanced the understanding and mapping of the important tools and techniques for designing adaptable transformation project while also explained the main uncertainties that increase the need for adaptability. To evaluate the final order of the indicator's and drivers' list it was important not just to calculate the "hierarchy" but also check the consensus that the group of participants achieved. The calculation of the Kendall coefficient of concordance *W* was generated through the SPSS software. The Kendall W "measures the degree of

association among *k* sets of rankings" (Remoy, et al., 2007). In this method the score varies from 0 to 1 and the meaning of this is presented in on the following figure (20) adopted by Remoy et al. (2007).

Kendall's W	Interpretation	Confidence in Ranks
.1	Very week agreement	None
.3	Weak agreement	Low
.5	Moderate agreement	Fair
.7	Strong agreement	High
.9	Unusually strong agreement	Very high
W = 1	Complete agreement	Very high

Figure 19: Interpretation of the Kendall coefficient of concordance W (Schmidt, 1997; adopted by Remoy et al., 2007)

3.1.5.a Drivers for adaptability

After of the conduction of the first (light green) and second (blue) Delphi round, the order of the external parameters that "cause" the need for adaptability was formed as shown in the Tables 5 and 6. Starting from the drivers for adaptability the most important ones are the Vacancy, the Municipality's vision and the market uncertainty. The second round provided exactly the same findings.

1	Vacancy
2	Municipality vision
3	Market uncertainty-Oversupply
4	Sustainability Issues
5	Zoning Legislation
6	Secondary location
7	Lack of good infrastructure
8	Future energy Legislation
9	Want to be a Frontrunner
10	Low aesthetical Quality
11	Lack of parking facilities

Table 5: Order of drivers, first Round, own illustration

1	Vacancy
2	Municipality vision
3	Market uncertainty-Oversupply
4	Sustainability Issues
5	Zoning Legislation
6	Secondary location
7	Lack of good infrastructure
8	Future energy Legislation
9	Want to be a Frontrunner
10	Low aesthetical Quality
11	Lack of parking facilities

Table 6: Order of drivers, second Round, own illustration

The participants prioritized the first set od indicators (external drivers) based on their importance on the decision-making process of a transformation progress regarding the need for use tools for adaptability. Even though, the question was about the transformation projects, but many participants underlined that these drivers are also important for new projects. Each professional stated his own perspective while rating the parameters, while also discussed about the low impact or non-impact of some. It is interesting to observe the differences among the professionals, not only on their expertise level but also among the participants that belong to the same "category". So, firstly will be discussed the consensus and the opinions between the architects, investors etc. followed by a comparison amongst all.

Concerning the ranking of the first set of indicators, the architects didn't reach consensus (Kendall W=0.25). This lack of agreement was obvious through their elaboration, different perspective (market or image perspective) and different design toolkit. In general, their opinions seem to be divided in two. The highest ranking of the architects group varied among "aesthetical quality", the "Municipality's vision", the "lack of infrastructure", the "ambition to be frontrunner", the "zoning", the "building's vacancy" and the "secondary location". The "aesthetical quality" is the only driver that was voted so high while in the total (17 participants) average was ranked on the last place. The less important driver for the architects was the "market uncertainty" as according to their saying, market is not their work. Nevertheless, the fact that the consensus was that small cannot give us enough homogeneity to use them as a solid group.

The "investors" is a more homogenous group (Kendal W=0.60), and they are between the "moderate" and "strong agreement" according to Kendall W legend (figure 16). Almost all of them agreed that the most important driver for adaptability is high building's vacancy and the sustainability issues. In the

third place for them comes the “environmental legislation”. On the other hand, the less important drivers were the “secondary location” and the “lack of infrastructure”. This is a result based on multiple criteria. Most of the interviewees supported that when the location, the amenities and the transportation are not good there is no reason to invest or transform at all. Moreover, in that case they did not believe that the re-development of an adaptable asset could confront the uncertainties that these drivers create.

Contradictory to the investors’ opinion, the academics and consultants (Kendall W=0.71- strong agreement) voted secondary location in a higher level of importance. Although, they also believe that high building’s vacancy is the most important indicator, exactly as the former group. The people from academia did not rank the other indicators in a same way. For both of them, aesthetical quality and zoning legislation are not important drivers for adaptability, as the latter one cannot affect a building after the permission is given and the first one is something generally easy to change.

Market uncertainty seems to be the most important driver for adaptable transformation projects in the case of developers (total consensus: Kendall W=0.44). According to them, zoning is also an important parameter for a re-development process but not specifically for transforming adaptable real estate. The same ranking elaboration was as also infrastructure and parking. Where we can find the biggest differences in, is the importance of the Municipality’s vision. Based on two out of four developers this is a really important driver while for the other members of the group was ranked in the lowest positions of importance.

Many different opinions and perspectives were selected during the first round of the Delphi panel. That was expected, as they represent different stakeholders of a redevelopment process and their interests and objectives vary. They didn’t manage to reach consensus, and they only achieved a really low Kendal W average of 0.15. In the end the most important parameters were the high building’s vacancy and the Municipality’s vision while the less important ones were the aesthetical quality and the lack of parking facilities. The driver “Vacancy” was understood in two ways by the participants. The majority of them translated vacancy as a risk or an uncertainty, while others (mostly architects) translated it as opportunity. Whatever the translation, all of them agreed that vacancy is an index that highlights the transformation into adaptable and no-static buildings. Concerning the Municipality’s Vision, the participants said that in the majority of times you need to go in align with the Vision. This includes uncertainty as the Municipalities can change administration every four years and the vision from one party to another can be different. Thus, it is important to have the ability to adjust. Another general outcome was that drivers like the infrastructure and the aesthetical quality, which were ranked low, are important reasons for re-development and transformation but not that important ones to create buildings with adaptive capacity (Sarafopoulos, 2019; Ector, 2019).

3.1.5.b The design indicators

The ranking of the design indicators for adaptability during the Delphi researched was based on three different ranking processes. The first one was about put the indicators in an order based on their importance for designing adaptability. So, which is the most important indicators in order to achieve an adaptable building. The other two were about their impact on the initial costs and the value on the project. An overall outcome of the first and second round is presented in Table 7. This is a result of equivalent weighting among the three different ranking factors (importance, cost, value).

Table 7: Orders of design indicators, first(green) and second (blue) Round, own illustration

1	Modular and dividable system
2	Zoning
3	Raised floors, openings
4	Accessibility to the control systems of components and installations
5	Multifunctionality
6	Demountable units and modules
7	Loose fit connections
8	Reusable components
9	Buffer zones
10	Lightweight materials
11	Movable an portable components
12	Oversupply of services, systems, facilities

1	Modular an dividable system
2	Zoning
3	Multifunctionality
4	Raised floors, openings
5	Accessibility to the control systems of components and installations
6	Demountable units and modules
7	Loose fit connections
8	Reusable components
9	Buffer zones
10	Oversupply of services, systems, facilities
11	Movable an portable components
12	Lightweight materials

After the conduction of the second round only some small things changed, mainly in the first positions. The design indicator that was "upgraded" in the second round was "Multifunctionality". At the first round there were quite some participants that didn't understand the difference of Space and Stuff Multifunctionality, problem that was solved after the conduction of the second round and the use of the vocabulary. On the contrary, lightweight materials were ranked lower and ended up only in the last position. This was mainly because of the general idea the things do not need to be so luxurious and expensive as the lightweight materials to be adaptable. An example by van Rijn was that a brick wall can be adaptable. It is so cheap to be built and demolished in comparison with lightweight materials that it makes it more feasible. Modular coordination and efficient zoning were voted as the most important and valuable indicators in both rounds, not only for their importance on adaptable design but also because these design strategies are important in any project.

Agreement (Kendall W scores)

In this set of ranking the investors achieved an overall consensus of 0.65 in the first round and a lower of 0.44 in the second round. That was mainly because only one of the participants decided to re-form his grading based on the average outcomes of the total group of participants and the provided vocabulary. The final grade of consensus (0.44) can be barely characterized as moderate agreement. The group of developers reached a total consensus of 0.44 in the first round but as happened with the investors their agreement was decreased on the second round (0.35). The agreement in this group can be characterized as weak. As happened with the two previous groups, the architects did not agree at all. That was also quite evident from the first round, as their perspective of valuable and adaptable design was obvious. In contrast with the developers and investors they increased their consensus in the second round, but still their average remains low (0.26). The group that achieved the highest agreement in the end was the academics and consultants, which almost reached a moderate agreement (0.47). The non-agreement of the second round amongst groups is probably a result of the fact that the participants were informed about the total average scores. Moreover, many of them decided not to change their rating as "this is their view of things" (Blauw, 2019). So, even though they couldn't reach a good agreement amongst their group they managed to have a fair to strong agreement among the total group (0.58 in the second round) about the importance of the design indicators.

Investors & Contractor			
Drivers for adaptability	**First Round**	**Second round**	**Change**
Modular an dividable system	1	2	-
Loose fit connections	7	6	+
Multifunctionality	11	9	+
Buffer zones	3	5	-
Reusable components	9	10	-
Lightweight materials	10	11	-
Oversupply of services, systems, facilities	5	4	+
Zoning	2	1	+
Accessibility to the control systems of components and installations	4	3	+
Raised floors, openings	6	7	-
Demountable units and modules	8	8	=
Movable an portable components	12	12	=
Kendal W	0.65	0.44	-21

Academics & Consultants			
Drivers for adaptability	**First Round**	**Second round**	**Change**
Modular an dividable system	1	1	=
Loose fit connections	5	6	-
Multifunctionality	4	3	+
Buffer zones	7	4	+
Reusable components	11	10	+
Lightweight materials	9	11	-
Oversupply of services, systems, facilities	12	12	=
Zoning	2	2	=
Accessibility to the control systems of components and installations	6	7	-
Raised floors, openings	8	5	+
Demountable units and modules	10	9	+
Movable an portable components	3	8	-
Kendal W	0.46	0.47	1

Developers			
Drivers for adaptability	**First Round**	**Second round**	**Change**
Modular an dividable system	2	1	+
Loose fit connections	12	12	=
Multifunctionality	4	4	=
Buffer zones	11	11	=
Reusable components	6	6	=
Lightweight materials	9	9	=
Oversupply of services, systems, facilities	10	10	=
Zoning	1	2	-
Accessibility to the control systems of components and	5	5	=
Raised floors, openings	3	3	=
Demountable units and modules	8	8	=
Movable an portable components	7	7	=
Kendal W	0.43	0.44	1

Architects			
Drivers for adaptability	**First Round**	**Second round**	**Change**
Modular an dividable system	1	1	=
Loose fit connections	3	9	-
Multifunctionality	4	10	-
Buffer zones	8	7	+
Reusable components	5	2	+
Lightweight materials	12	6	+
Oversupply of services, systems, facilities	11	12	-
Zoning	2	3	-
Accessibility to the control systems of components and installations	10	5	+
Raised floors, openings	6	4	+
Demountable units and modules	7	8	-
Movable an portable components	9	11	-
Kendal W	0.21	0.26	5

Table 8: Delphi Findings and agreement scores of different professionals' groups

	First Round Ranking		Second round ranking
1	Modular and dividable system	1	Modular an dividable system
2	Zoning	2	Zoning
3	Raised floors, openings	3	Multifunctionality
4	Accessibility to the control systems of components and installations	4	Raised floors, openings
5	Multifunctionality	5	Accessibility to the control systems of components and installations
6	Demountable units and modules	6	Demountable units and modules
7	Loose fit connections	7	Loose fit connections
8	Reusable components	8	Reusable components
9	Buffer zones	9	Buffer zones
10	Lightweight materials	10	Oversupply of services, systems, facilities
11	Movable an portable components	11	Movable an portable components
12	Oversupply of services, systems, facilities	12	Lightweight materials
	Agreement (Kendall W)= 0.56		Agreement (Kendall W)= 0.58

Table 9: Total, First and Second rounds' ranking

The final ranking results of the first and the second round didn't; present big differences. In fact, only minor repositions happened which created an agreement between the two rounds of (Kendall W) 0.98. The final agreement among the participants was more than moderate (0.58, Table 9). The order of the design indicators was based on their average score of importance, added value and cost impact. No weighting factors were used in this research. The reason for this decision is that all the three categories are important on the decision-making process of designing a transformation project. It is quite probable that importance, cost impact or added value can be evaluated differently in different cases. Thus, as the goal of the final design framework is to be a general model which can be adjusted based on each unique project, all the "principles" are considered as equal.

To finalize the design framework and the order of the design indicators data collected from the interviews and some experiments of the weighting were used. Starting from the latter, the experiments were about how the order would change if the cost, importance or value is more important (Table 10). Looking at the experimental table we can see that the outcomes do not seem too much (0.49 Kendall W). The most different ranking is the one with the value. This is quite rational, if someone considers that the question about value was not specified to adaptable buildings but

generally to the added value on a project. In this question many answers had dipolar meanings. So, even though the participants believed that some indicators are really important for adaptability they did not believe that could add extra value to the building. Therefore, some indicators, like the "loose-fit" connections are ranked too low. At this point, we need to consider what does value mean, and again in the case of "loose-fit connections" it is not something that can be sold to a client (Mackay, 2019). If we compare the agreement of the experimental tables without taking into consideration the "value" ranking, the agreement is getting stronger (0.75), which shows that we are in a good stage of the final formation of the framework. Thus, to design the final framework, it was really important to include some more qualitative data, the ones selected by the interviews.

Table 10: Experimental ranking, own illustration

	Second Round , average ranking	Second round: Importance only	Second round: Importance and cost	Second round: Importance and value
1	Modular an dividable system	Modular an dividable system	Modular an dividable system	Modular an dividable system
2	Zoning	Zoning	Zoning	Reusable components
3	Multifunctionality	Raised floors, openings	Multifunctionality	Movable an portable components
4	Raised floors, openings	Demountable units and modules	Accessibility to the control systems of components and installations	Accessibility to the control systems of components and installations
5	Accessibility to the control systems of components and installations	Loose fit connections	Demountable units and modules	Lightweight materials
6	Demountable units and modules	Buffer zones	Loose fit connections	Raised floors, openings
7	Loose fit connections	Oversupply of services, systems, facilities	Lightweight materials	Zoning
8	Reusable components	Accessibility to the control systems of components and installations	Reusable components	Buffer zones
9	Buffer zones	Reusable components	Raised floors, openings	Multifunctionality
10	Oversupply of services, systems, facilities	Multifunctionality	Movable an portable components	Oversupply of services, systems, facilities
11	Movable an portable components	Movable an portable components	Buffer zones	Demountable units and modules
12	Lightweight materials	Lightweight materials	Oversupply of services, systems, facilities	Loose fit connections

3.2 Interviews

As required by the Delphi methodology, the research took place in one-by-one meetings. So, after the conduction of the first Delphi round, process of about 30 minutes in average, the interview part started. The author, benefited by the elaboration of the interviewees on the indicators and drivers, gained the possibility to ask more in-depth questions organized in a semi-structured interview (Bryman, 2012). In semi-structured interview, both open and closed questions are included. According to Bryman, a semi-structured interview is a flexible way to interview participants based on an interview guide. In that case, the questions are not required to be stated in a specific order but based on the flow of the discussion. Also, extra questions can be added during the process of the interview. Even though the process is not structured, the wording of the questions asked to each interviewee should be similar on the same topics (Bryman, 2012).

The interview part of the empirical research was more interactive than the first and helped the interviewees to share their knowledge easier. This was also a way to understand how the participants ranked specific factors, based on what beliefs and which is their general understanding and activities on the topic. In the end, all of the interviewees were positive to reply in extra questions, if needed. So, in the email that was sent for the second round of Delphi, some of the interviewees received extra questions based on their answers. In these cases, the full transcript of their interview was also provided. For the final analysis the software, atlas.ti will be used.

Objectives of the Interviews:

1. Clarify the decision-making process, obstacles towards adaptable transformation projects
2. Assess the characteristics of adaptability
3. Define new (or not) design indicators that the interviewees use towards adaptability
4. Define the value of adaptable buildings
5. Gain some extra knowledge on techniques and costing, when that was feasible
6. Enrich the literature study of the research

3.2.1 Interviews' Analysis

The analysis of the interviews was made in the Atlas.ti 8 software which is a tool for qualitative data analysis. These software supports the better organization of the data using quotations, codes and "families". The "quotations are the primary data derived from the interviewees, the codes are tags in which we can attach quotations with similar objectives while "families of codes" are groups which include two or more equal codes. This type of categorization is helpful, especially when many interviews are conducted, as it provides a clear mapping and better control of the qualitative data. Except of creating clear groups we can also link different codes by creating networks of codes that are related. This function is more important when quotations are attached to more than one codes as we can understand the internal hyperlinks (van Oel, 2019).

So, based on the research objectives the first codes were created. While attaching the quotations of the interviewees on the different codes the necessity for extra, more specific codes, developed. This would help to create more detailed patterns which could explain better the inter-relationship of the derived data. As was referred in the theory, some quotations were relevant to more than one codes and the use of networks for a better understanding was required. By doing so, a map of contradictory, parallel and completely different perspectives on the same codes was made (Figure 21).

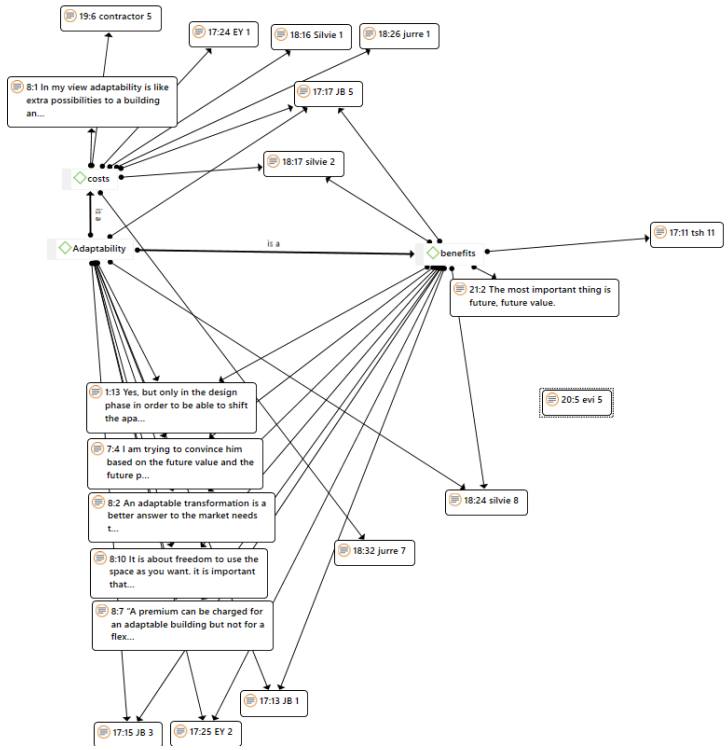


Figure 20: Example of qualitative data analysis in Atlas.ti, own illustration

3.2.2 Findings

The first code was the "Benefits of adaptability". The benefits of adaptability can be grouped into three main categories (three extra codes) which are the benefits of adaptability during the design phase, the benefits at the exploitation phase and the financial benefits of adaptability. The next codes were about the cost of adaptability (again into three perspectives), the techniques and tools for adaptability, the important characteristics of adaptability (based on the four characteristics derived by Schmidt III, 2014) and the lessons learned.

Adaptability can be beneficial in all of the phases of a project. During the design phase it is important to be flexible and adaptable (apartments' typology), as it lowers the risks of vacancy and increases the satisfaction of the users as you can give them freedom of choice (Lokhorst, 2019; Schleurholts, 2019; Bijdendijk, 2019; Catalgol, 2019; Ector, 2019; Bruil, 2019). Talking about the benefits of adaptability, Ector said that it is important to be able to change your space based on your demand, tour requirements should be the trigger point not the cost of adaptation (Ector, 2019). Moreover, Bruil highlighted the importance of adaptability for creating a more sustainable real estate stock while can reduce the future costs be the creation of adaptive capacity (Bruil, 2019). Another benefit is that an adaptable building has better potential of a higher end value in comparison with a non-adaptable one (Hobma, 2019; van Rijn, 2019).

One of the main obstacles, or disadvantages, of adaptability according to the interviews is the incapacity of the existing financial models to incorporate sustainability and the value of an adaptable building cannot be measured financially. This is a big obstacle in the decision-making process and when an investor will accept to do this step. So, it is important to be able to convince him in any possible manner (Ector, 2019) (Blauw, 2019; EY, 2019). Moreover, there were interviewees who supported that the future uncertainty is a big risk for adaptability as you do not know If you will need to use it and there is a high possibility of investing more for nothing (Blauw, 2019; Schrauwers, 2019; Bruil, 2019).

Concerning the most important characteristics of adaptability, so answering the hypothetical question of "why to go for adaptability?" the majority of the interviewees supported that the ability to remain fit is the most important reason as according to Catalgoc "*We need to create buildings that can adapt to the future needs, it is irrational to make big conversion investments every 5-10 years".* The second one was the ability to change which is about the change of performance (van Rijn, 2019; Bruijning, 2019), or the convertibility according to Schmidt III (2014). An important connection between the characteristic of adaptability and the need for adaptability is the following quotation:

"***Adaptability is becoming more and more important, especially because of the crisis. The functions and generations are changing fast. The living, the way we work the way we use buildings is changing much faster than it used to change***." (Lokhorst, 2019)

The important elements and the techniques for designing adaptability are the next two codes. Even though we talk about qualitative data there seems to be a strong agreement about the two most important things, zoning and grid. Although, almost everybody underlines the need for a good structure. The techniques usually used by the interviewees vary. Once again, the grid and the efficient zoning were on the top of the list. Other important parameters are the Multifunctionality, accessibility, a bit over-dimension and demountability (de Jong, 2019; van Rijn, 2019; Bruil, 2019; Mackay, 2019). Moreover, there were interviewees (developers) that supported that lightweight materials can be extra beneficial because you can extra volume while they are easier managed in the construction site (Lokhorst, 2019; Mackay, 2019).

The last input from the interviews is the "lesson learned" that the participants wanted to share. The first one was that only with adaptability you can confront functional obsolescence. The dry connections and reusable materials are the basis for a good adaptable design and a building that can be future-proof (Schleurholts, 2019). A quite same perspective was that If you have a multifunctional building and a good, adaptable structure "you and do everything" (van Rijn, 2019). Also, the need for detailed plans and using the layers of Brands' as a basis for the transformation were underlined by the majority of interviewees (Blauw, 2019; Bruijning, 2019; Catalgol, 2019; Lokhorst, 2019; Mackay, 2019; Sarafopoulos, 2019; Schleurholts, 2019; Hobma, 2019; Remoy, 2019)

3.3 Conclusions

Many conclusions and thoughts can be created after the end of this empirical research. Starting with the multicultural approach of the participants, it was truly educative to map the different perspectives, interests and tools shared by the experts. The most important, qualitative finding that aligns fully with the literature review is that the first step for adaptability is to respect the layers of the building proposed by Brand (Brand, 1994). As being explained in the literature, the layers that have bigger life-cycle dominate the ones with the smaller ones (Brand, 1994). This "statement" was used by many participants of the Delphi panel in order to rank the design indicators. So, the ones related to structure were ranked as more important than the ones related to stuff. Another important finding was that the selection of an adaptable strategy it is not only related to costs, but it is dependent on the balance

between the financial risks of an investment and the potential that can be generated by adaptability. Another finding that is in an agreement with the literature is the list of indicators. The techniques used by the interviewees to develop adaptable buildings were all discussed in the framework. Lastly, all of the interviewees agreed that each transformation project each unique and that it is really hard to make cost assumptions.

Chapter 4_Research Results

Important considerations before the implementation of the Framework

and the Criteria for its Synthesis

4. Costs and benefits of adaptability- Research Findings

In the previous chapters the importance of adaptability for the creation of a sustainable and future proof-built environment was discussed, mainly based on the findings from the literature study. In this chapter will be summarized and presented all the findings from the scientific and empirical research which will result the criteria for the framework's development.

Adaptability is a long-term-beneficial concept for which the financial value cannot be estimated with the existing financial models. Additive to this, the use of a building's adaptive capacity is dependent on future uncertainties, risks, trends and the "pay-back" time cannot be determined (Schmidt III, 2014). These make the investors, contractors and/or real estate developers and architects less enthusiastic on adaptable assets as there is no guarantee of increased future value. Uncertainty combined with a possible higher investment are the main obstacles in designing adaptable real estate. According to Geraedts, a higher investment can be a high risk without potential of higher IRR (Geraedts, 2001; Schmidt III, 2014).

On the other hand, a building's alteration during the exploitation phase can be extra costly when no adaptable design solutions are implemented in the initial design (Geraedts, 2001; Schmidt III, 2014). There are adaptability design strategies without extra cost that can be applied in a transformation of a central-core office building (Schenk, et al., 2009), and these according to Geraedts (2001) are the most appealing ones. The most important one, according to the literature and the empirical research is the use of coordination system, a grid. Nevertheless, extra flexibility or adaptive capacity can be added in the initial phase of a project (transformation or not) with an unfortunate increase on the initial investment. Therefore, the tools for adaptable design vary but should be selected and implemented driven by the financially feasibility of the project and based on its specific requirements.

4.1.1 Barriers and Benefits for/of adaptability

4.1.1.a Barriers: Findings from Literature research

Based on literature and according to the extensive list provided by Schmidt (2014), there are many exogenous and endogenous factors that can act as barriers or benefits for adaptability. Starting from the former, the barriers and the exogenous factors, the most common barrier to invest in adaptability seems to be the future uncertainty. This factor was highlighted from both, literature and empirical research. According to Arge (2005) the "timelapse between the costs and benefits of flexibility" is dependent on the future real demand, which is highly uncertain or can be present after a long period of time (Schmidt III, 2014). This "timelapse between Cost & Benefit" is also expressed as a higher investment risk as it is unknown If the (adaptable) tactic will be used in the future, the existence or not of incentives for sustainability and adaptability/adaptation. Another common barriers are the "Convencional mindsets", "Industry conventions" and "Higher risk". These include the traditional way od developing and re-developing real etsate, the investments decision makers, the stakeholders (short-term/long-term interests), the the future's unpredictability, the structure of the existing financial models, the higher initial costs and policies. Moreover, there are building specific barriers like the incapacity of the load bearing stratucture, the shape of the building, the accessibility points, the complexity of the final project, its image and characteristics (Schmidt III, 2014,at his Appendix G).

4.1.1.b Barriers: Findings from Empirical research

Additional to the literature research, a lot of the above-mentioned parameters and their negative impact, on deciding for adaptability, were mentioned during the interviews. The most highlighted factor was the risk and uncertainty. As was mentioned, an extra investment on adaptability is a high risk especially in a good market. This comes due to the "pay-back's" uncertainty. In that case, they

would only prefer to invest on less risky and more short-term valuable things like quality and love-ability of the asset. Another factor was the incapacity of the existing financial models to incorporate the end value of adaptability in a market where the investors are mainly looking for higher IRRs (Bruil, 2019) (Blauw, 2019). Both interviewees underlined the difficulty to assess the future value of adaptability and the difficulty to evaluate its possible value at the time that the investment is made (t=0).

"Many of the investors are financially driver and ***if sustainability does not appear in the cash flows they do not care****, and they will not appreciate it."* (Blauw, 2019)

4.1.1.c Benefits: Findings from Literature research

On the other hand, there are many benefits in designing adaptable buildings. Based on the list of Schmidt's, the more common ones are the "Improved investment value", "Increased building's longevity", "Reduced change impact" and "Improved operational efficiency". The former benefit is a proof of long term value for users and owners, accommodation of a variety of uses/ higher densities/ functions, ease of subletting, better rental growth and increased rental value, improved net value, more attractive to new users while enhances the satisfaction of the exiting users (lower vacancy and mismatch), maintenance of resale value and of the ease of being maintained or transformed while being in operation (Schmidt III, 2014, Appendix G). The extended building's longevity comes as a result of waste reduction, longer life-cycle, sustainability, durability, extension of useful life with less capital while extending the financial viability of the project. "Reduced change impact" and "Improved operational efficiency" stand for reduction of re-transformation time and costs, "*endurance of longer periods between refurbishments*" which are supposed to be less radical, minimization of conflicts, efficient real estate supply, improved management and cross utilization of space (Schmidt III, 2014, Appendix G). Except of these, there are also other benefits like the increased users' satisfaction and the reduction of life-cycle costs (Schmidt III, 2014, Appendix G).

4.1.1.d Benefits: Findings from Empirical research

The same benefits were highlighted during the interviews (Table 11). Bruil and Ector talked about the freedom of choice, the increased sustainability and durability. J. Bruil was also referred to the reduction of costs in long term as a result of minimized re-transformation and adaptation costs. Moreover, R. Mackay explained that an adaptable building has a higher re-sale value (up to 20% while the initial costs increase is maximum 10%) in comparison of a similar asset that is not adaptable. The importance of adaptability and flexibility of the design was underlined by other architects and developers due to the reduction of uncertainty and increase of users' satisfaction (Bruil, 2019; Ector, 2019; Lockhorst, 2019; Mackay, 2019). Additionally, Remoy stated that by implementing strategies for adaptability threats like changing technology and innovation can be confronted (Remoy, 2019). Nevertheless, Remoy and Schleurholts agree that adaptability is a concept that exists for many years in the architectural practise and the basic difficulty is not how to convince an investor but how to design it propely (Schleurholts, 2019; Remoy, 2019).

"An adaptable transformation is a better answer to the market needs than a standard transformation*. A slightly bigger investment can give you better opportunities".* (Ector, 2019)

"Adaptable buildings can reach a higher future value." (Hobma, 2019)

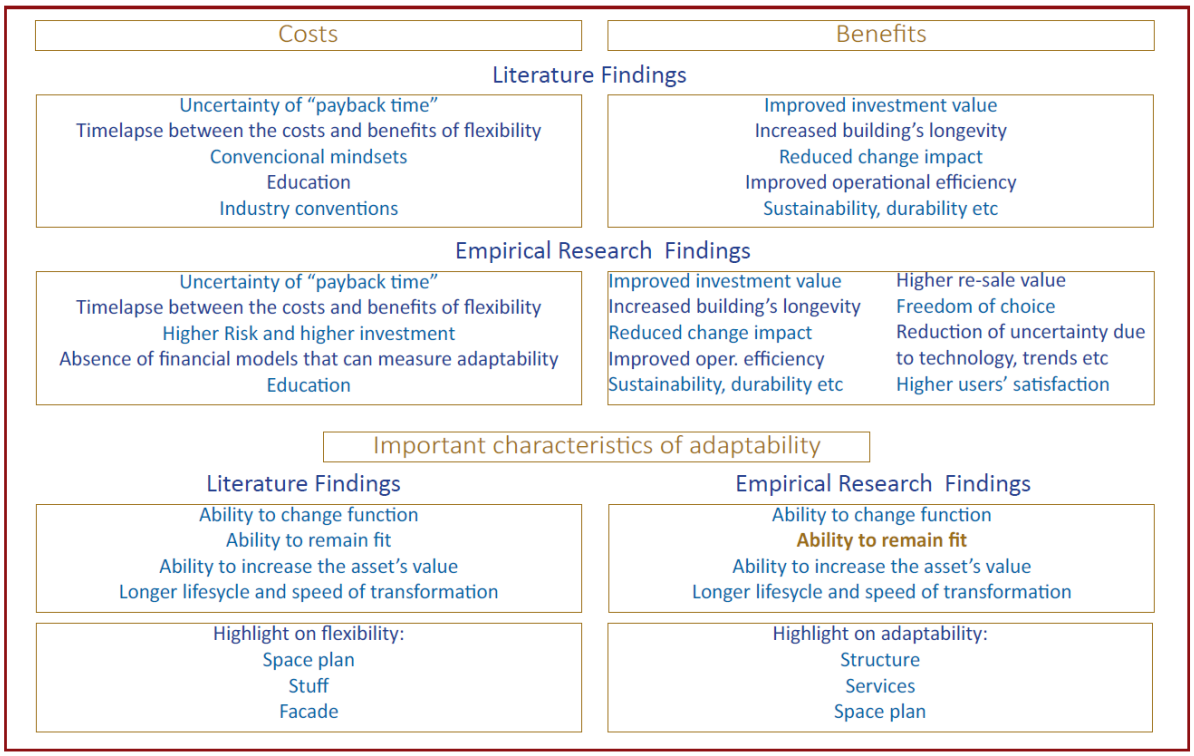


Table 11: Main research findings on adaptability

4.2 The financial impact of design indicators (and tools) for adaptability

The actual financial impact of adaptability is really hard to be estimated. Considering that each project and each adaptation and adaptable (or not) real estate strategy is unique and highly influenced by external and internal factors, only assumption can be made (Mackay, 2019). In the literature, we can find researchers claiming that adaptability is extra costly while others talk about negligible numbers (Manewa, 2012). According to Geraedts the main extra costs of adaptability are the ones related to the extra design detail and the complexity of construction. Moreover, what can be extra costly are the materials, mainly in the case of demountable ones, the layout organization, the maintenance and the operation costs (Geraedts, 2001).

On the other hand, this can be confronted by the use of modular systems and components, where the construction time is considered to be from 15%-50% less than the traditional construction. Modularity was also one of the indicators that was assessed in many ways during the empirical research. The average outcome was that there is a higher cost in the designing of the systems and components which will reduce the construction time and the labor cost at the construction phase (Lawson & Ogden, n.d.; Moiseenko, 2017). Furthermore, some of the indicators used in the Framework was described as the ones that you need to implement in any project, regardless the orientation to adaptability. So, things like the grid, the efficient zoning and routing, the division of support and infill components are valuable parameters for a transformation project, adaptable or not. According to Schenk et al. (2009), adaptability can only cause an additional extra cost less than 5% for office buildings (Schenk, et al., 2009), while in another source maintenance is estimated to cost less than 3% (Manewa, 2012).

Also, the design indicators of adaptability can be analyzed based on their balance of benefits and costs. According to Schmidt, there are parameters which can cause a small amount of money while creating a lot of extra benefits. On the other hand, there are design parameters that cost a lot without adding certain value to the project. The majority of the selected indicators of the framework are included in

the category “Good buys” of Schmidt’s matrix (Figure 22), which represents the quadrant of low cost and certain benefits (Schmidt III, 2014). Some of them, like the raised floors and the light-wall partitions were estimated to have high investments cots during the Delphi research while in the literature they are allocated at the low-cost part. This example easily indicates the differences of prices among different countries and different periods. This is evident also through the interviews where all the developers and consultants were referred to the big increase of construction costs during the past four years. Although, the future is uncertain, and we are not able to estimate the actual costs of construction after 15 years neither forecast when exactly the next crisis will come. **Thus, in this research the use of actual numbers is not that useful, as it addresses a long-term global problem**. Also, considering that the actual costs and benefits are project specific and dependent on the actual need for change in function, space or components over the years (Manewa, 2012), the numerical generalization is unimportant.

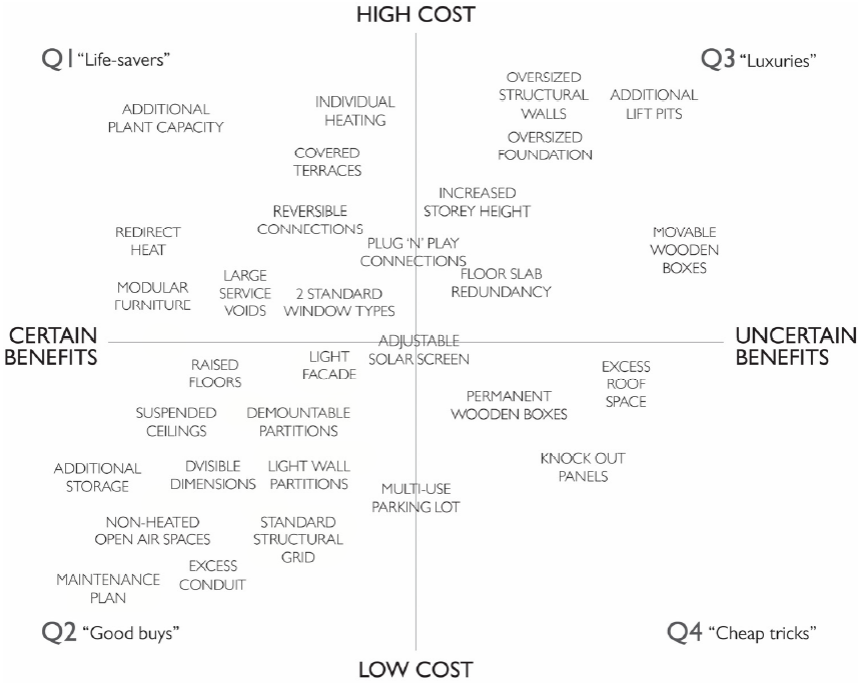


Figure 21: Cost certainty, by Schmidt III, 2014

Moreover, according to Manewa a way to evaluate the costs and benefits of a design strategy in long-term is the Whole Life analysis (WLA). This method provides a solid background in order to understand the current and future benefits adaptability (change in accommodation supply). However, none of the existing cost models is able to calculate the cost of adaptations for non-adaptable buildings in a life cycle perspective (Bruil, 2019; Manewa, 2012). Manewa assumes that a proper use of such tools for adaptable buildings compared to non-adaptable ones is probable to reveal “*unimagined economic benefits to investors*”. This can be easily obvious by considering that for an adaptation of a building which is not adaptable there is a high chance that the costs will be equal to a new construction (Manewa, et al., 2013). This fact is crucial especially while considering that a transformation project has already been under big conversion (and financial investment) for at least two times in its life-cycle. Nevertheless, the data about adaptable buildings are limited due to their small existence in the buildings’ industry (Manewa, 2012).

"*The economic life of a building can be best extended by adaption, rather than just maintenance.* ***Thus, adaptable buildings provide economically sound benefits over the long term***"[16]. (Manewa, 2012)

Additive to the existing knowledge and information gathered by scientific sources there are the data derived by the Delphi research. The participants were asked to grade and elaborate their answers on the financial impact of the given design indicators. Thus, based on the literature review and the Delphi research a map of the economic consideration of the different design indicators was selected (see Table 12).

4.3 Synopsis of the research findings

Criteria for the Framework Design

As has been already discussed, a variety of data were gathered from the different methods used. These data cover all the aspects of adaptability, starting from the definition to limitations, layers and abilities. As the theoretical framework was explained in detail in Chapter two, this section is focused on the criteria and requirements set for the development of the framework and the understanding of the importance of adaptability's aspects (See table 12 for the main research findings).

Starting from the latter, one of the main research objectives is the importance of adaptability; what makes adaptability valuable. Based on the definition of adaptability adopted by Schmidt there are four things that adaptability consists of (Schmidt III, 2014). During the semi-structured interviews section, the interviewees were asked to elaborate on these four aspects, and an outcome created was that the most important is the ability of a building to remain fit[17]. This seems to be rational, at least in comparison with the ability to change (function) as the latter is a more expensive activity during a building's operation phase (Schleurholts, 2019).

Secondly, the research about the costs and benefits of adaptability adduced a pattern of pros and cons. Regarding the drawbacks of adaptability and the data gathered from the hybrid methods a main shortcut seems to be the incapacity of the existing real estate industry and the financial models to captures the value of adaptability. In addition to this, adaptability is usually related to higher investment costs and uncertainty of payback time, which create a negative atmosphere when deciding about the re-design of a(n) (adaptable) project. Of course, these shortcomings can be recognized in new projects. The information gathered during the empirical research was valuable as confirmed the literature study and added the personal perspective of the practitioners. That was helpful as some "solutions" to overcome these drawbacks were indicated.

Main Findings			
Costs	Benefits	Adapt-Abilities	Lessons Learned
Uncertainty of "payback time"	Improved investment value	Adjustable	Uniqueness of each Project
Timelapse between the costs and benefits of flexibility	Increased building's longevity	Versatile	Importance of Layers
Higher Risk and higher investment	Reduced change impact	Refitable	Ability to remain Fit
Absence of financial models that can measure adaptability	Improved oper. efficiency	Convertible	Detailing
Education	Sustainability, durability etc	Scalable Movable	Multifunctionality
Industry conventions	Higher re-sale value	Future Proof	Adaptable Structure
Convencional mindsets	Freedom of choice	Durable	Design Principles
	Reduction of uncertainty due to technology, trends etc	Feasible	
	Higher users' satisfaction		

Table 12: Main Research Findings, own illustration

[16] Douglas, J., 2006. *Building adaptation.* 2nd edn. UK: Butterworth-Heinemann Ltd.

[17] Almost all the interviewees agreed that the ability to remain fit is the most valuable aspect of adaptability.

The benefits of adaptability, the most-wanted abilities and the tools to create the required level of adaptive capacity is the third set of input by the research. Concerning the tools, fortunately the empirical research confirmed the design indicators that were adopted by literature (see section 2.5-2.7). The most wanted "abilities" is an input based on the scientific knowledge, as the existing research is comprehensive and well developed (Geraedts, et al., 2014; Nakib, n.d.; Schmidt III, 2014). Lastly, the list of benefits was created having as backbone the literature and as finishing the interviews and the Delphi elaboration (the value creation grading part). Additive to this, come the "lessons learned". This part is mostly created by the interviews section (see 3.2.2).

So, the criteria for the Framework's development follow the findings (Table 13). The first thing to be mentioned is the "Layers", the importance of respecting their order and the necessity of not combining tools that respond to different Brand's levels. The latter can be translated to the design solution of divide support and infill (Nakib, n.d.). Afterwards, the solutions that are focused on short-term values are not that important for the practitioners. This means that flexibility is welcome, especially if not extreme costs are required, but will not add that much end value to the project (this is an outcome of the two parts of the empirical research). The second "criterion" comes is parallel with the first one, as both describe the importance of the layering and the long-term value of adaptability, which as described in Chapter two, is deferent from flexibility. Finally, there are design tools/indicators that do not add extra costs, and these are the most desirable ones. Nevertheless, in some cases more indicators need to be used to make a future proof project.

Criteria
• Balance between cost-value • Analysis of the project a. Transformation potential b. Building's and environment's characteristics • Basic Principles of Adaptability • Desirable Accommodation Opportunities • Definition of existing risks and threats • Impact on Layers

Table 13: Criteria for the Framework development, own illustration

Chapter 5_ The Framework & its Implementation

5. A solution towards future proof transformation projects

5.1 The development of the Framework_ The process

The expectations

In the beginning of this research, adaptability and flexibility were for the author synonyms. It took around three months to clarify their differences and create solid boundaries regarding their meaning and value. Based on the scientific knowledge which was discussed in Chapter two (2), adaptability is defined as a long-term strategy that creates value during the years while flexibility is a short-term concept that responds to changing needs (Pinder, et al., 2011). Having these in mind, the author mapped flexibility as an "easy to achieve" strategy while adaptability seemed to be a more detailed and in-depth process. Additive to this was the pilot study, where simple solutions, like multifunctional components, seemed to be the easiest choice to enrapture flexibility and adjustability (MOR, 2019). Indeed, some of them which are mainly focused on spatial flexibility are easy to be designed and have obvious end-product results (Geraedts, 2008; Schmidt III, 2014). Thus, the idea that the small, short-term and easy to be implemented strategies on the lower levels of the building (based on Brand-stuff, space plan) are the most favorable or the least expensive-difficult to be included in a real estate strategy (see figure 22). This led to a first attempt to develop a framework (Table 14) which had as basis the simple design indicators, the ones that can change easily and without a possible big cost, and ended with the more expensive or hard to implement strategies (Geraedts, 2008). As can be observed in the following table, the strategies of the Framecycle are still followed, according to their clockwise sequence on the circle (Schmidt III, 2014; Manewa, et al., 2013).

AD1 - ADJUSTABLE & VERSATILE			AD1 - ADJUSTABLE & VERSATILE & REFITABLE				AD2 - ADJUSTABLE & VERSATILE & REFITABLE				AD3 - ADJUSTABLE & VERSATILE & REFITABLE & SCALABLE & MOVABLE			
Minimum Grid	Space		Minimum Grid	Space			Minimum Grid	Space	structure		Minimum Grid	Space	structure	
Modular system	Space	stuff	Modular system	Space	stuff	Services	Modular system	Space	stuff	Services	Modular system	Space	stuff	Services
Dry connections	Space	stuff	Dry connections	Space	stuff		Dry connections	Space	stuff		Dry connections	Space	stuff	
Reusable/multifunctianal elements	stuff		Reusable/multifunctianal elements	stuff			Reusable/multifunctianal elements	stuff			Reusable/multifunctianal elements	stuff		
distributed and individual controlled facilities	stuff		distributed and individual controlled facilities	stuff	Services		distributed and individual controlled facilities	stuff	Services		distributed and individual controlled facilities	stuff	Services	
loose fit connections	stuff		loose fit connections	stuff			loose fit connections	stuff			loose fit connections	stuff		
separation of support-infill	space		separation of support-infill	space	Services		separation of support-infill	space	Services	structure	separation of support-infill	space	Services	structure
Disconnected components	stuff		Disconnected components	stuff			Disconnected components	stuff			Disconnected components	stuff		
Access points to units	Space	stuff	Access points to units	Space	stuff		Access points to units	Space	stuff		Access points to units	Space	stuff	
Day night cycles - Multifunctionality	Space	stuff	Day night cycles - Multifunctionality	Space	stuff		Day night cycles - Multifunctionality	Space	stuff		Day night cycles - Multifunctionality	Space	stuff	
			Movable walls	stuff	Space		Movable walls	stuff	Space		Movable walls	stuff	Space	
			Movable installations	service	Space		Movable installations	service	Space		Movable installations	service	Space	
			Buffer zones	space			Buffer zones	space			Buffer zones	space		
			Circular routing	space			Circular routing	space			Circular routing	space		
			lightweight materials	stuff	Space		lightweight materials	stuff	Space		lightweight materials	stuff	Space	
			Open layout	space			Open layout	space	structure		Open layout	space	structure	
							Oversupply of services and systems	service	structure		Oversupply of services and systems	service	structure	Site
							Centralized facilities, core system	service	structure		Centralized facilities, core system	service	structure	
							zoning	space	services		zoning	space	services	
							accessibility to the control systems of components and installations	space			accessibility to the control systems of components and installations	space		
							Raised floors, openings	Structure			Raised floors, openings	Structure		
							overcapacity of facilities	structure	services		overcapacity of facilities	structure	services	
											demountable units and modules	stuff		
											detailed connections of internal and external components	stuff		
											Movable components	stuff		
											Portable components	stuff		
											dropped ceiling	stuff	strucure	Space

Table 14: First experiment of the framework, own illustration

The input by the Empirical research

The empirical research was critical for the final design of the framework. The first part of findings is absolutely related to the design indicators. During the Delphi and the semi-structured interviews, the selected by the author and derived by the literature design indicators, were confirmed as appropriate (there were not missing indicators). However, the perspective of the practitioners was different than the method described in Table 16. The majority of the participants stated that is better to invest on the higher levels of the building (structure, façade, services) than investing in furniture (Bijdendijk, 2019; Ector, 2019). This opinion was elaborated based on the life-cycle of these parts. For example,

stuff and/or furniture are expected to be replaced after five to seven years. So, a higher investment on something that is not going to last was not a favorable choice by the professionals. For them, a probable need for adaptation in a time-span less than ten years means that the development was not successful (Bruil, 2019; Lokhorst, 2019; Catalgol, 2019). Of course, there is a bandwidth of accepted changes or renovations dependent on the project and the expectations (Schleurholts, 2019; Schrauwers, 2019). Moreover, during the grading of Delphi it was obvious that the indicators which received higher ranking on value and importance are the ones related to the higher levels, like the raised floors and the grid which are related to structure (Chapter 3).

The outcome

The problem stated for the conduction of this research is the (re)-obsolescence of the building stock. Obsolescence is a situation that cause a series of negative externalities which affect the stakeholders of a building, its users, neighborhood or even the city when there is a big density of obsolete assets. As explained in the previous chapters, and mainly in the introduction, a sustainable way to confront obsolescence is the adaptive re-use and/or transformation of the vacant, under-performing and outdated buildings. In addition to this, the risk of re-obsolescence was added in the research objective as a risk for future obsolescence after a building's transformation occurs in a constantly changing world. In this case a building's re-design into a non-dynamic object seems to increase the potential of buildings' re-obsolescence which can be mitigated by endorsing to it adaptive capacity. Thus, the research focus on the creation of a framework that can be used by practitioners for designing future proof transformation projects. Nevertheless, most of the principles referred in this framework can be applied in also in new real estate developments.

During the research process many data were gathered and the final framework was designed based on scientific and empirical knowledge. The framework is supposed to work as a tool that indicates an order of actions and their impact on a project and not as a strict guideline. This is due to one of the **"main lessons learned"** which is about the uniqueness of each project (Mackay, 2019). So, although there was a specific researched typology and a design framework could be developed, the claim of a guideline with veto rules is considered to be non-realistic. The difficulty of such a guideline is increased due to the fact that transformation projects can be a surprise, as things can be revealed only during the re-construction process (Ector, 2019; Schleurholts, 2019).

Concerning the different requirements that each project may state; the proposed design framework consists of three degrees (grades). These were created based on the Delphi results regarding the cost impact, value and importance in order to give solutions that fit to different circumstances. The existence of these three grades can be translated to extra values (accommodation opportunities) of a transformation project. The one degree does not negate the other, but they work as three steps. The first, is the most basic one which can guarantee the creation of an adaptable basis and convey to the project the pillars of adaptive capacity without adding extra costs on the initial investment. Then, dependent on the specific demands and analysis, more abilities may be needed. In that case the decision makers or the designers can use design tools from the next degrees.

The word "degree" underlines an order based on which an adaptable strategy should be developed.

So, the first degree is a precondition for the next two. The second degree is the continue of the first while the last one closes the circle of "adaptive capacity" possibilities. So, based on the use of a "Degree of Adaptability" a grade that determines the capacity of a building to change during the design and exploitation phase can be estimated. Moreover, each degree is followed by some cost and benefits assumptions; facts that need to be under consideration when designing a real estate strategy.

This parameter was assessed to be useful due to the multi-stakeholder's identity of real estate transformation projects (Manewa, 2012).

5.2 The final Framework

The final framework consists of three Degrees(Figure 23). The first one is called "Freedom" as it creates the necessary condition for spatial flexibility and functions' adjustment, thus gives a freedom of choice to the owner. The second one is called "Adaptation", as it brings closer the main indicators for adaptability, as it includes parameters of oversupply, vertical and horizontal flexibility. The last one is named "MORability", in respect to the pilot study and expresses all the possible adapt-abilities. However, someone can use more design indicators per project instead of the groups of four, eight and twelve design parameters proposed in the Framework. In this case, the user of the framework needs to make sure that the selected ones can be implemented without disturbances (ex: without a proper grid and efficient zoning the use of movable and portable components will probably be dysfunctional).

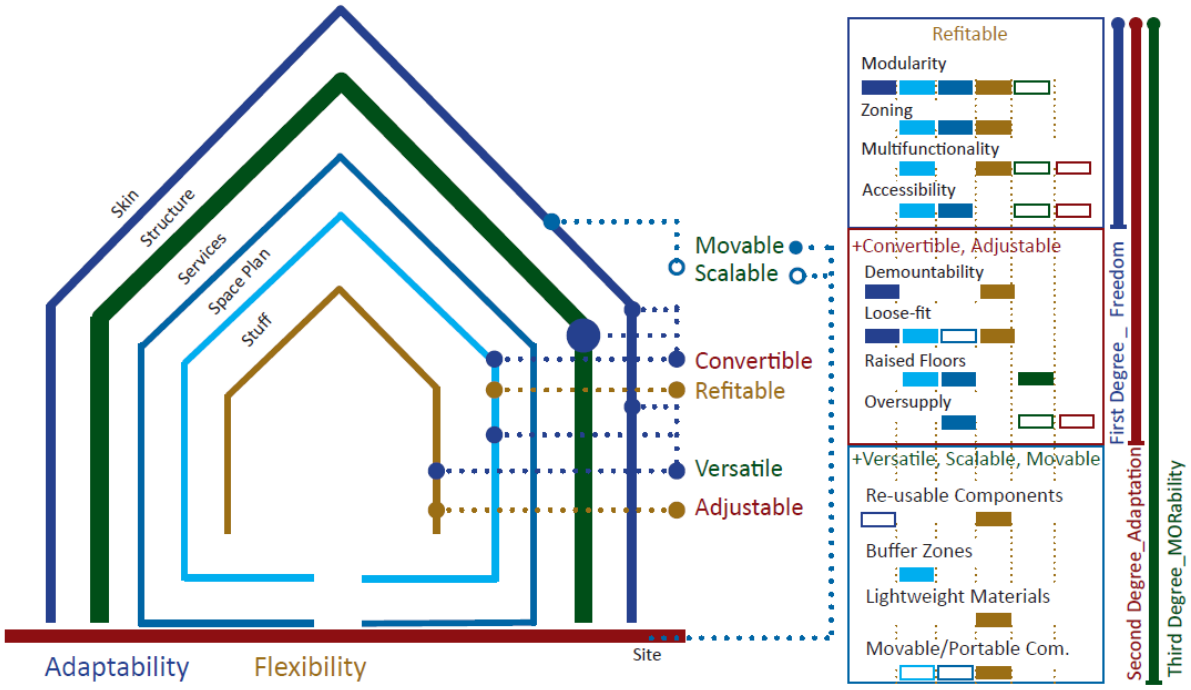


Figure 22: The Degrees of Adaptability, own illustration based on Brandt and Schmidt

The First Degree – "Freedom"

The first degree is the most generic one, developed on design techniques that have high value independent on the project. These are the ones that should be applied not only in transformation project but in the majority of projects as they increase the buildings' efficiency. It consists of the first four design parameters of Framework. The "modular and dividable system", "zoning" and "accessibility" can be considered as indicators for high qualitative buildings or as was stated during the interviews "must have a good zoning, a good grid and the ability to maintain and access properly your systems" (Hobma, 2019; van Rijn, 2019). So, the **first degree** can be considered as the basis or the **"backbone" for an adaptable project**. Extra initial costs are not considered in this degree, as the design indicators do not include any extra material costs while they only need a more detailed and proper design. Therefore the first degree can be assumed that only includes increased architects' fees, because of the extra detailing in design (6% instead of 4%) (Geraedts, 2001) (Moiseenko, 2017).

Moreover, the assumption of low-cost impact is supported by the conducted Delphi research, where these four parameters had a low-or zero- cost impact on the initial investment.

	Site	Structure	Skin	Services	Space	Stuff	
Modular an dividable system							Refitability
Zoning							
Multifunctionality							
Accessibility							

Table 15: First Degree; The design indicators and the layers they are expressed on, own illustration

In more detail, the design indicators used for the creation of the first degree of adaptability are four, the "modularity and divide-ability", the "zoning", the "accessibility to control systems and units", and the "multifunctionality" of space. In this case, the multi-meaning parameters are translated into specific components. In the first Degree by "modularity" is meant the standard grid, the standardized measures based on which the transformation project is designed and developed. Modularity at this stage is in the layers of the structure, space plan and skin, while the layer of stuff will be added in the next degrees. In the MOR case the grid is 3.60 m, a number that can divided by 90 centimeters which is the basis measurement for installations and services (Sarafopoulos, 2019). "Zoning" is expressed in the layers of space plan, services and structure. It is again about how the project is designed in order to create an efficient layout, clear organization and facility zones. Furthermore, "accessibility" comes at the levels of services and space plan. This indicator, common in design practice also for non-adaptable buildings, is about the design of access points for installations and services, the accessibility and visitability of the units in order to enhance a good operation and easy maintenance. Accessibility and zoning are two parameters that are highly linked and have similar value in this stage. The last strategy is "Multifunctionality". In the first degree we talk about multifunctional spaces and not stuff. Is about space that can be used in multiple functions, in multiple sizes and for multiple densities. An example by E. van Rijn was about parking levels that can be transformed to offices (van Rijn, 2019).

The combination of these parameters creates the basic context for an adaptable transformation project. The most relevant types of adaptability that can expressed by this Degree are the rearrange-ability and the divisibility-partitionability[18] due to the modular coordination system and the standard grid (Geraedts, et al., 2014; Geraedts, 2001), the space convertibility due to space multifunctionality (Schmidt III, 2014), the visitability due to accessibility of space plan (Estaji, 2017), the lifetime compatibility in the services and skin layer (Estaji, 2017), scalability, the durability and maintainability (Estaji, 2017). Although, considering the Framecycle by Schmidt III (2014) the ability gained with the first Degree is **"Refitability"**.

Accommodation alternatives [function, space componentry]

The benefits and abilities expressed in this degree create some extra potentials on the accommodation supply (Figure 24). Starting from the modular coordination gives to the floorplan a standard grid. The grid is the basis for the spatial allocation resulting a homogeneity and repetitiveness on the floor plan. This enhances creation of units which are developed on the multiplication of standard dimensions. This makes it easier and quicker to adjust the internal in the circumstances, by adding or rejecting "modules" without affecting the efficiency of the floor plan. Moreover, it can reduce the construction and design time of the interior due to the fact that the componentry to be used must be a multiplication of the grid. This is extra beneficial in prefabricated projects-units-components (Moiseenko, 2017).

[18] This is an expression of transformation Dynamics (Geraedts et al., 2014)

The internal adjustments and re-arrangements are also benefited by the efficient zoning. Zoning, in this building typology is based on the existing core which should work as the place where the services should be placed. By putting all the services and facilities in a standard place there is created more spatial freedom, as it is called open layout. Zoning and accessibility also create an efficient circular rooting (in yellow, figure 25) and increase the visitability on the different elements of the space plan. Moreover, accessibility and the fact that the services and facilities do not interrupt the "functional" space increases the maintainability and the repairing without affecting the building's daily operation. Last but not least, multifunctionality. This design indicator is a tricky one as it can express different design strategies. In the first degree, where only a light version of adaptability is acquired, multifunctionality is about the use of space for different functions. To do so, there are some buildings' restrictions concerning the free height and the services. Although, as we are talking about transformations of office builsdings we can assume that the staircases, the shafts, ducts and internal height are sufficient, and the building can support both living (residential, hotel) and working functions (flex-working, corporate offices). As in this degree no oversupply of services is included, we can estimate that the change of functions is dependent on the existing density capacity of the building[19]. Keeping in mind that no contracts or legislation are taken into account, multifunctionality enhances multi-tenancy which according to Dynamis is important in commercial sector (Dynamis, 2018).

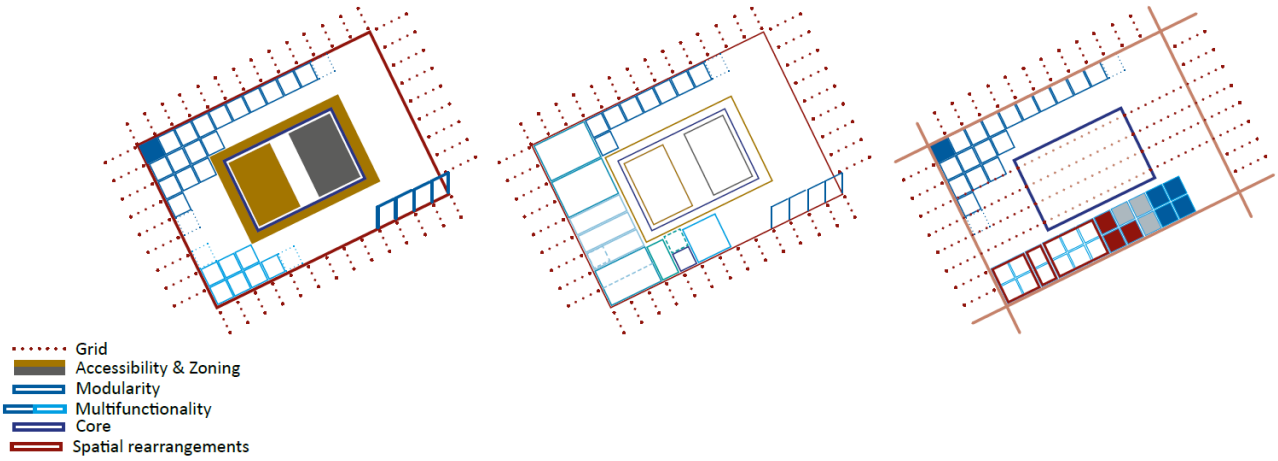


Figure 23:First Degree; Floor-plan sketch, own illustration

The Second Degree - Adaptation

The second degree consists of the first eight first design parameters of the Framework. In comparison with the previous, low-cost degree, the second one includes two design parameters that can be quite costly for the project, the oversupply of services and the raised floors. In this degree these parameters will be used in their "less expensive" version. On the other hand, the context of "modularity", "zoning", "multifunctionality" and "accessibility" of the first degree is extended. Therefore the second degree will have 5% additional costs in the initial investment phase and increased (6% instead of 4%) architects' fees due to the high need for detailing (Moiseenko, 2017; Schmidt III, 2014; Geraedts, 2001; Schenk, et al., 2009; van Eerden, 2018).

In more detail, the extra design indicators used for the creation of the second degree of adaptability are four, the "raised floors", the "loose-fit connections", the "demountable units", and the

[19] Density is dependent on the fire-safety, HVAC and mechanical systems. (MOR, 2019)

"oversupply of services". In the second degree the meaning of "modularity" is not extended to the layer of stuff as this would not add any value at this point. Same with the parameters of "Zoning" and "accessibility". Multifunctionality of space can be more dynamic due to the oversupply of services, in comparison with the first degree. The "demountable units" as also the "loose-fit connections" are highly connected to "modularity". These indicators are mainly expressed in the layer of skin and space (internal connections of partition walls etc.). They are both creating the basis for re-usability of materials and multifunctional objects and partitions, principles that will be added in the next degree. The loose-fit connections, in the case of skin support the more efficient and quick maintenance (or replacements and upgrade) of façade, which is one of the most important characteristics of a building (Nakib, n.d.). Moreover, the layers of skin (façade) except of the image of the building creates a solid ground for its sustainable performance by the use of PV panel, passive shading and U values (MOR, 2019). In this degree façade needs to be designed in a modular manner and be easily demountable and accessible. All the costs for adaptation, refurbishment or upgrade should be considered as extras and are dependent on the selection of materials and contractors. Although, the good zoning and accessibility supports the easiness and speed of the whole process (MOR, 2019).

Continuing with the economic considerations, the indicators of "raised floors" and "oversupply of services" were ranked as two out of the three costlier indicators. For the latter one, the belief was that if you invest now to systems that will be depreciated in maximum of 20 years you will lose your money (Hobma, 2019; Schrauwers, 2019). That was based on the fact that, in normal conditions, you do not expect to change the function of your building in a shorter period of time. Therefore, the oversupply is quite expensive and can only be used in an extreme market otherwise is an extreme financial risk (Schrauwers, 2019; Blauw, 2019; Bruil, 2019). On the other hand, this oversupply can be simply translated in a bit over-dimension of shafts in the places where all the dimensions and services are placed. This is also about the piping and cable systems which need to be pre-designed with a bit of over-dimension. Oversupply increases also the technical flexibility of the project and supports the multifunctional use of spaces (dependent on the use, industrial is excluded) (van Rijn, 2019; Catalgol, 2019). The "raised floors" is a more expensive strategy that can add more quality to the final product. It gives two-floor spaces and unlocks the vertical extendibility (van Rijn, 2019). In the case of the second degree the raised floors are expressed in the layer of structure and the space plan. The "openings" should be based on the grid and be temporarily closed with a loose-fit or demountable construction and are mainly used as connection points (staircases). The number of these openings should be minimized in order to reduce the costs while this strategy is mainly recommended in office and commercial spaces. Moreover, in the case of multi-story or tall residential buildings, the openings can be included in the first design (t=0) and be closed later on If there is no need for internal vertical connections. According to Schmidt III (2014), such a pre-cut strategy is better to be implemented at the redevelopment process (Schmidt III, 2014).

The combination of the first basic parameters and the four extra ones creates a more adaptable project. The advantages of it is the vertical flexibility and connectibility, the easy and quick in change construction details and the technical flexibility for different uses. The most important types of adaptability that can expressed by this Degree are the rearrange-ability[20] (Geraedts, et al., 2014), the space convertibility (Schmidt III, 2014), the visitability (Estaji, 2017), the divisibility-partitionability (Geraedts, 2001), the lifetime compatibility in the services and skin layer (Estaji, 2017), vertical and horizontal scalability, the durability and maintainability (Estaji, 2017). Moreover, expandability in the quantity-density of spaces (Estaji, 2017) and refitability are added (Schmidt III, 2014). Although,

[20] or according to Geraedts et al., 2014, the transformation Dynamics

considering the Framecycle by Schmidt III (2014) the ability gained with the first Degree is **Refitability**, **Convertibility** and some aspects of versatility (Table 16).

	Site	Structure	Skin	Services	Space	Stuff	
Modular an dividable system							Refitability
Zoning							
Multifunctionality							
Accessibility							
Demountable units and modules							Versatility & Convertibility
Loose fit connections							
Raised floors, openings							
Oversupply of services, systems, facilities							

Table 16:Second Degree; The design indicators and the layers they are expressed on, own illustration

Accommodation alternatives [function, space componentry]

The accommodation options, or the alternatives of accommodation supply are illustrated in the following figure (25). This version includes the principles of the first degree while adding some extra ones. These are the vertical extendibility-rejectability, bigger variety of living and working typologies, better mixed-use programmers and bigger bandwidth of convertibility. The grid is again the basis for the spatial allocation, while the floor plan and accessibility serve the best possible maintenance and operation phase. Multifunctionality is enhanced by the oversupply of services, creating a pattern where more function combinations can happen. resulting a homogeneity and repetitiveness on the floor plan. This enhances creation of units which are developed on the multiplication of standard dimensions, both vertically and horizontally. Moreover, the reduction of adaptation time is achieved by the demountable components and loose-fit connections. This also adds extra value to the durability of the object, the reduction of tenancy turnover and hidden vacancy. In the illustration (Figure 25) we can see how the same floor plan can support different spatial and functional allocations. In blue we can see the new, two-floor typology that can be used in commercial and residential while in brown we can see how different type of tenancies can be spread in the floor plan. Once again, the grid and the core are essential for these alterations.

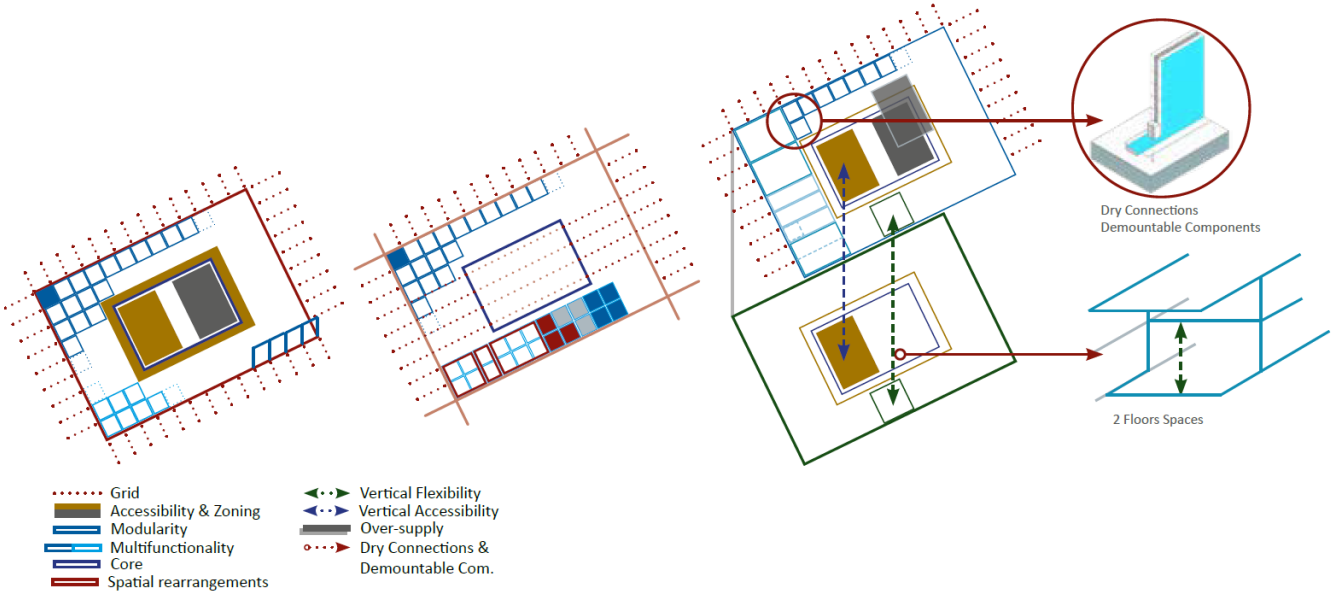


Figure 24: Second Degree; Floor-plan sketch, own illustration

The Third Degree - MORadaptability

In the third degree, all the (12) design indicators are included. In this stage, all the design indicators can be used in their maximum capacity, while the final strategy design should be formed based on the project and the market. The four new ones are namely “buffer zones”, lightweight materials”, “movable and portable components” and “reusable components”. This degree is graded with the highest grade of adaptive capacity, as it includes elements and capacities in each layer (Table 17). Of course, this adaptability generates extra investment costs. The difficulty at this stage is to calculate the actual amount of extra money due to the diversity of building costs and the lack of data. Even though, the characteristics of the third degree can be easily recognized in the MOR case, the project is still in the process of making and no final cost estimations can be made.

So, what is completely new is the layer of stuff which can make the project **adjustable, scalable and movable**; aspects that are not expressed in the previous degrees. The interpretation of these abilities includes movable and plug-in components, re-used materials and speed in adaptations and re-arrangements. The last principles are mainly expressed through the movable, portable and lightweight components, the buffer zones (which work as tension absorbers) and the re-usable materials (Schmidt III, 2014). In the case of the third degree, the buildings can be re-arranged, converted, expanded or rejected at the design and exploitation phase according to the demand, with minimum labor costs and vacancy period in comparison with the other degrees. An example or this is the following figure (26), where we can see how the buffer zones work in order to support multiple densities at the floor level depended on the requirements (MOR, 2019). The Buffer zones have the function of common spaces which can be smaller or bigger, according to the requirements. The grid, the core with the services and the movable partitions supports quick adjustability. What is also obvious is the different apartment typologies and space configuration. Moreover, in the third degree the meaning of “modularity” is extended to the layer of stuff. It is about the modular design of infill components (stuff). These are prefabricated components like bathrooms or walls based on the designed grid and measures. This perspective of modularity can save costs and during the design, construction phase and adaptation process[21] (Moiseenko, 2017). One last thing that need to be highlighted is that the oversupply of services and facilities at this degree is also about sustainability, and consequently future-proofness. So, in cases like MOR net positivity and the use of innovative systems to support such a circular and sustainable decision should be included. Although, the way to design a net-positive or circular building is not an objective of this research it is important to recognize that these values can be expressed through an adaptable design strategy[22] (MOR, 2019).

Figure 25: Densities; MOR floor plan, team's illustration

To conclude, all the parameters are able to be implemented in all of their possible aspects and generate values as sustainability, circularity, re-usability, movability, partitionability, extendibility, adjustability, modularity and multifunctionality. This degree is possible to create extra initial costs

[21] By adaptation process it is meant the internal rearrangements, refurbishments or renovations during the operation phase due to changes in accommodation demand.

[22] Indicators such as reusability, demountability, loose-fit and oversupply enhance the operation of sustainable systems (MOR, 2019).

(based on the literature and interviews) that can be estimated to be around 10%. Although, the finishes, materials and furniture to be used is a project specific decision of the stakeholders.

	Site	Structure	Skin	Services	Space	Stuff	
Modular an dividable system							Refitability
Zoning							
Multifunctionality							
Accessibility							
Demountable units and modules							Versatility & Convertibility
Loose fit connections							
Raised floors, openings							
Oversupply of services, systems, facilities							
Reusable components							**Adjustability & Scalability,** Movability
Buffer zones							
Lightweight materials							
Movable an portable components							

Table 17: Third Degree; The design indicators and the layers they are expressed on, own illustration

Accommodation alternatives [function, space componentry]

The last degree expresses the biggest number of accommodation options and is the most multi-scale approach in comparison with the first two degrees (Figure 27). Whatever was included as floor-plan alternative for the previous degrees is included in the new formation. What is completely new is the "reusable components" which add a more circular approach to the project. Re-usable, can be the interior walls which in the case of re-arrangements can be used as partitions in different locations, in the same or in a different building (movability) with the same or equal grid. Another example based on the MOR project is the bathroom module. Following the same rational with the walls, bathrooms can be re-located and reused in different spatial arrangements in the building which is quite beneficial -in case of spatial adaptations- as only a small amount of money will need to be invested in materials.

As described in the previous section, circularity and sustainability are principles that can be expressed in a design strategy that follows the third degree and both are important for the future proofness of a transformation project. The Buffer zones serve the best functioning of vertical and horizontal flexibility by providing space that can absorb the needed changes. That does not mean that this space is empty, but can be used in a secondary function, like common space or storage rooms.

Concerning the layer of stuff, the lightweight materials is a parameter only added in the third degree. There are some special benefits derived from this design indicator that can make it valuable generally for transformation projects (adaptable or not). By using lightweight materials, we can increase the volume of an existing building. An example, provided by Mackay was that by using lightweight, modular components on a specific transformation project they managed to add two extra floors and consequently create more lettable floor area (Mackay, 2019). On the other hand, lightweight materials can be really expensive and in cases that the vertical extension (scalability) is not legally or structurally possible the financial risk will be big (Sarafopoulos, 2019). Last but not least, lightweight materials are linked to the movable and demountable components as they support their mobility and portability.

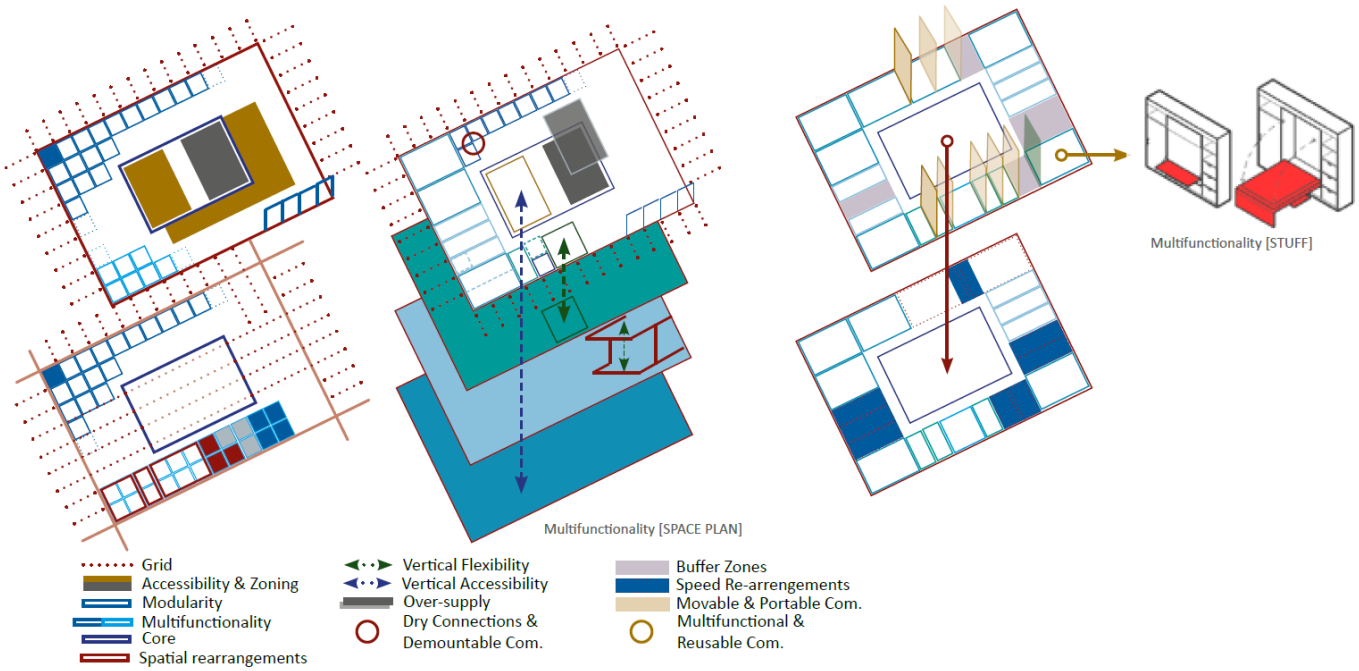


Figure 26: Third Degree; Floor-plan sketch, own illustration

The Pilot Study and the Third Degree of Adaptability

5.3 The necessity of the pilot study

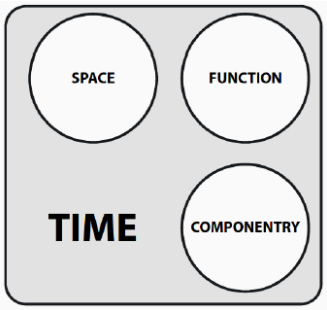


Figure 27: Perspectives of adaptability, Schmidt III, 2014

Starting from what do the Degrees mean, a series of floor-plan sketches were made to explain the accommodation alternatives of each degree (see figures 28-31). These opportunities are based on the function, componentry, space and time (figure 28), which according to Adaptable Futures research group are the main perspectives of adaptability (Manewa, 2012; Pinder, et al., 2017; Schmidt III, 2014). The first three will be expressed through the floor-plan illustrations while the perspective of time will be expressed through a timeline of possibilities and risks. All these developed on a pilot study, the MOR case (see section 1.2.5). The use of a specific case is beneficial as represents the researched methodology while offers a realistic background for initial analysis. Moreover, as the author is a member of the MOR project and applied the knowledge of adaptability during the development of the design, internal information and process can be added for the better explanation of the design indicators.

The assessment will be based on qualitative and quantitative techniques. Firstly, scenario planning and DAS will be used in order to identify future accommodation scenarios and evaluate the mis-match of the (adaptable or not strategy) of the Pilot Study (de Jonge, et al., 2009). Then, based on the market, demographics and real estate risks a timeline illustration is presented. The timeline is based or uncertainties that were traced through the Delphi research, the market and literature research and the SWOT analysis on the case study. Concerning the quantitative techniques, they include the Flex method developed by Geraedts et al. to identify the adaptive capacity score of each degree (Geraedts, et al., 2014; Geraedts & Prins, 2015). The implementation of the framework on the pilot study

proposes an order of actions that should be made to choose the right degree for a specific transformation project.

5.3.1 The case

The pilot project of this research is an obsolete office tower in the in Rotterdam. Rotterdam is the second biggest city of the Netherlands and is characterized as a dynamic city with strong infrastructure and a young, international population. The city is increasingly getting densified by young professionals, "starters" which are the young adults and the recent graduates (MOR, 2019). The harbor, being one of the biggest worldwide, makes Rotterdam to be the gate of Europe for the international markets and increase the confidence for real estate investments in the area. As a city, it demonstrates a good growth potential while the Municipality encourage the shift towards an economy of technology and knowledge (Arcadis, 2018).

The project is located in the M4H District, and more specifically in the Marconiplein (Figure 29). The District is an under-development area and based on the Municipality's planning it is going to have an innovation and entrepreneurial character. Already, many start-ups focused to robotics, innovative manufacturing, technology etc. are attracted in the area. Thus, the need for residential and commercial-industrial accommodation is getting more important. This includes co-working and flexible working spaces, exhibition areas, industrial units while also dwellings for starters and young professionals (MOR, 2019).

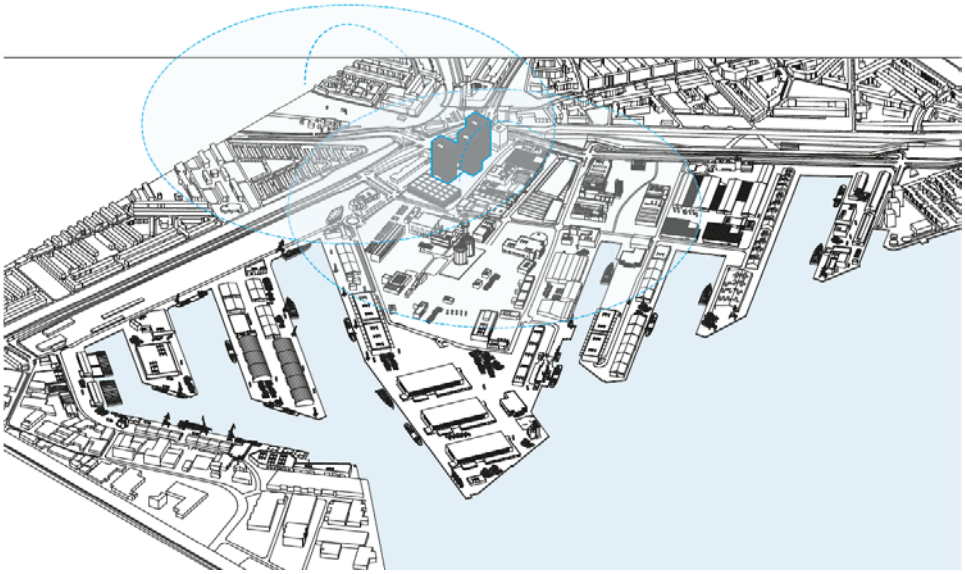


Figure 28: The M4H District in Rotterdam, MOR 2019

The project itself is focused on the Marconi Towers complex, which includes three 90meters-height towers that mark the entrance to the district. Developed by SOM based on the principles of the International style, they express the typology of the core office buildings that was described before. As being inefficient both functionally and environmentally the project proposed by the MOR team for the Solar Decathlon 2019 competition strives for a net positive, circular and adaptable transformation (MOR, 2019). The goal of the team is to provide affordable housing for starters in a mixed-use building that will be environmentally, functionally, societally and financially feasible.

5.3.2 SWOT

As the author is one of the members of this team and the project is the pilot study of this thesis, many data, strategies and directions implemented on the project are a result of the design indicators used in the Framework of the Degrees. The starting point of implementing adaptable real estate strategies is to analyze to project on its internal and external characteristics (Winch, 2010). To do so, a SWOT analysis (Figure 30) was created by the members of the MOR feasibility committee[23].

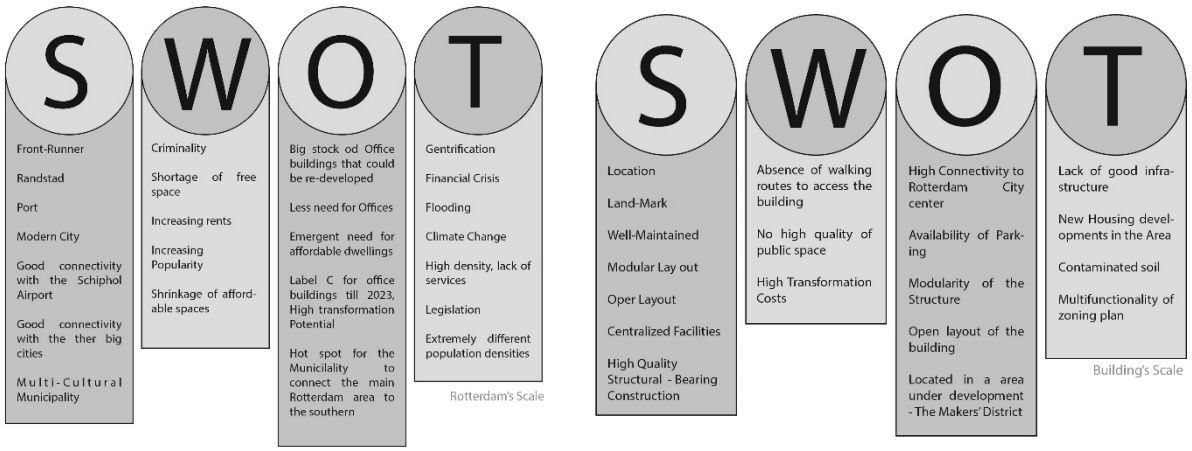


Figure 29: SWOT analysis on the MOR case study, team's illustration

The analysis was made both at the Rotterdam's and building's scale. The strength of the location is that it is a part of the Municipality's vision for re-development, it is located in one of the biggest cities of the Randstad, has a good connectivity with the Schiphol airport and a multicultural character. The opportunities of developing real estate in Rotterdam is mainly that there is a big stock of vacant/inefficient buildings (Savills, 2018). On the other hand, the building is not located in the city center, not in the business district, but in an under-development area which has the character of manufacturing and innovation. This creates some risks related to the working and living style in the area, the target group, the required amenities, transportation and public space (PWC, 2018).

Considering the building' scale, the layout and the well-maintained structure of the existing building are good for adaptation and alongside with the good location (in the entrance of the district) work as strengths for the transformation. An opportunity is the importance of the district for the Municipality and the increase attractiveness of the area (MOR, 2019; Koornneef, 2013). On the other hand, there are some weaknesses and threats. The increasing construction and labor costs, the scarcity of land, the quality of public space, the gentrification and the environmental regulations are things that need to be considered when developing the transformation strategy (Arcadis, 2018; MOR, 2019).

5.3.3 Scenario Planning and Testing of strategies

Scenario planning is a technique used in order to decide and design real estate strategies. It is highly related to trends, future changes and possibilities. Scenarios can be described as "*a vivid description of possible futures*" and include forecasts but also visions about desirable futures (Lindgren & Bandhold, 2009). The need for developing scenarios and scenario planning techniques is due to the instability and constantly changing world that enables mismatches between the demand and supply. Scenarios are important in order to design strategies that will be beneficial in the future (Hitt, et al., 1998). According to Lindgren, a good scenario consists of plausibility, decision making power, alternatives, consistency, differentiation, memorability and challenge (Lindgren & Bandhold, 2009).

[23] Charikleia Christina Kougea, Khushboo Asrani, Anurag Deherkar

A method for scenario planning is TAIDA, developed by Lindgren et al. (2009). TAIDA stands for Tracking, Analyzing, Imagining, Designing and Acting, which are the five main parts of this method. The first part is about identifying future trends, signs of threats or opportunities. In the Analysis phase the interrelationships amongst trends and the development of scenarios take place. Imagining is about generating ideas of future strategies and new visions about the future supply while at the deciding phase the evaluation of the strategy can take place, is the phase where everything is put together. In the end comes the Acting which has two perspectives, start implementing the strategies and continue working on trends and scenarios. Another popular real estate tool is the DAS framework developed by de Jonge et al. This tool has nine main steps while scenario planning takes place as the fifth step. In comparison with TAIDA, the DAS framework (Figure 31) includes a mismatch-table between the existing supply and the scenarios and this is where the future supply (strategy) should be based on (de Jonge, et al., 2009). In both strategies the tracking and analysis part is the same.

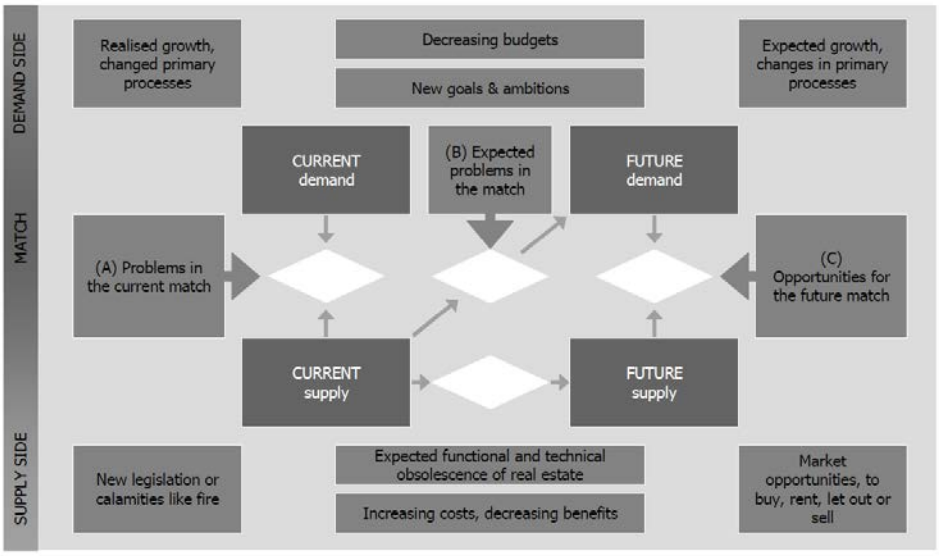


Figure 30: DAS explanation, de Jonge et al., 2009

For this research, which is focused on creating a design framework, scenarios are needed in order to identify future opportunities, threats and risks. These are the fundamentals based on which the comparison among different accommodation scenarios will take place. So, the first attempt will be made on the "mis-match table" developed based on the DAS framework, where certain variables will be tested on the different strategies (degree of adaptability and non-adaptability). Of course, to reach this point the trends analysis and the scenario planning are crucial. Thus, by identifying the future trends, uncertainties and risks (through scenario planning) and checking the matching of future demand with the different strategies (mis-match table) the final step of the comparison will be made. This is a timeline on which certain risks will be implemented into the business models of the different (adaptability) cases for evaluating the scenarios on the dimension of time.

The process starts with the gathering of relevant trends and possible future threats. The trends were tracked via many sources like the web and literature (Bouwinvest, 2018; Emmer, 2018; Leung, 2017; CBS, 2017; PWC, 2016; CBS, 2017). The threats are an outcome of the obsolescence types and what can cause them alongside with the drivers for adaptability that were highly ranked in the Delphi research. The next step is their allocation on the steerability-impact matrix. The trends (or group of trends) that are positioned on the two right quadrants may be re-positioned to the predictability-impact matrixes. The ones that are located on the top-right quadrant are characterized as strategies

while the ones with low predictability and high impact can be used for the development of scenarios (de Jonge, et al., 2009; Lindgren & Bandhold, 2009).

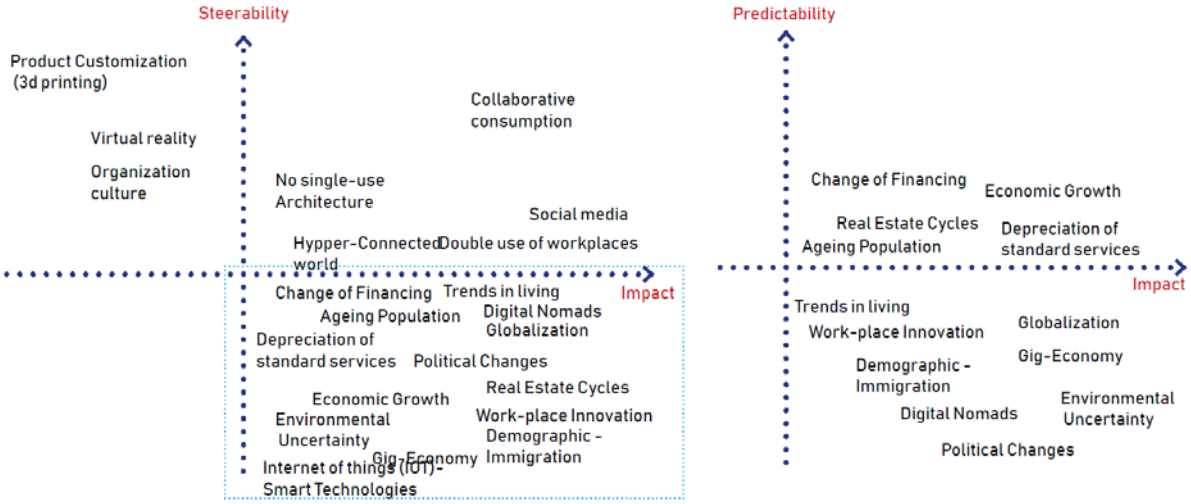


Figure 31: Steerability-Impact and Predictability-Impact matrixes created for scenario planning, own illustration

The last matrix presents groups of trends that are low predictable while having a big impact on the real estate (figure 32). Based on these, a set of scenarios and their accommodation strategies will be developed. The next step is the creation of the four-scenario matrix and the cross analysis of two out of four diagonal scenarios (bad and worse extreme cases) (de Jonge, et al., 2009). The most unpredictable trends belong to the political and policy sector, economy as it is getting reformed constantly, environmental regulations, the way that circularity and shared economy will be developed, IoT and ICT and populations' mobility. These form a set of specific groups, economic and political, population, environmental and technology. The creation of different scenarios will be based on the extreme versions of these groups. The scenarios (Figure 33) will be about the future (extreme) accommodation needs.

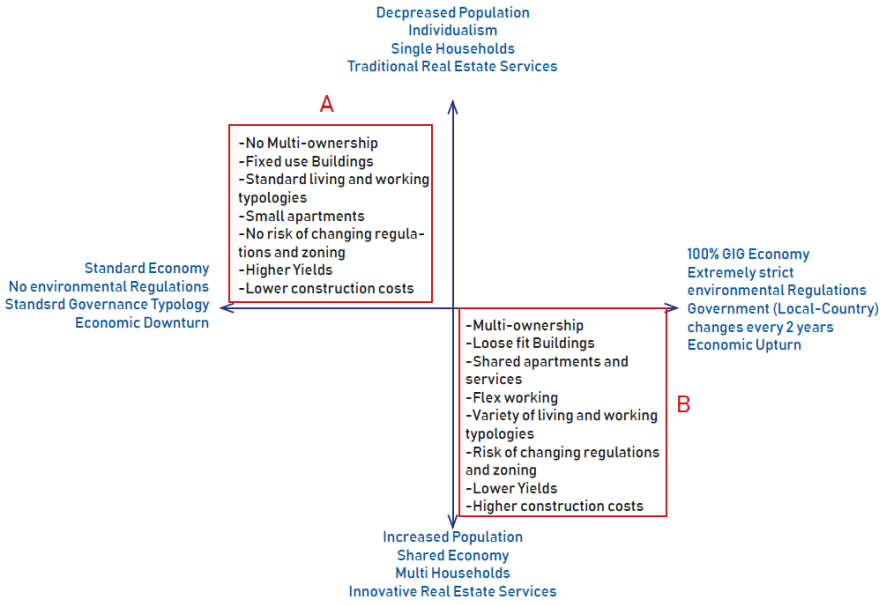


Figure 32: Scenarios Development, own illustration

As the comparison will happen between diagonal scenarios (Figure 33), the inclusion of all the extreme perspectives is ensured (de Jonge, et al., 2009). So, two extreme accommodation demand scenarios are developed. In the mis-match table (Table 17), the different accommodation and real estate related variables are presented. These variables, developed based on the characteristics of the extreme scenarios, are describing how a real estate final product would look like. Basically, looking at this Table (18) we can see what the different real estate demand of these two extreme scenarios would probably be. As all the variables are same for both scenarios, this table can be used in order to evaluate the capacity of a strategy designed by the

Degrees (or not) to accommodate future demand. The scenario A is called “Basic Loneliness” while scenario B is called “Vibrant careness”. Their names created based on the different trands and situations they describe.

Moreover, based on the trends and their predictability some possible future risks can be assumed. These will not be in the extend of an extreme scenario but of probable future uncertainties. They are developed in the context of the pilot study (MOR), thus by having specific target group, location and market information. Starting from the accommodation demand and the residential units, the target group is the starters (Hernandez Quiñones, 2017).

Starters can be characterized by mobility, and their accommodation demand is much different than families or elder people. Moreover, their demand will probably change after some years as they won’t be starters any more but senior professionals. This process needs around 5-7 years to happen and we can estimate that after five years we will have to phase a high tenancy turn-over (MOR, 2019; Hernandez Quiñones, 2017). Something similar we can expect for the commercial use. Having in mind that the area is attracting mainly start-ups and not directly big brands or companies we can understand the need for multi-occupancy spaces, flexible working, innovative ICT support and smart technologies (JLL, 2013; Dynamis, 2018; MOR, 2019). Once again, the need of adaptation seems to be important when the occupants change, when there are innovations in office’s technology or when a start-up want to expand. Another main risks, based on the political and environmental trends alongside with the new scientific researches and certifications like BREAMM, is sustainability and circularity. What we can expect is that after some years the importance of measurable circularity or sustainability of a building will be really important, like other characteristics as re-usability of materials and net positivity (Circle Economy, 2019; Geraedts & Prins, 2015; van Rijn, 2019). Last but no list, the economic cycles. This factor influences the market and consequently the inflation, construction, materials and labor cost (Winters, 25.10.2016; Pyhrr, et al., 1999; Pinder, et al., 2011). All these create a risky pattern based on which we will evaluate the importance of same building’s adaptation in order to express the parameters of time, uncertainty and possibilities. To do so, some assumptions need to be made.

5.3.4 Risk

The risk response can be translated into the real estate strategies implemented in order to confront specific risks. In this case, adaptability is one of these strategies but the extend at which we need to implement it dependents on the object specific risks which need to be determined. According to Gehner, there are two main perspectives on how to identify the risks related to a project. These are the qualitative and quantitative techniques and the risk identifications can determine the impact of these risk at the life-cycle of the project. The qualitative techniques are used in order to identify the probability and effects in order to create project objectives while the quantitative ones are used for numerical risk analysis. There are many techniques for risks analysis like the SWOT, scenario planning, decision tree analysis, probability-impact analysis, sensitivity analysis etc. (Gehner , 2008)

According to literature, the quantitative techniques are not widely used, in comparison with the qualitative ones. This is due to the “*lack of reliable data, lack of understanding the potential benefits and the idea of subjective judgment raise the question of whether the quantitative risk analysis techniques can deliver better performance”* (Gehner , 2008). This is correlated to the “financial impact of adaptability” where was mentioned that the exact use of numerical data is not that relevant as we need to base our findings in assumptions and forecasts. Thus, for the purposes of this research it makes more sense to use qualitative techniques to identify trends and uncertainties that may have a great impact on the project instead of trying to determine exact costs’ and benefits’ numbers.

Although, an attempt of development a series of DCF models for the different scenarios and degrees of adaptability will be made due to the clear risk impact on the IRR (Gehner , 2008).

The way to reduce risks is to reduce the uncertainties, thus by gaining more information about the future possibilities. Thinking of the factors that cause uncertainties and consequently higher risks is a first step to map and start reducing the future risks. Even though, the real estate sector has a highly uncertain nature as it includes long term investments in relation to the economic cycles and the market that a developer or investor operates, thus the estimations are limited. Due to the long-life perspective and in order to reduce the risk of an investment is important to anticipate future changes that will have a negative impact on the project (Gehner , 2008).

General Real Estate Risks Table

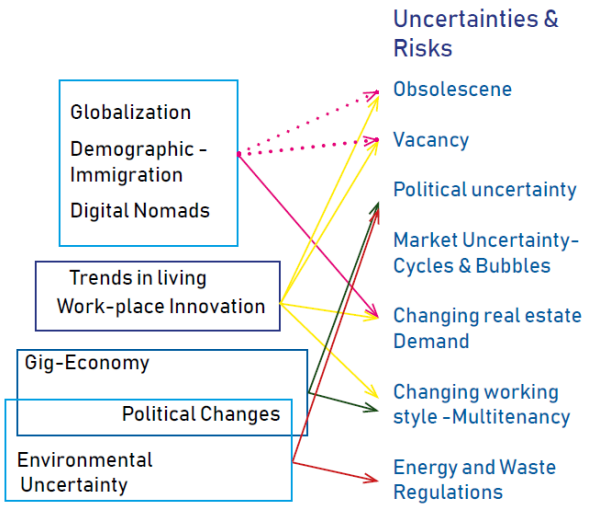


Figure 33: Uncertainties and risks derived from literature and trends, own illustration

VARIABLES/ STRATEGIES	Scenario A	SCENARIO B
Apartments' typology	Small	Variety
Functions	Single	Mixed
Ownership - Tenancy	One owner	Multi
Offices' Typology	Big offices	Flex/ Co-working
Target Group	Standard	Multiple
Density	Standard	Dynamic
IOT, ICT	Basic	Innovative
Sustainability	No/Basic	Yes
Net positivity	2050 rule	More than 2050 rule
Quality, Character	Basic	Landmark

Table 18: Mis-match Table

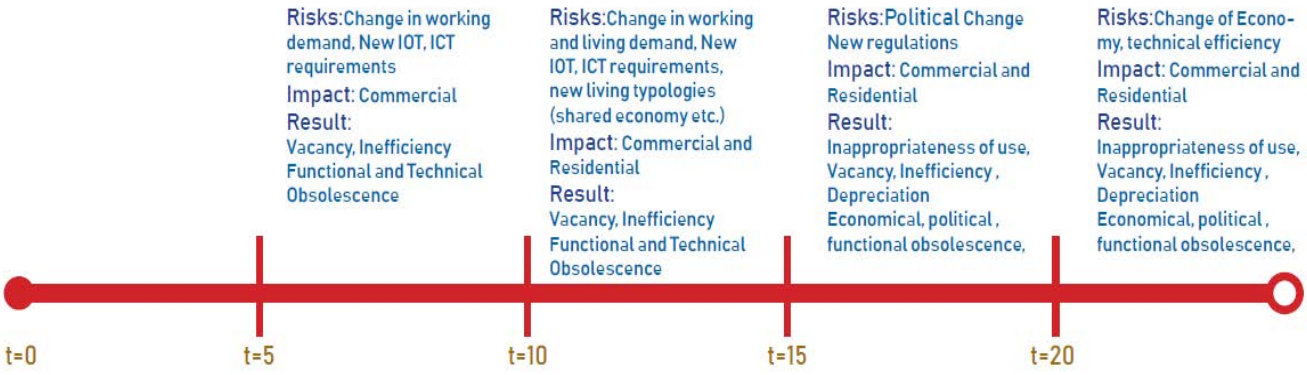


Figure 34: The timeline of risks, own illustration

Accommodation supply mis-match: The first degree

Based on the literature of the DAS framework (de Jonge, et al., 2009) the following mis-match table was developed. This is an illustration through which we can explain the different accommodation potentials of a strategy, and the way it can respond to extreme accommodation scenarios (see section 5.1.3). A building of the first degree seems that can respond to both scenarios demands. Of course, there are limitations. As multifunctionality is based on the existing services and building's capacities

there should be a bandwidth on which the functions, densities and typologies may vary. So, even though there is a potential of re-arrangement and refitability, this is not un-limited. Concerning the sustainability, net-positivity and technology the building can be adjusted to the new demand, but it does not already acquire it.

Variables/Strategies	BASIC-LONELINESS	VIBRANT CARENESS	FIRST DEGREE
Need for internal re-arrangements	Low	High	Medium
Apartments' typology	Small	Variety	A&B
Functions	Single	Mixed	A&B (with limitations)
Ownership - Tenancy	One owner	Multi	A&B
Offices' Typology	Big offices	Flex/ Co-working	A&B (with limitations)
Target Group	Standard	Multiple	A&B
Density	Standard	Dynamic	A&B (with limitations)
IOT, ICT	Basic	Innovative	A&B (existing stuff-services can be easily replaced)
Sustainability	No/Basic	Yes	A&B (existing stuff can be easily replaced)
Net positivity	2050 rule	More than 2050	A&B (existing stuff-skin can be easily replaced)
Quality, Character	Basic	Landmark	A&B (existing stuff-skin can be easily replaced)

Table 19: First Degree; Mis-match Table, own illustration

Accommodation supply: mis-match: The Second Degree

As explained in the previous degree, another mis-match table based on the DAS framework was created in order to test the alternatives of the second degree of the future extreme demand (de Jonge, et al., 2009). A building of the second degree seems that can respond to both scenarios demands. The limitation in functions and densities is overcome by the raised-floors and the oversupply of services. Moreover, the upgrade of ICT or IOT is getting much easier due to the loose fit connections and the oversupply of shafts and space for mechanical systems. So, the second strategy can accommodate the two presented extreme demands although with some adaptations, basically n the level of stuff, services and skin. An example of how to adjust to the new demand by a "step-by-step" plan is to change the façade to the most innovative one. Although it is highly recommended to look a step further while transforming the obsolete building to one that can be future proof without the need for big adaptations after 10-15 years [24].

Table 20: Second Degree; Mis-match Table, own illustration

Variables/Strategies	BASIC-LONELINESS	VIBRANT CARENESS	SECOND DEGREE
Apartments' typology	Small	Variety	A&B
Functions	Single	Mixed	A&B
Ownership - Tenancy	One owner	Multi	A&B
Offices' Typology	Big offices	Flex/ Co-working	A&B
Target Group	Standard	Multiple	A&B
Density	Standard	Dynamic	A&B
IOT, ICT	Basic	Innovative	A&B (existing stuff-services can be easily replaced)
Sustainability	No/Basic	Yes	A&B (existing stuff can be easily replaced)
Net positivity	2050 rule	More than 2050	A&B (existing stuff-skin can be easily replaced)

[24] According to the layers' theory by Brand the services have a lifetime of around 20 years. So, at this moment we can assume that a refurbishment or upgrade of the existing services is rational to be made.

Quality, Character	Basic	Landmark	A&B (existing stuff-skin can be easily replaced)

Accommodation supply: mis-match: The Third Degree

An accommodation strategy that is developed under the principles of the Third Degree of adaptability is compared to the two extreme future scenarios in the table 21. As the previous ones, this strategy can support each extreme scenario while at the same time includes the added values of materials circularity (through re-usable materials) and sustainability (via the oversupply of services, based on the net positivity principles of the MOR project). So, in a case of extreme environmental legislations the building can operate properly without any extra adaptations and investments (MOR, 2019).

Variables/Strategies	BASIC-LONELINESS	VIBRANT CARENESS	THIRD DEGREE
Apartments' typology	Small	Variety	A&B
Functions	Single	Mixed	A&B
Ownership - Tenancy	One owner	Multi	A&B
Offices' Typology	Big offices	Flex/ Co-working	A&B
Target Group	Standard	Multiple	A&B
Density	Standard	Dynamic	A&B
IOT, ICT	Basic	Innovative	A&B (MOR concept)
Sustainability	No/Basic	Yes	A&B (MOR concept)
Net positivity	2050 rule	More than 2050	A&B (MOR concept)
Quality, Character	Basic	Landmark	A&B (MOR concept)

Table 21: Third Degree; Mis-match Table, own illustration

The NO Degree

For the purpose of comparison, the NO-Degree strategy is also developed. In this case the building, or a floor plan, does not have any adaptive capacity during the exploitation phase. In this case any differentiation of the market's or users' demand can play a crucial role for a possible future (re)obsolescence. A transformation strategy that do not include any adaptive capacity is vulnerable to uncertainties, especially when we are re-designing future-proof buildings. Moreover, the end value of the building can be negatively affected if in the design process the building was analyzed as a whole and not in its layers (Bijdendijk, 2019; Sarafopoulos, 2019). This will make much more complex and riskier a future adaptation and the need for a new transformation is quite possible (van Rijn, 2019). As a not adaptable transformation project example can be considered the actual transformation of the Marconi towers developed by Egeria or the TSH in Amsterdam. The first one is a mixed use building with a bare capacity of change while the second one is a hotel in which only the ground floor and the last floor are multifunctional and adaptable (Catalgol, 2019). For this research only the first example will be used in the comparison as it has exactly the same potentials as the floor plans presenting the alternatives of the Degrees.

Accommodation supply mis-match: A non-adaptable Strategy

A mis-match table was also created for this strategy. The following table is based on assumptions about the current supply, as the project is not finalized yet (Mackay, 2019). Although, we can drop some conclusions by the fact that there was no intention by Egeria to develop an adaptable project in this case. So, we know that it is a standard, finished object with no adaptive capacity. So, based on the decided strategy end the end design we can estimate that this project will be able to support one out of two extreme scenarios. In case that a reverse situation occurs, an extra re-investment or re-transformation is possible.

Variables/Strategies	BASIC-LONELINESS	VIBRANT CARENESS	NON-Adaptable
Apartments' typology	Small	Variety	A or B
Functions	Single	Mixed	A or B
Ownership - Tenancy	One owner	Multi	A or B
Offices' Typology	Big offices	Flex/ Co-working	A or B
Target Group	Standard	Multiple	A or B
Density	Standard	Dynamic	A or B
IOT, ICT	Basic	Innovative	A or B
Sustainability	No/Basic	Yes	A or B
Net positivity	2050 rule	More than 2050	A or B
Quality, Character	Basic	Landmark	A or B

Table 22: No Degree; Mis-match Table, own illustration

Comparison of the mis-match tables

Through the Mis-match tables, all the design strategies from highly adaptable to not adaptable can be tested on the future extreme scenarios (Table 23). All the four different strategies were evaluated on their accommodation supply in relation to probable future demand. This give to the author a valid ground to make some first assumptions on which strategy is more proper for the possible future. Moreover, the cross-comparison among all the accommodation strategies provides a better overview of the differences, opportunities or shortcomings that they may have.

Based on the specific variables the two first degrees seem to have small differences. The points that segregate them are the ones related to the load capacity (layer of structure) and the capacity for internal re-arrangements. These critical points are created due to the added on the Second-Degree design indicators which give extra services capacity, ability of raised floors and ceilings for vertical re-arrangements and dry connections that guarantee speed on adjustments. The biggest difference with the third degree comes out from the layer of stuff. In the latter case, the materials can be re-used in the same building, can be moved easily or sent back to the supplier and changed with new ones. This saves money and time when adaptations are needed. Moreover, the buffer zones provide the necessary space to expand, storage or add components or functions. The Non-adaptable strategy is possible to respond only to one future scenario in the case that it is designed based on it. In any other situation the buildings will need to be fully converted in order to avoid obsolescence.

Variables/Strategies	BASIC-LONELINESS	VIBRANT CARENESS	NON-Adaptable	FIRST DEGREE	SECOND DEGREE	THIRD DEGREE
Apartments' typology	Small	Variety	A or B	Medium	A&B	A&B
Functions	Single	Mixed	A or B	A&B	A&B	A&B
Ownership - Tenancy	One owner	Multi	A or B	A&B (with limitations)	A&B	A&B
Offices' Typology	Big offices	Flex/ Co-working	A or B	A&B	A&B	A&B
Target Group	Standard	Multiple	A or B	A&B (with limitations)	A&B	A&B
Density	Standard	Dynamic	A or B	A&B	A&B	A&B
IOT, ICT	Basic	Innovative	A or B	A&B (with limitations)	A&B can be easily replaced)	A&B (MOR concept)
Sustainability	No/Basic	Yes	A or B	A&B can be easily replaced)	A&B can be easily replaced)	A&B (MOR concept)
Net positivity	2050 rule	More than 2050	A or B	A&B can be easily replaced)	A&B be easily replaced)	A&B (MOR concept)
Quality, Character	Basic	Landmark	A or B	A&B can be easily replaced)	A&B can be easily replaced)	A&B (MOR concept)

Table 23: Mis-match comparison, total

5.5 Testing of risks [Time]

After describing the different floor-plan options follows the illustration of possible reactions of transformation projects when some risks occur (Figure 35). This analysis can help to understand and

finally decide on the most appropriate design strategy. The real estate threats and the future uncertainties that are presented on the timeline are gathered by the trend's analysis, the Empirical research (drivers for adaptability), and the causes of obsolescence (Blakstad, 2001).

The first risk (t=5) is based on the working trends, technology's innovations and the gig-economy (see in the section of scenario planning, 5.3.3). So, the first risk is more probable to affect mixed-use or commercial projects as these changes are about the office function (Dynamis, 2018; JLL, 2013). The second risk (t=10) is about probable changes in both, residential and commercial demand. The new trends in life-style, the scarcity of land, the increasing population or densification are factors that can create a change in accommodation demand (CBS, 2017; CBS, 2017; PWC, 2018; Lokhorst, 2019). In addition to the previous ones, another risk can be the Vision of Municipality or the new EU/Dutch legislation for sustainability. This is something that we can expect for the future as the discussions, certifications and the researches for circularity (Remoy, 2019), and sustainability are gaining more and more importance. What we cannot forecast is if and when more strict regulations or incentives will be released.

The risk of political change in the scale of the country or the Municipality can be expressed through differentiations in the zoning plan (Bruijning, 2019), the vision or the buildings' operation requirements (an example of this is the required label C for office buildings until the 2023). The vision can be about strict monofunctional or mixed-use areas, smart cities, open data etc. while the legislation can be about new energy and waste regulations. The last risk (t=20) is the one based on the lifecycle of layers and the possible need of refurbishment. The risk, or what cannot be predicted, are the yields, the labor and construction cost, the inflation and the availability of row materials (Lokhorst, 2019; Blauw, 2019; van Rijn, 2019). All these are influenced by the market's cyclical nature while the technical or functional obsolescence is dependent on the building's characteristics (Baum, 1988).

The Degrees on the Timeline

A building re-designed under the principles of the **First Degree** of adaptability can confront some risks, while it can also minimize the effect of others. Considering the first risk (t=5) the building will be benefited by the initial design due to refitability. In detail, the internal office rearrangements will be easily and quickly made in the spatial plan due to the modular coordination system. So, the space plan and the way the floor plan works in order to support the new requirements can lower the risk of (hidden) vacancy, inefficiency, or obsolescence. Moreover, due to maintainability and durability generated by "accessibility" and "zoning" the upgrade of systems and smart technology can happen quickly and without affecting the building's operation. The effect of the second and third risks can be minimized. Internal re-arrangement of office or residential floors can happen easily while in extreme cases where one function is not attractive at all multifunctionality can be used. This is an ability that can be mainly used in mixed use buildings. For the third risk (t=15), the building is easily rearrangeable in order to fit the new demands as happened in the previous risks (t=5, t=10). Of course, as described in the mis-match table there are limitations of density capacity of the building (mechanical and electrical systems, fire safety etc.) In those three cases, maintainability, durability and accessibility in services and skin can support such relubrications while multifunctionality can support the change in use. The biggest advantage is the easiness of accessing and rearrange the space-plan, skin and services. This can save a lot of time when adjustments are needed and can cause less vacancy (or vacancy turn over. A disadvantage is that new investments are needed for stuff and materials, especially in the case of change of use as convertibility is not one of the abilities included. So, the structure is able to accept changes, but new transformation is needed. Moreover, the re-construction costs and time are dependent on the materials that will be selected but is estimated to be reasonably shorter that a normal re-transformation. The last risk cannot be confronted or minimized by the first

degree of adaptability, as no oversupply, reusable or portable components that could reduce the load of a new transformation are included.

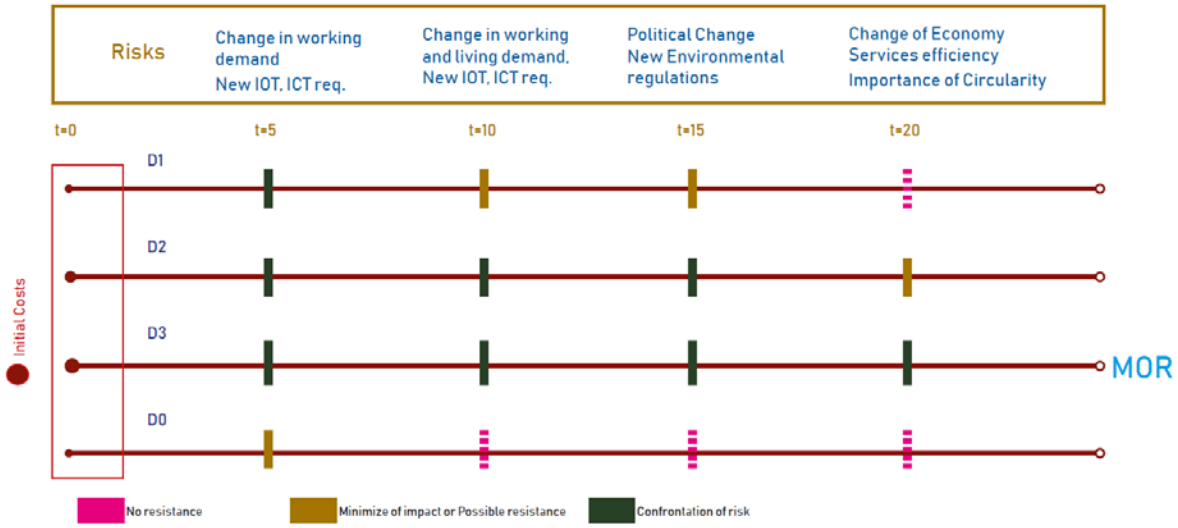


Figure 35: The analogical comparison of adaptable and not adaptable strategies on the MOR case study, owl illustration

The adaptation to the new demand created by the risks is easier in buildings that express either the **Second** or third **Degree**. Having in mind that whatever works for the first degree is transferred to the third and second, what makes the two last degrees more "future-proof" is the oversupply of services (higher densities and different uses can be supported). Indicators such as raised floors, just give an extra internal flexibility and adjustability on the users' preferences while demountability and loose fit connections reduce more the time needed for re-arrangements and introduce the principle of re-usability. This is the parameter that alongside with lightweight materials, movable and portable components enhance a building designed under the third degree to minimize the impact of the last risk (t=20).

The **Third Degree** decreases the shortest possible the re-construction time while the oversupply minimizes the extra costs (creating new shafts or ducts) and the impact of external factors on the building. Generally, the third degree enhances the creation of a building that can respond to the risks and uncertainties and is less possible to be obsolete again. Thus, the second degree can confront the first three risks and minimize the effect of the fourth while the third degree has a high possibility to confront all the risks in a feasible manner. On the other hand, and as described previously a building which has **NO adaptive capacity** is extremely vulnerable to risks and uncertainties. So, a new obsolete period may re-occur due to functional, technical, economic or political reasons (Baum & McElhinney, 2002; Aytac, et al., 2016; JLL, 2013).

MOR-Decision Making Process

In the MOR project the Third Degree was selected. The reason for such a decision is that the building is located in an area which is still under development. So, the location cannot be characterized as central and the building cannot compete other buildings with the same characteristics located in the city center. This makes the project vulnerable to demand changes while being also sensitive on the alteration of its neighborhood. Thus, more adaptability is needed as there are increased possibilities of changing demand in the area. Moreover, as not located in a central location functions like commercial and residential are dependent on the market and on the infrastructure. At this point is crucial to recall what the investors said "*If the infrastructure and/or the area is not ready or not proper we do not buy*" (Bruil, 2019). So, in order to create an asset that is more attractive extra values need to be added.

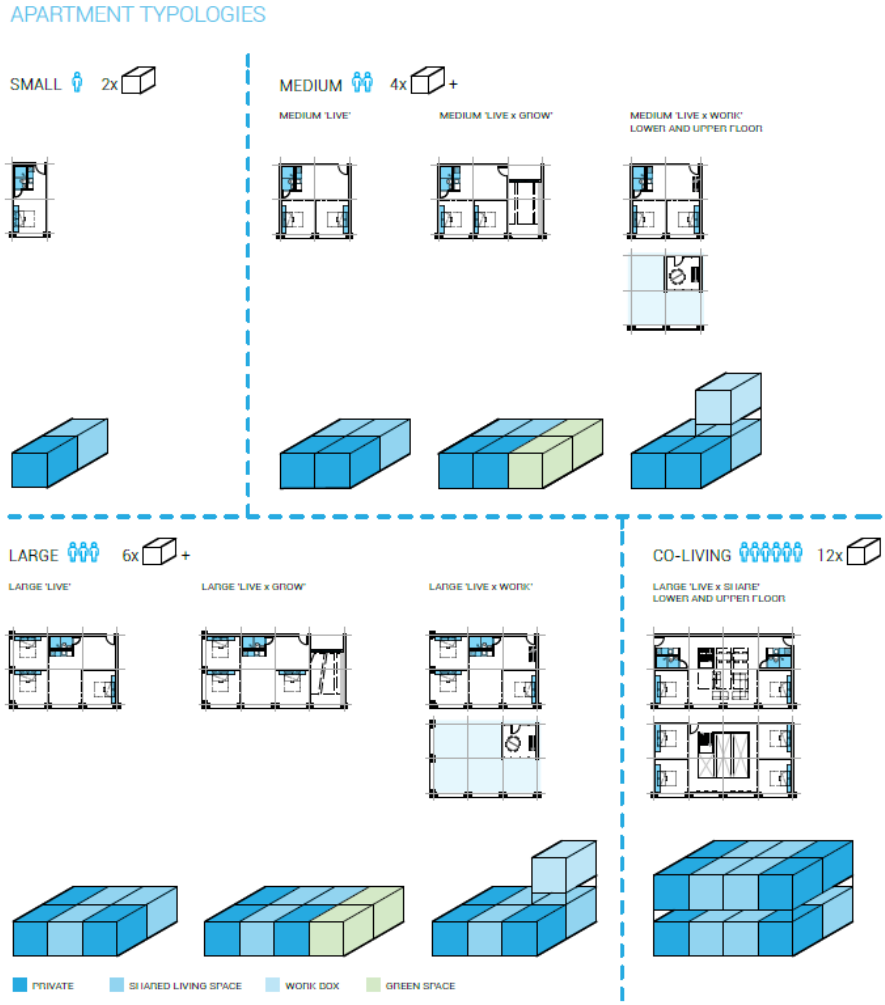


Figure 36: The accommodation supply of MOR regarding the residential units, MOR (2019)

Additionally, to the area and market characteristics (described also in section 5.3.2) are the characteristics of the target group and the vision of the developers (in this case the MOR team). Starting from the latter, the Third Degree of adaptability expresses fully the vision of the MOR team of being a frontrunner in the perspective of materials and energy while one of the pillars of the MOR concept is Circularity-Net Positivity. Considering the target group, starters are a tenants' typology which can be characterized by mobility and progress (Hernandez Quiñones, 2017; PWC, 2018). Mobility can be observed in the part of jobs, as they are highly possible to change their working environment after a couple of years which will possibly affect their housing accommodation (Capital Value, 2018). Considering their house preferences, they are willing to start living in a small place like a studio, but their expectations can grow as their salary or family also grows. Thus, the target group necessitates some form of house adaptation (Capital Value, 2018).

Finally, the Third Degree was chosen to be implemented as it can support the incremental growth of the target group, can enhance circularity, materials re-use and net positivity while can be change from one function to another and respond to the changing demand (MOR, 2019). However, If the

importance of materials and energy was not included in the Team's vision the Second Degree should have been selected. This is why even though it is not located in the most central position the project has good potential for adaptivity, a good structure and the Municipality of Rotterdam seems to support such transformation projects (MOR, 2019).

Considerations - if the case was not MOR

The MOR case study was used as a tool, or a mean, of the Degrees explanation. All the last chapter explains how a normal procedure of decision should making and designing transformation project and proposes a sequence of actions. The author used the Case and based on it developed the analysis and the synthesis of Degrees' selection (in a big percentage that was the real process followed for the competition). In MOR, the design indicators described in the third degree were used and adjusted on the project's specific requirements, and this is the proposed implementation way. The Framework should be the basis on which a design strategy should be built on, not a strict list of rules.

The pilot study is highly benefited by the existing structure and layout. The core and all the structural elements are evaluated to be proper for transformation and conversion to another use while due to the initial commercial function the floor to ceiling height is proper for residential use. Also, the positioning and the rectangular shape supports the daylight while the loadbearing façade leaves an open layout. In another case here the shape is weird, or there is no load bearing façade the design indicators of zoning and accessibility are getting higher importance.

The spatial and organizational freedom that the Third Degree proposes can be feasible as all the space is intended to by rented and not sold. If the building, or part of it, will be developed in order to be bought by another user or investor the design strategy should be adjusted to the new circumstances. An easy solution to this problem is the combination of Degrees (some levels can be designed based on the Second and others on the Third or First Degree) as all the Degrees share the same principles. Moreover, in a real case scenario, the legal perspectives of multifunctionality and multi-ownership need to be accepted and confirmed by the responsible authorities. To conclude, the tricky points that need to be taken into considerations when analyzing, developing and implementing a design strategy for adaptable transformation projects.

Chapter 6

Conclusion & Discussion

6.1 Conclusion

The addressed problem of this research is the obsolete building stock and the negative externalities created by its existence. Obsolescence in buildings can be caused by many factors (Blakstad, 2001; Aytac, et al., 2016; JLL, 2013) like functional, political or technical. The consequences of it, which are more evident through vacancy, are extended to the society, the neighborhood and to the stakeholders of a building. Vacancy, as an end result of obsolescence (JLL, 2013), is a situation that can be confronted by adaptive re-use of the existing vacant stock or by demolition and redevelopment of it (Bullen, 2007). Both strategies have costs and benefits dependent on the specific characteristics of the vacant building. However, adaptive-reuse is a sustainable redesign strategy in comparison with demolition which cause a lot of energy consumption and waste of materials (Bullen, 2007). Therefore, in an era where sustainability is getting more and more importance adaptive-reuse seems to be the best option when the building allows for its adaptation (Dynamis, 2018; Manewa, et al., 2013; JLL, 2013; Bullen & Love, 2010).

Although a transformation seems to be the best choice for confronting the buildings vacancy this does not directly mean that there is no risk for future obsolescence. Designing a building as a finished (non-dynamic) product which has no capacity to be adjusted on the new demands, risks or uncertainties. increases the possibilities **of RE-obsolescence** (Schmidt III, 2014; Manewa, et al., 2013; Brand, 1994). Talking about risks and uncertainties, unfortunately in the real estate sector play a crucial role. Starting from obsolescence to depreciations there is a variety of factors that can negatively influence the image and functionality of a building. Following the definition of risk and thinking the real estate cycles the importance of sustainability the necessity for future proof buildings rise (Baum & McElhinney, 2002; Aytac, et al., 2016; Gehner , 2008).

"A risk is the probable negative impact on the expected value of a real estate development project caused by uncertainty about an event or events that might occur and/or the reduced ability to influence the events, after an actor has irrevocably allocated his scarce resources to that project". (Gehner , 2008, p. 43)

To conclude, the problem stated in this research is the obsolete building's stock and its probable transformation to a non-dynamic object. The way that real estate strategies are implemented towards non-dynamic objects enhances the possibility where obsolescence is re-generated. Thus, this research is dealing with the following research question in order to give a solution to the problem or (re)obsolescence.

Main Research Question

"How can adaptability design strategies be applied in order to develop a future-proof transformation project?"

To answer this question, some sub-questions need to be answered first:

- Which is the theoretical background of adaptability?
- Which are the main design indicators of an adaptable transformation project?
- How a holistic Framework of adaptability (Degrees of adaptability) can be developed?
- What is the impact of the Degrees of adaptability on the future potentials of the building (pilot study)?

Thus, the objectives of the research are to identify the design indicators for adaptability, create a tool to implement an adaptable transformation strategy and describe the costs and the benefits of it. In order to make the research outcome more tangible the research is focused on a specific buildings'

typology: The office buildings with the core and the open layout which were mainly constructed in 70s and 80s.

6.1.1 Answer of the Research questions

"Which is the theoretical background of adaptability?"

To answer this question an extended literature review was conducted. The trigger points of this question were the definitions of adaptability and flexibility; as being two interrelated and many times overlapping concepts (section 2.1). In the end, adaptability is defined as: ***"The capacity to change the building's built-environment in order to respond and fit to the evolving demands of its users/ environment maximizing value throughout its lifecycle."*** (Schmidt III, 2014) and flexibility as: ***"an adaptive response to environmental uncertainty as a reflection of the ability of a system to change or react with little penalty in time, effort, cost or performance"***. (Upton 1994 in Gijsbers & Lichtenberg, 2012)

Other topics that have been researched are the frameworks of designing adaptability, the existing strategies and the tools for measuring adaptive capacity. These data helped the author to map the important and valuable for adaptability indicators, understand the desired outcomes for an adaptable building and start listing the design indicators for adaptability. Starting from the theoretical background regarding the concept of adaptability, two theories were adopted as the backbone of the research. Both are generally accepted by the scientific community and further used and extended by other researchers. The two theories based on which this research was structured, are the Brand's Layers (Brand, 1994) and the Framecycle of Adaptable Futures (Schmidt, et al., 2009). The first framework describes the way that the components of a building should be divided based on their life-cycle while the second framework is describing the different capacities ("abilities") of an adaptable building (Figure 38).

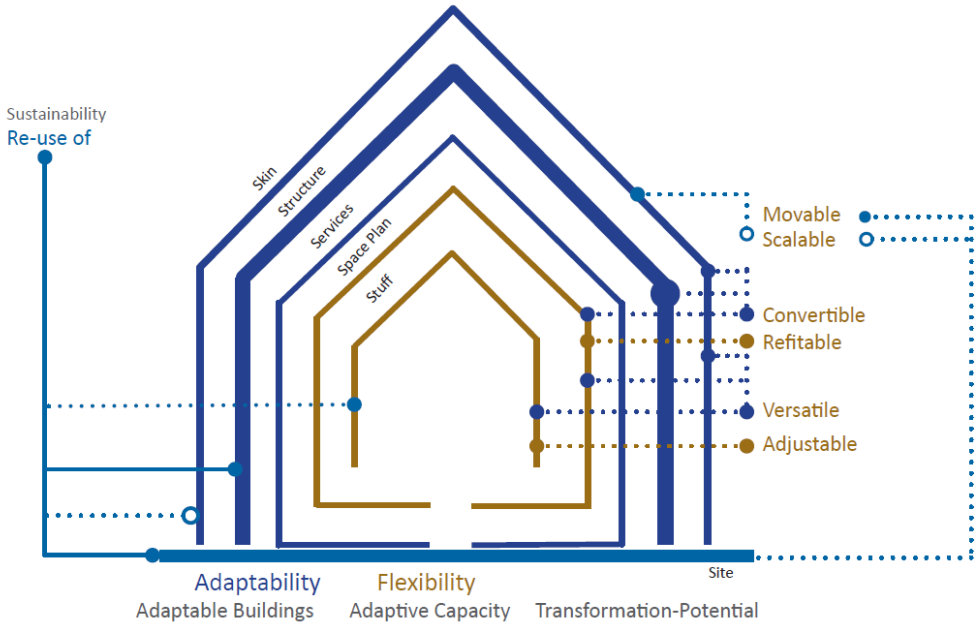


Figure 37: The Layers (Brand,1994) and the Adaptable strategies (Schmist III, 2014), own illustration

Adaptability is a well-structured and researched topic which can effectively support the development of future proof buildings (Chapter 2). The consistency of adaptability, its meaning and multiple perspectives give the opportunity of being applied under a variety of versions which can fit to specific

projects' requirements. As real estate strategy, adaptability, includes principles and factors that can be measured and evaluated. For this reason, tools and techniques for assessing adaptability (Flex 2.0, CSA, AdaptStar) were researched to provide knowledge on the important characteristics and the value (weight) of different aspects of adaptability. The principles' formation and design implementation can create different patterns of adaptive capacity and options in real estate supply (Blakstad, 2001; Aytac, et al., 2016; Bullen, 2007; Geraedts, et al., 2014; Remoy & De Jong, 2011). Thus, enhancing in an appropriate way urban resilience, sustainability and future proofness (Aytac, et al., 2016; Bullen, 2007; Gosling, et al., 2008; Estaji, 2017; Geraedts, et al., 2014; Scuderi, 2019).

"Which are the main design indicators of an adaptable transformation project?"

The design indicators for adaptability were defined through the literature study (Chapter 2) and confirmed by the Empirical research (Chapter 3&4). The research of the design parameters consisted of two processes, the gathering of data and the rejection based on the researched typology (Chapter 2). However, a list of general principles and design indicators is provided for further research and implementation on new buildings and/or transformation of different building typologies (Table 4). The rejection of parameters was vital for this research as not all of the indicators presented in Table 4 can (or should) be used in transformation projects of the selected typology (commercial buildings with a main core, load bearing façade and open layout, section 2.5). Especially, indicators about the location and design of the structure (ex. the internal floor-to-ceiling height) were not that relevant as the structure and the site of transformation projects are given. So, the most comprehensive ones were collected and further described by the author in section 2.7.

Adjustable	Versatile	Refitable	Convertible	Scalable	Movable	Top Characteristics
Plug and Play Elements User Control Stackable No-fixed Objects Detachable Connections Operable Elements	Movable Walls Variety of room sizes Wide corridor widths Frame construction Flexible ducts Storage space Excess service points	Access Points Standard Shapes Dry connections Coordinated systems Interchangeable components Minimize points of contact	Loose-fit Raised Floors Simplicity Dropped ceilings Multi-functional spaces Excess service capacity	Product Platforms Local materials Known tech-niques Structural Redundancy Modular Units Extra space Dividable/ Joinable rooms	Inflatable Component Weight Kit-of-parts Easy connections Collapsable Components scale	Configurable Stuff Oversized space Multi-functional Spaces Over-design Capacity Standardised compo-nents Support space (Buffer Zones) -Daylight Schmidt and Adaptable Futures

Flexibility		
Rearrange	Extension	Rejection
Re-locate/ Re-design Grain size Facilities Quality	Expansion	Rejection Transfer

Facilities-Quality
Multifunctional Units Centralized and de-centralized facilities Disconnect ability of facility components Accessibility of facility com-ponents

Re-arrange/ Change Function		
Division Support-Infill Access points -Oversized building Multifunctional Location Multifunctional Building Multifunctional Units Measurement system (GRID)	Replaceable inner walls Demountability-Dismountability Measuring system Facade Routing-Circulation Detailing in connections (vertical and horizontal) Exchangeability of infill construction components	Layout Accessibility of facility components Elevators Geraedts et al. (2014,2015)

Multifunctional spaces
Partitions andStuff: light, mobile, demountable, reusable and recyclable
Elasticity-Divisibility
Modularity
Buffer Zones
Circulation Routes
-Oversized spaces (vertical and Horizontal)
Dry connections
-Divisible support structure
Division of support/infill
-Minimise internal columns and load bearing walls
Prefabricated-standardized components
Detailing
Double, modular facade (Nakib, n.d.)

Building Proximity	Technical Span	-Building Height	-Building Size	Services System
-Structural Design	-Floor to Ceiling Height	-Plan depth	Fire Safety Design	Manewa et al., 2013

Table 24: Design indicators for adaptability

The final list consists of twelve multi-layer indicators named “modular and dividable system”, “Loose-fit and dry connection”, Multifunctionality”, “Buffer zones”. “Lightweight materials”, “Oversupply of services and systems”, “Zoning”, “Accessibility”, “Raised-floors and slab openings”, “Demountable components”, “Re-usable components” and “Movable and portable components” Figure 18. The selected design indicators are a summarized version of sub-indicators and/or overlapping strategies. Different combination on them can create different patterns and strategies for adaptability in buildings (Chapter 2, Figure 18).

So, the design indicators can give to the building some extra adapt-Abilities when applied to specific building’s layers. Through the different frameworks, like the Framecycle (Schmidt III, 2014), and the assessment tools, like the Flex 2.0 (Geraedts & Prins, 2015), the author linked the design indicators with the different design/real estate strategies, Brandt’s Layers and the Framecycle with the different favorable outcomes (Figure 18).

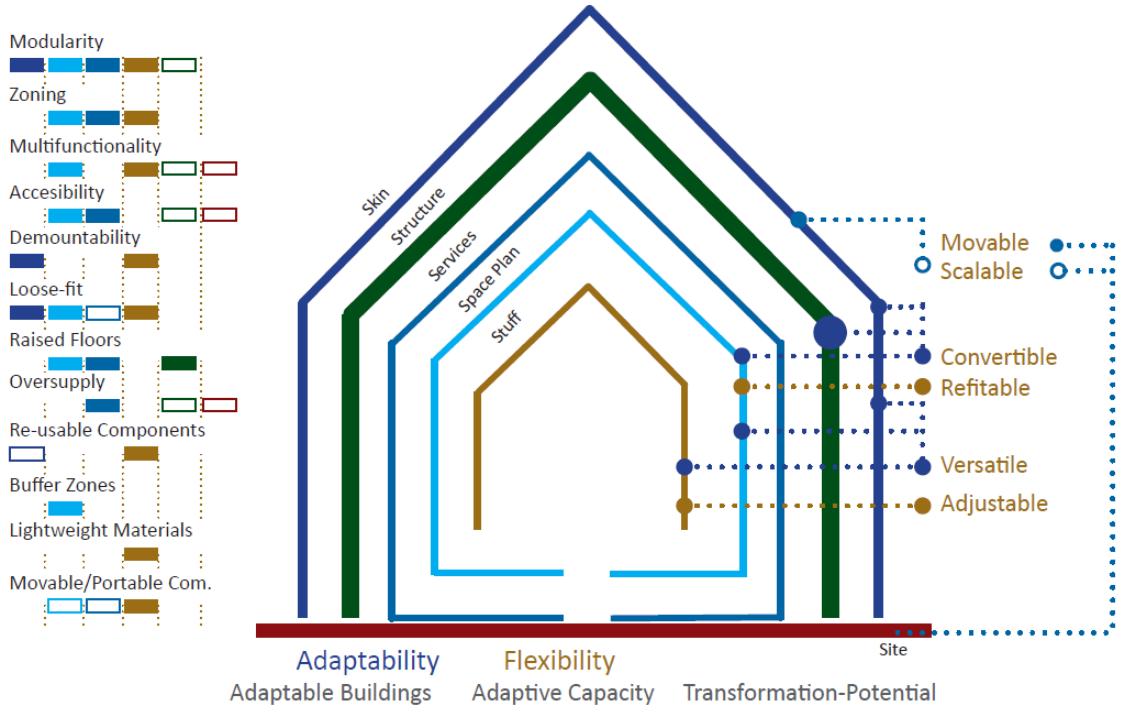


Figure 18: The design indicators for adaptability, own illustration

“How a holistic Framework of adaptability (Degrees of adaptability) can be developed?”

Starting with the clarification of the meaning of a “holistic framework, it is a set of indicators which combined can create adaptability including all the layers of a building. Generally, it is defined by the author as a tool which incorporates all the different aspects and perspectives of adaptability (on the researched typology), based on the existing scientific knowledge and on the additional research methods. As was discussed in the methodology and objectives sections (see 1.23,1.2.5) the existing literature is not specified on adaptable transformation projects neither fully incorporates the perspective of the professionals. So, an extra method was added to the research. A Delphi panel was created in order to rank the importance of design indicators (quantitative data) while interviews were held to acquire information (qualitative data) about different stakeholders’ interests and professionals’ perspectives on the topic of adaptability (Chapters 3&4).

The input gathered by the Empirical research gave some direct answers on the topics of importance, values, cost and benefits and supplemented the qualitative data gathered by the literature. Following

what was described in chapter 4 “Criteria” and the cost and benefits of adaptability knowledge, the author developed a sequence of steps towards future proof transformation projects (see Table 13 in section 4.3). The ability of a building to be future proof is achieved through adaptable real estate strategies which must be developed based on the characteristics of each project (Mackay, 2019). As this research is specified on a standard layout and buildings typology the author developed a framework of design indicators and proposed an order that these should be used. In the end the Framework named “Degrees of adaptability” was created as a tool to develop future proof real estate strategies which, by Implementing the desirable degree, gives to the project the required adaptive capacity.

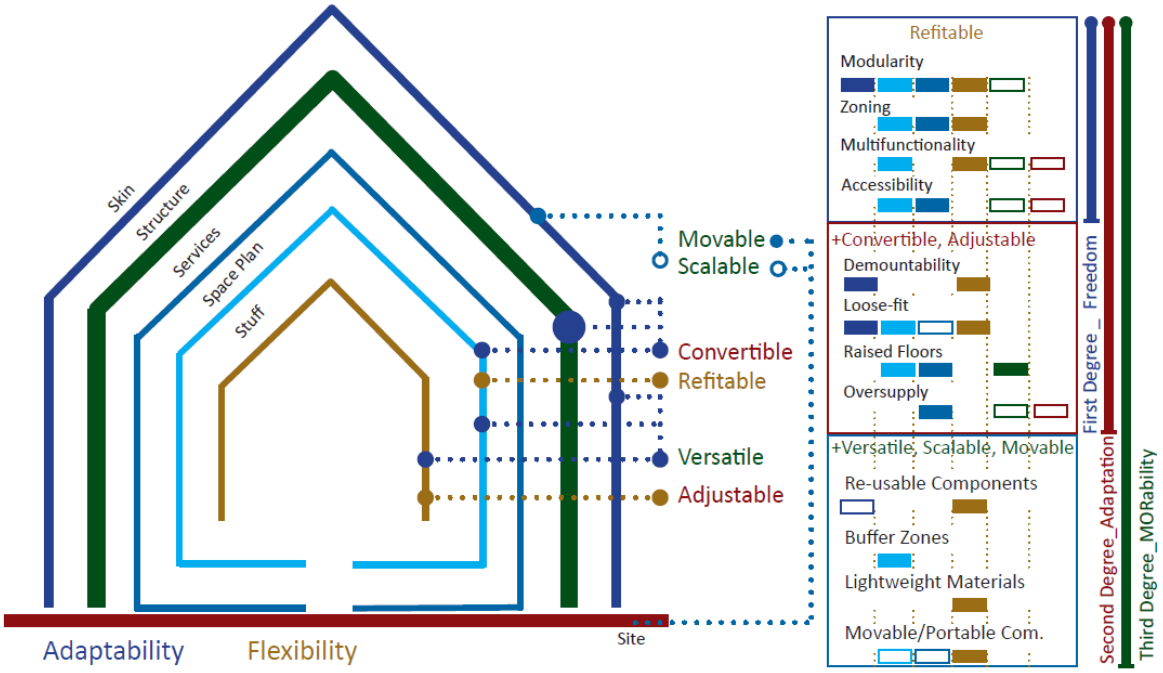


Figure 23: Degrees od Adaptability, the Framecycle and the Building's Layers, own illustration

The framework illustrates an order of design sequence based on the indicators ranking, the interviewees elaboration and the theory of adaptability (Chapter 4). The essence of it, is to provide design solutions in order to acquire the required level of adaptability. However, as there are many layers on which the different indicators can be implemented and the combination of these can create imbalance between the required supply and costs the author divided the framework in three, additive “degrees”. The first degree is the basic one, while the second and the third ones add extra abilities on the designed previous capacities. The first degree describes how to create a Refitable transformation object, the second one how to design a Refitable, Convertible and Adjustable object while the last one includes all the abilities described by the Framecycle (Schmidt III, 2014). However, other capacities and values are included in the final dynamic object that vary from durability to recyclability and transferability (Estaji, 2017; Geraedts, 2008). As the different degrees describe and create different and/or extra options for real estate accommodation it is assumed that their costs and benefits are different (Geraedts, 2001; Schmidt III, 2014; Schenk, et al., 2009).

What is the impact of the Degrees of adaptability on the future potentials of the building?

Knowing that every project is unique, any generalization without the visual explanation of the accommodation supply options would be too vague and possibly not valuable. So, for the author was important to explain the rationale behind the Framework in a more illustrative way, to talk about the

advantages and disadvantages, use different scenarios and describe risks and uncertainties that a future-proof building is probable to deal with. Thus, a pilot study was used to describe the impact of the different degrees on the accommodation supply options created by adaptability. So, the MOR project was selected, analyzed and synthesized as a case study. Firstly, the case was described based on SWOT analysis method in order to identify the opportunities and the threats of the specific object and location. Then, scenario planning was conducted to identify future extreme real estate demand, real estate risks and uncertainties. The trends and real estate risks were gathered by the literature, the characteristics of obsolescence and the worries-reflection of the interviewees (Chapter 4).

The "synthesis" of the floor-plans describes the principles of each adaptability degree. Therefore, the potential adaptations, risk limitations and accommodation alternatives are presented. There were many outcomes retrieved by this analysis and synthesis. The first one is about the potentials of each degree. The "Degree of Adaptability 1" offer a Refitable building that can confront the risk obsolescence in case of small differentiation of accommodation demand (especially in office buildings where the need for flexibility is higher). Moreover, a building that addresses the first degree can minimize the negative impact of risks like changing living and working trends, innovation in technology, economic and political changes. The third and second degree can confront obsolescence in a bigger scale, as they are designed to respond to all the pre-discussed risks in a viable and efficient manner. Also, these two degrees address some principles of circularity and re-usability of materials that can be extra beneficial If the restrictions and regulations for environmental sustainability be stricter.

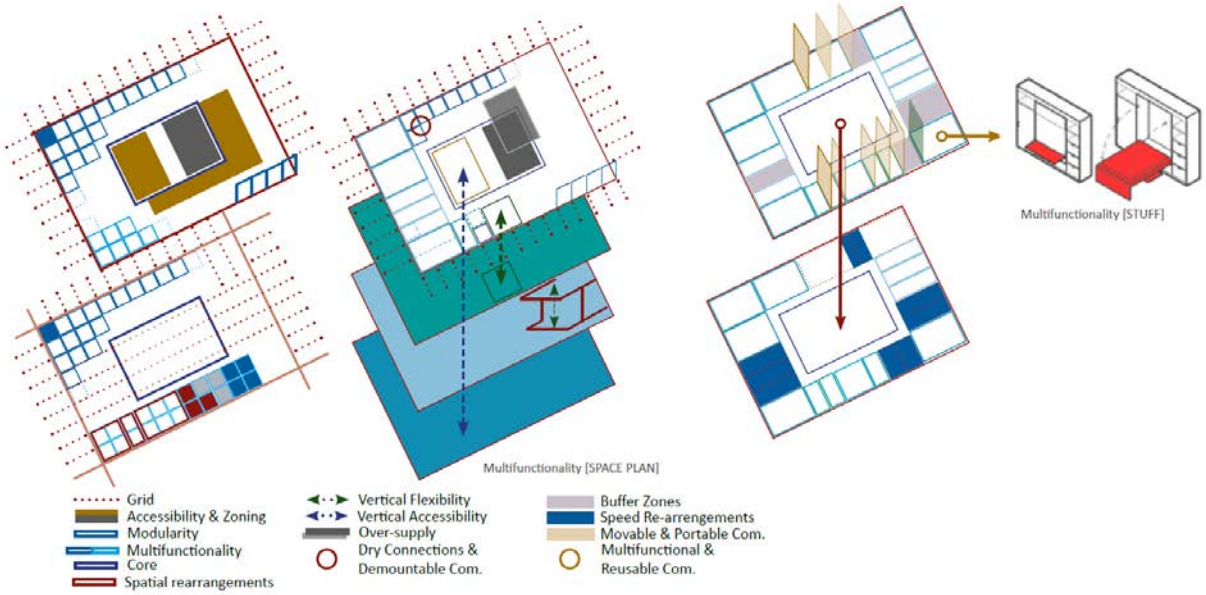


Figure 38: Accommodation alternatives based of the Framework: Degrees of Adaptability, own illustration

In the end, by comparing the different real estate strategies that can be developed by the use of the Framework with a non-adaptable strategy we can draw conclusions on what is more reasonable to choose. In all the cases where risks and uncertainties occur, the strategies which include some degree of adaptive capacity create a more effective and suitable (future proof) real estate supply. As the Framework is designed to be applicable on a specific building typology we can assume that the same results can be expected in other similar cases (commercial buildings of the same typology). What can be quite different is the impact on costs. An example given by Schenk et al. (2009) is the difference between two typologies of commercial buildings, the core and the single corridor. As the researchers describe, there is a cost difference between the adaptation of these two types, as the single corridor

one is expected to be more expensive (Schenk, et al., 2009). The differences between the costs of adaptation have been also highlighted during the empirical research (Mackay, 2019; Schleurholts, 2019).

What is advised by the author is that a detailed analysis on the external environment and building scale should be made before the selection of a Degree. In the MOR case the building is not located in Rotterdam's central district and the vision of the project was to develop a future proof building that can be a paradigm for similar projects. Starting from the location, due to the distance from the city center it can be characterized as a riskier project in comparison with a building that is located nearby the Rotterdam's Central train station. Moreover, the vision for the project is to be a landmark for net-positivity, circularity and adaptability. Thus, the Third Degree (MORability) that expresses adaptability, re-usability and demountability was decided to be the most appropriate one in this case. Nevertheless, due to the benefits of high exit-value of the materials and sub-components, the lower expected vacancy and depreciation through the years, the MOR project can be characterized as financially feasible (see Appendix 1 for the DCF created for the MOR case study).

Continuing with the balance between quality, time and costs the feasibility of a future proof project is highly dependent on the location and the real estate market (section 1.1.b, 1.1.c). Another finding of the empirical and the case study was about the construction costs which can vary a lot dependent on the real estate cycle (downturn or upturn) (Bruil, 2019; Lokhorst, 2019; Sarafopoulos, 2019). An example given during the interview with Mackay R. (2019) is that four years ago a qualitative transformation would cost 1200-1.400 euros/sq.m, while nowadays costs around 2000 euros/sq.m (Mackay, 2019). The author tried to stimulate possible DCF calculations which reveal that in every case (three comparison scenarios were developed) the adaptable building has better Net Present Value and IRR (scenarios based on the MOR pilot study). Nevertheless, the numbers are based on assumptions and historical data and were used as experiments to map possible differences and disadvantages while developing the Framework (Appendix 1).

6.1.2 Answer of the Main Question

"How can adaptability design strategies be applied in order to develop a future-proof transformation project?"

According to literature, adaptability is relevant when talking about sustainability and future proofness (Aytac, et al., 2016). By following the definition of adaptability, we can find the characteristics of the concept which lead to the extension of a building's life and its more efficient operation. The ability to remain fit, the capacity to change functions and forms, the increased value and the extended lifecycle alongside with the speed of adaptation, are components that constitute a future proof real estate object (Schmidt III, 2014; Geraedts, 2008). Into this context the building is not perceived as a finished product (non-dynamic) but as a dynamic asset that has the capacity to be adjusted to external parameters that can cause obsolescence.

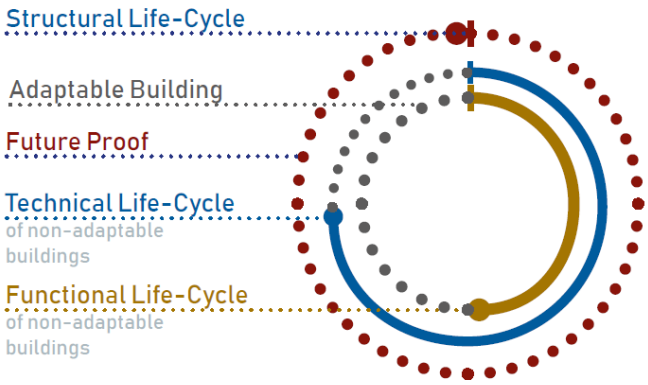


Figure 1: The circle of a building's potential lifecycle, own illustration

To propose a scientific way for real estate developments of future proof transformation objects the author conducted a research and created a design framework which supports the development of adaptable transformation projects. This is called “Degrees of adaptability” and consist of a set of twelve design indicators. Each indicator and each degree contain certain advantages and characteristics. The “Degrees” describe a sequence of steps that should be followed for the development of an efficient, adaptable project. The reason for these three grades is not related with a better or worst building but it is about the most appropriate real estate strategy. A balanced use of the Framework based on each case’s requirements and characteristics should be made to develop a feasible, future proof project which has the needed adaptive capacity based on its context. The parameters that need to be taken into account is the location, the market and the economy of the country and city where the transformation object is located, the demographics, the regulations and whatever can cause obsolescence (Aytac, et al., 2016; Baum & McElhinney, 2002; Blakstad, 2001; Remoy & De Jong, 2011).

Figure 39: Obsolescence and risks, summary of literature, own illustration

To conclude, the Design Framework called “Degrees of Adaptability” was created in order to give a solution to commercial buildings’ (re) obsolescence. It describes a set of design techniques to develop future proof buildings that can confront future risks and uncertainties, be adjusted to the changing real estate demand and serve satisfied users. This can be achieved by using the proposed framework in the extend (degree) that is more valuable for each specific case. The Framework was made to be used in transformation projects, which were created under the typology of the commercial core buildings. Nevertheless, the Framework is not a strict guideline. It includes some flexibility on its implementation to fit in all cases of obsolete office buildings (core) regardless their location and market specificities.

6.1.2 General Conclusions

"Adaptability is becoming more and more important, especially because of the crisis. The functions and generations are changing fast. The living, the way we work the way we use buildings is changing much faster than it used to change". (Lokhorst, 2019)

According to the researched literature and the empirical study conducted, adaptability seems to be a sustainable and confirmed by the professionals' way to deal with real estate risks, trends, changing demand and obsolescence. In order to achieve adaptability, there are numerous design techniques which can grant to the building some flexibility, or on a larger scale, adaptive capacity (Chapter 2). The way that they can be combined, alongside with their importance and cost implications were the main research topic on this thesis.

The mapping and definition of the different patterns of design tools and their end-product achievement was a complex topic. This is due to the fact that there can be traced many, crucial, differences among buildings with alternate layout, age, location and character. This is also quite evident between the transformation and the new projects. The transformations, a concept quite urgent nowadays (Dynamis, 2018; JLL, 2013), contain a number of obstacles in comparison with new projects which can be designed from scratch. Finally, the author chose to focus the research on a specific, transformation, typology to create a more specific and comprehensive tool for designing adaptability.

The structure of this research was divided in two main parts, the gathering of data and then their synthesis towards a tool, which was later called framework, that can be used by professionals in order to develop future proof transformation projects. The main findings were about the importance of a set of design indicators, the value and the cost of adaptability. In the scientific literature many data were provided but what gave more vital understanding on the topic, its benefits and obstacles was the empirical study. During this process the author gained a deep knowledge on the hardships and on the perspectives of adaptability that are more desirable for the professionals. It came out that adaptability is not an easy concept to be implemented, mainly due to the fact generally the real estate sector is focusing on specific objects (Blauw, 2019; Bruil, 2019; Sarafopoulos, 2019) and is highly dependent on the market. Investors, developers and contractors try to create financially feasible, with no financial risk projects which are developed based on the current market, nevertheless almost all the participants agreed that adaptability is important. So, based on their interviews adaptability is mainly included in the design phase in order to be able to adjust quickly on new, urgent demands but the implementation of adaptive capacity is something different (Bijdendijk, 2019; Bruijning, 2019; Lokhorst, 2019; Schleurholts, 2019; Sarafopoulos, 2019).

The main concern against adaptive capacity was that it will probably cost more money while there are no financial tools to prove the actual financial revenues (Bruil, 2019; Blauw, 2019). Moreover, it is dependent on the project requirements and characteristics. According to van Rijn, a building which is developed to accommodate commercial or institutional use has higher necessity for adaptable features as the client-tenant has a long-term business plan (van Rijn, 2019). On the other hand, adaptability in residential use is more difficult and highly dependent on the leasing contracts, the investor and the vision of the project (Ector, 2019; Mackay, 2019; Schleurholts, 2019).

Having in mind the different requirements of a transformation project and the incapacity of the existing financial models to capture the values of adaptability, the author tried to develop a framework which includes steps with no extra costs and limited adaptive capacity while also patterns that endow full adaptive capacity and sustainability but create higher costs. This process and the final framework,

which is called “Degrees of Adaptability” due to the before mentioned reason, was highly influenced by the pilot case study. The research was conducted in parallel with the design of the MOR proposal and the author, as one of the developers, had the chance to cross-check the theory, the design and the actual result. In addition, the interviews and the Delhi research confirmed some steps of the case study while negated others. A conclusion made by the combination of the different input resources and reflected on the final Framework was that the value is created by the bigger scale in balance with the aim and the target group of the building. That means that spatial flexibility, smart and multifunctional furniture are not that valuable in the long term if they are not combined with adaptable services, space plan and skin (Bijdendijk, 2019; van Rijn, 2019; Bruil, 2019).

Economic considerations

In general, the empirical research confirmed the Brands theory about the Layers and the tools gathered by the literature. However, it revealed the extend that the financial feasibility influences the actualization of a project and that is the point where the author found a mis-match with the theory. The scientific literature is focused on an ideal situation of adaptability, where the adaptive capacity can be often used while in real life changes is expected to happen at least after ten years (Mackay, 2019; Bruil, 2019). The economic considerations that follow the topic of adaptability are many, and as stated above adaptability can be difficulty proved by actual numbers, especially in transformation projects. This is rational if someone considers the difference between the construction and materials price, the locality of the service suppliers, the market, the depreciation and the risks. For a long-term concept, like adaptability, the systems that needs to be combined and added to the cash flow are complex. Although it is difficult to find exact numbers, some estimations can be made. Proven by the Delphi research and the literature (chapter 4) there are low design techniques and some that are more expensive.

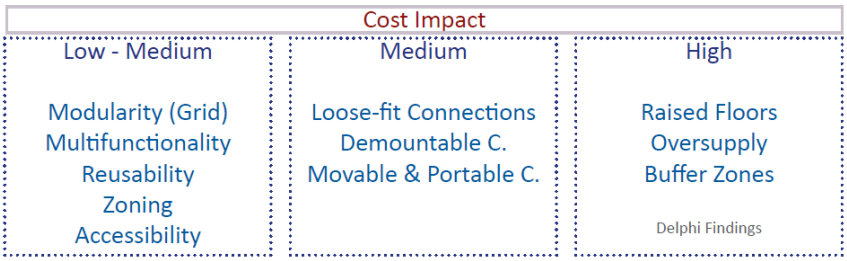


Figure 40: Cost impact based on the Delphi Research, own illustration

Based on these, on extra input from literature (van Eerden, 2018; Leupen, n.d.; Remoy & De Jong, 2011; Manewa, 2012; Schmidt III, 2014; Schenk, et al., 2009), the interviews (Mackay, 2019; Lokhorst, 2019; van Rijn, 2019; Schrauwers, 2019) and the pilot study (MOR, 2019) the author tried to enrapture the value of adaptability by using DCF (Appendix 1). Three scenarios were developed. The first one is about a transformation project in a bad market. The comparison is made between a transformation with the Third Degree and a transformation to a non-dynamic object. It was assumed that after 20 years a renovation-or transformation- need to be made due to a big real estate risk or great change on the demand. Twenty years we chosen as this is also the expected lifetime of “services” by Brand, a layer that need to be maintained for a good building’s operation. Many experiments made in order to check the NPV and the IRR after 30 years. In the first table (Table 29) it is assumed that regardless the adaptive capacity the buildings have the same discount rate (based on the risk) and exit yield. In the second table (Table 30) the risk was adjusted on the future risk confrontation potential, so for an adaptable building is lower. The same logic was followed for the next two scenarios which represent a different degree of adaptability and different market conditions. In all the cases the adaptable assets

present better NPV and IRR (except of the first case, same risk). If there is no need for adaptation after 20 years (Table 31) the adaptable buildings seem to have higher NPV but a bit lower IRR. The main conclusion which can be made by this, is that adaptability might be costlier than a non-adaptable asset but this does not immediately mean financial unfeasibility. Moreover, balanced use of adaptability (needed degree based on the project and circumstances) give higher potential of increased future value.

	NPV	IRR	Discount Rate	Exit Yield			
Scenario 1 Standard - Bad Market	€ 1,765,745.26	10.60%	9.00%	8.5%			100% transformation cost
Third Degree - Bad Market	€ 1,984,190.69	10.47%	9.00%	8.5%	+15% extra cost	+2% extra architects fees	20% transformation cost
Scenario 2 Standard - Good market [central location]	-€ 1,859,512.17	5.68%	6.50%	7.0%			75% transformation cost
First Degree - Good market [central location]	-€ 538,345.09	6.28%	6.50%	7.0%	+3% extra cost	+2% extra architects fees	50% transformation cost
Scenario 3 Standard - Neutral market	€ 1,076,498.26	7.57%	7.00%	7.0%			75% transformation cost
Second Degree - Neutral market	€ 2,306,878.22	8.03%	7.00%	7.0%	+10% extra cost	+2% extra architects fees	25% transformation cost

Table 25: Outcome 1 of DCF, same risk considerations, own illustration

	NPV	IRR	Discount Rate	Exit Yield			After 20 years, obsolescence risk and need for change
Scenario 1 Standard - Bad Market	€ 1,765,745.26	10.60%	9.00%	8.5%			100% transformation cost
Third Degree - Bad Market	€ 5,643,149.94	10.47%	7.00%	8.5%	+15% extra cost	+2% extra architects fees	20% transformation cost
Scenario 2 Standard - Good market [central location]	-€ 3,416,581.23	4.89%	6.50%	7.0%			100% transformation cost
First Degree - Good market [central location]	€ 2,153,626.96	6.28%	5.50%	7.0%	+3% extra cost	+2% extra architects fees	50% transformation cost
Scenario 3 Standard - Neutral market	-€ 57,771.17	6.97%	7.00%	7.0%			100% transformation cost
Second Degree - Neutral market	€ 3,599,376.01	8.03%	6.50%	7.0%	+10% extra cost	+2% extra architects fees	25% transformation cost

Table 26: Outcome 2 of DCF, own illustration

	NPV	IRR	Discount Rate	Exit Yield		
Scenario 1 Standard - Bad Market	€ 3,919,522.23	12.02%	9.00%	8.5%		
Third Degree - Bad Market	€ 6,210,284.66	10.72%	7.00%	8.5%	+15% extra cost	+2% extra architects fees
Scenario 2 Standard - Good market [central location]	€ 2,811,695.01	7.55%	6.50%	7.0%		
First Degree - Good market [central location]	€ 5,914,399.11	7.43%	5.50%	7.0%	+3% extra cost	+2% extra architects fees
Scenario 3 Standard - Neutral market	€ 4,479,306.54	9.06%	7.00%	7.0%		
Second Degree - Neutral market	€ 4,845,031.26	8.47%	6.50%	7.0%	+10% extra cost	+2% extra architects fees

Table 27: Outcome 3 of DCF, own illustration

Relevance of the Framework

As described in previous sections (1.2.3, Chapter 2, 2.4) the Framework includes principles that can be generally implemented in the built environment. With some additions (design indicators that are presented in red, Table 2) the "Degrees of Adaptability" can be used in other real estate objects, new or transformation ones and is expected to have suchlike results concerning the qualities. Considering the different buildings' layouts, it is important to be tested their transformation potential, their accessibility routes and the daylight (van Rijn, 2019; Remoy, 2019; Lokhorst, 2019). Although, the "Degrees of Adaptability" was not implemented on different typologies the data gathered during the research process can be generally applied. What cannot be concluded is the cost impact as different structures have different requirements.

6.2 Discussion

The findings of this research indicate that the use of adaptable design strategies can generate a future proof transformation project (Manewa, 2012; Blakstad, 2001; Schmidt III, 2014). These strategies can be based on the "Degrees of adaptability" which is the deisgn outcome of this thesis. This was a result based on both literature and empirical research. The author was quite skeptical on the Framework's designing process and undertook many experiments in order to reach the best outcome. The data used were mainly qualitative as it was not easy to indicate specific quantitative data for the pilot study, as it is yet in process.

Existing data and consensus

Many researchers had worked on the topic of adaptability and the scientific knowledge on the topic is quite extended. Adaptability has already been described and analyzed on its characteristics, benefits, costs and design indicators. Nevertheless, adaptability is not a common-used strategy in real estate sector. This is because the benefits of adaptability are becoming stronger as time passes and especially when risks, or extreme scenarios occur. Generally, the value and the benefits of adaptability cannot be recognized in short term. Moreover, real estate projects are quite complex and include many stakeholders. So, the decision-making process of the strategy to be implemented on a (transformation) project has many steps and negotiations, during which each stakeholder is trying to achieve his own interests.

Discussion on the Methodology – Expectations and findings

The scarcity of adaptable transformation projects while there is so much research undergone on the topic of adaptability was the biggest reason of the empirical research. The author wanted to capture the general understanding of adaptability in both ways, practically and scientifically. Starting from the existing research, the expectations from the literature study were met in an acceptable grade. All the theories and tools described were valuable for the conduction of this thesis. However, what was missing was the actual, qualitative data for designing adaptability. What was surprising is that even though there are many research papers and publications for adaptability, adaptive capacity and transformations it was really hard to find quantitative data, but assumptions and percentage bandwidths. That was a big hardship for this research, but it was expected to a certain extend as for the conduction of a research with both quantitative and specific qualitative data it is needed a lot of time, case studies and available practitioners and researchers. Nevertheless, the scientific literature supports that adaptability can only lower the financial costs in the long term and ensure higher end values.

Due to the absence of data concerning the real time projects and decision-making processes, the empirical study was planned. This time the expectations were met, as the author gained the information that was looking for. Through the Delphi method certain quantitative data were gathered, alongside with qualitative ones, that helped the author to interpret on the literature and existing theories. Moreover, the Delphi in combination with the semi structured interviews offered a "clear picture" of how projects are developed, which are the make concerns of the professionals, the barriers and the benefits of transformation project and the value of adaptability; derived by seventeen multi-expertise participants. The variety of opinions, perspectives and goals also the low consensus among them. Practitioners, dependent on their position, have their own interests and objectives. So, they understand in a different way what is valuable and what is quality and future proofness. Moreover, that is highly influenced by their experience in transformation projects and their personal considerations of what a successful project is. Nevertheless, a drawback was that not all the

participants wanted to share real case data due to confidential issues while at some points it was evident that they presented the principles of the company they work and not their personal beliefs. The latter was confronted by asking them more in-depth questions and by conducting a second Delphi round.

Moreover, the consensus among participants calculated in terms of Kendall W provided some valuable data to be analyzed. Except of the academics, consultants and the biggest percentage of inventors the professional related to design process achieved low agreements scores amongst them. Although, with a more careful analysis of their interviews (not the ranking) we can see that their background is not that different, they just express it in a different way. Another reason of the moderate consensus amongst them is their understanding of the actual meaning of the indicators. So, during the second round the author explained once again the indicators and made comments and specific questions to the participants that presented deviation between their ranking and elaboration.

Discussion about the Framework

The Framework is designed for implementation on a specific offices' typology. The reason is that due to time limitations not more cases could be analyzed and tested. Moreover, the selected typology is quite common in office buildings and due to the open layout can be easily transformed. Thus, for this typology it was not important to check the transformation potential. This does not mean that such a building should not undertake this procedure if a transformation may occur, but for academic purposes this typology was a great sample to be researched. The selection of the design indicators derived from literature was also based of the specific typology. The framework would not be the same if it had to be used for all the obsolete office buildings regardless typology. An example of a different design indicator that could be used in another transformation type is the open layout. In the selected case, this parameter is already there while in other typologies need to be created. The same works for new constructions. Of course, the Framework has a big relevance to a new building's adaptable design but again there are other indicators, like the free floor-ceiling height, which are really important and need to be included.

Discussion about quantitative data and IRR

One of the basic gaps on the research about adaptability is the lack of reliable connection between adaptability and the cash flows. Moreover, the lack of quantitative data (like a shared platform for scientific purposes with all the transformation projects and their financial data) makes this process really difficult to be accomplished. So, it is not surprising that even in PHD and Master Thesis related to costs and economic considerations od adaptability the majority of data used are assumptions or extremely case specific numbers. The author tried to derive data about costs, transformation and adaptation time and yields during both the empirical and scientific research, but the end result was not evaluated as valuable. The main constraint to use these data and evaluate the consistency and feasibility of the Degrees of Adaptability was that many assumptions needed to be made. So, based on what Gehner said about the validity of the resulting outcome, the author decided not to include them in the main body of the research. Although a format of how a business model would look like and which are the indicators to be adjusted for each transformation project are provided in Appendix 1.

Limitation posed by the author

The first important limitation is the absence of legal considerations. As the framework aims at being useful in an international scale, the use of legal constraints was not relevant for this research. Moreover, due to the time limitations the analysis and synthesis of more than one cases was not

possible. Also, as the Framework is quite flexible and only proposes an order of how to design adaptable transformation projects the value of using more cases (under the same typology) would be added only in case of buildings located in different countries or in completely different areas of the same country. Again, in order to make a reasonable cross-case comparison numerical data and plenty time will be need.

Discussion about the relevance of the research

Starting from the scientific relevance, this research filled a gap about adaptability in transformation projects. The biggest part of the existing literature on adaptability is about the potential of a building to be transformed, the obstacles and the cost considerations of it, tools for evaluating the adaptive capacity but not really on how to design a strategy for development of adaptable transformation projects. Thus, the resulting Framework in the first one (as far as the author knows) that is dealing with the problem of obsolete buildings and proposed design indicators or actualizing adaptability in transformation project in order to prevent future re-obsolescence. Moreover, the author created an analysis (chapter 5) and illustrated how the degrees look like, which are their added values and abilities in order to make the understanding for the necessity of adaptability more obvious.

As discussed in the introduction part of this report, buildings' obsolescence can cause many societal problems as depreciation of areas, low quality on the built environment and lack of efficient space to live and work. The use of the proposed by the author Framework can confront these problems by the creation of future proof buildings that can be adapted to the future societal demands (ex: requirements for shared economy and shared apartments, flex-working spaces or densification and lack of affordable housing; like the MOR case).

Further research

The Framework was developed based on an "easy" typology. The commercial buildings with the core and the open layout are usually able to be transformed to other functions like residential. This is because they have load bearing façade and open layout with a depth usually less than 10 meters. This ensures the daylight can reach the interior, that the space plan can take many different formats and that the interior height is enough for other uses. Thus, in other cases where the daylight o the internal height is not enough the framework, or the adaptable strategy should be adjusted to cover the main requirements; requirements that are evident on the researched typology. An important next scientific step would be to create a bank of information about transformation projects. Information about specific difficulties, uncertainties, costs, strategies and revenues is important for the creation of a holistic design framework. Moreover, this can probably help to the mapping of consequences on the cash flows of developers and investors. Such a research would be highly beneficial for the "calculation" of accurate numbers and bandwidths to support further the decision-making process of a strategy.

Recommendations for practice

The proposed Framework can be used by all the professional in the real estate sector who are interested on developing, designing, investing, researching or consulting adaptable transformation projects. The Degrees is a way to grade the different "abilities" of a project and help to make decisions specified on the needs and characteristics of each specific case. The order described should be followed mainly for the easiness of the framework users and in order to avoid extra complexity and mis-understandings. This is why all the design parameters and degrees are expressed on the scale of Brand's layers and Schmidt's abilities, theories that are widely accepted.

P5

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Point of departure

The starting point for this research was the Pilot Project of the MOR Team and the proposal of a future proof transformation project in the competition of Solar Decathlon Europe, 2019. The main principles of the project are circularity, adaptability and feasibility. Being responsible for the domain of adaptability and motivated by the existing situation of my home country, I wanted to conduct a research about how to confront buildings' obsolescence in order to improve the efficiency of the existing building stock and create better places for living and working. Quite quickly I understood that the capacity of a building to be adapted can notably contribute to an extended, more efficient life-cycle of the building. So, I immediately started researching the different aspects of adaptability in the theory of the built environment and looking for a topic in which I could use my experience as an architect and my knowledge as an MBE master student. The creation of a designing tool for adaptability was the idea that I had in my mind and quite quickly was defined as my research aim. For me this is the ideal topic to work on, as it expresses societal and scientific importance alongside with the close relation to architecture. Moreover, I was benefited by the fact that I was participating in a team whose project could be my "experimental space". By being liable for designing adaptability I was working closely with the team architects in order to create a future-proof design based on the principles derived from the theory. That was a great opportunity for me to test the accuracy of a set of design indicators on a real case scenario.

Research challenges

As a researcher on this topic I phased many challenges during these nine months of working on adaptability. The first obstacle was to define what is the meaning of adaptability and how to communicate it firstly to my teammates and secondly on the Business model of the MOR project. Even though, all this process is not presented in this report (as is not that relevant with the final research objectives) it was a big personal challenge which educated me and helped me understand that designing a framework is not only talking about drawings but also evaluating their value and their co-existence with other concepts. All this knowledge was the basis for my master thesis. Continuing to the obstacle of definitions, I did not have the chance to interview two of the main researches whose work was a milestone for my understanding, R. Geraedts and A. Manewa due to personal reasons. Another challenge and difficulty was the data collection. Due to big project delays (which still occur) it was not possible to gather data about the cost, transformation and adaptation data for the pilot study. Moreover, it was quite difficult to find these set of data through external companies and professionals.

Reflection on the initial and the adjusted research aim

My ideal thesis would include a fully developed business model, with exact labor and construction costs, transformation and adaptation data for both an adaptable and non-adaptable strategy. Quite early in the process I understood that this would never be possible due to time limitations, in-transparency of shared data and a pilot study that was not finished yet. Nevertheless, my interest on architecture and the way that it can be related with real estate development in order to confront the problem of obsolescence was still feasible. So, I redefined my aim from the financial to a more creative perspective which included more qualitative than quantitative data. To overcome the problem quantitative problem, as in the literature not many things are researched, I decided to conduct empirical research and gather data from specialists.

The process

The first words that come in my mind about the process of this thesis are “busy” and “experimental”. I was always busy with trying to define what is meant by adaptability and how this can be described for transformation projects and “experimental” as I tried many different paths and sequences to reach the final form of my Framework. Although, even If it was a tiring and stressed period it was also fun, creative and absolutely interesting. I started from the literature study for understanding the topic and gather design indicators to create a list of them meant for transformation projects. Even though the literature study was supposed to be only the first part of my thesis, I only stopped looking at new scientific papers on adaptability when I started writing this reflection to ensure that what I am writing is still up-to-date. The next step was the conduction of the Delphi research and a series of interviews about the design indicators and the practitioners’ perspective on adaptability. This process was highly intense, but I am contented with the results. If I could change something would be the first Delphi meetings; as in the process I learned how to better describe my questions and indicators to avoid confusion and overlapping. Moreover, considering the selected design indicators I would probably group some of them. However, the way that they were presented helped me to understand their importance and when I was developing the framework I managed to group them with the ones that are more related to. So, the last part was the analysis of the selected data and the synthesis of the design Framework. Both literature and empirical study were into consideration in the whole process, and the end result presents a comprehensive outcome.

The findings

The outcomes of the literature study were quite clear and descriptive. On the other hand, the data gather through the empirical research were more complex to be analyzed. Seventeen people were interviewed for this research in a semi-structured way. This resulted a variety of different information and different lessons learned provided by the interviewees. In the end, and with the help of the second round of the Delphi research, some things became more specific and the Framework was created. Concerning the implementation part of the Framework on the pilot study, the data and findings are case specific and should not be received as standard situation. Although, the process of implementation can be repetitive and replicable in similar transformation projects.

Conclusion

The outcome was the Framework, called by the author “Degrees of adaptability”. It is a design framework that can be used by real estate professionals, like architects and real estate developers, in order to design adaptable, future proof transformation projects. It consists of twelve design indicators, gather from the literature and confirmed during the empirical research. The framework describes a sequence of steps to develop the favorable adapt-abilities of a transformation project, based on its specific requirements. Nevertheless, its principles are general and with some small adjustments and/or additions can be used in a bigger scale of projects, regardless if they are transformations or not.

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Appendices

Appendix 1

The Discounted Cash flow is an income-based method to evaluate the return (IRR) and the Net Present Value (NPV) of an investment. This cash flow method is based on the income and outcome flows during the exploitation period of a project (holding period). In this method are included the market value, the direct capitalization, the yields and the risks (through the discount rate). Although, many assumptions should be made when the holding period is big (more than 10 years). Concerning the required data, these are the inflation, the rental growth, the vacancy, the risk, the initial and exit yield, the costs, the income and the other maintenance and operation expenses (van Eerden, 2018). According to the literature the end value of a property is quite difficult to be estimated but it a crucial part of the NPV and IRR results. This is why in order to determine the end value after the holding period you need to know the exit yield which is highly uncertain and dependent on the market and the real estate cycles (Lugard, 2009; van Eerden, 2018). As being a "deterministic model[25]" the flexibility is not included, and this makes harder the estimation of the value of adaptability. Although, this is the most widespread method among the real estate investors and thus the clearest way to prove a higher IRR and a feasible Business model. For this research, the values that will be changed in different scenarios is the vacancy, the risk, the exit yield, the costs (initial and transformation). All these will be assumption based on the existing market and on the interviews. The lack of existing models to measure adaptability was criticized by Ellison and Sayce (2007):

"An appraisal that fails to reflect a property's potential to adapt is likely to be proved erroneous over time by not accurately reflecting the extent to which one property may represent a higher risk in terms of depreciation than another. This is of growing importance to investors as lease lengths shorten, making re-lettability a more critical issue, and as discount rates fall, increasing the significance of cash flow over the lifetime of the asset." in (Pinder, et al., 2011)

The following is the Business Model created for the MOR case and explains an adaptable building. The cells marked in red are the ones which are critical for the end result, and highly dependent on the specific project to be acquired, the market, the city and the country.

						Expected rates of return (IRR's)				
Information						Property return	6%			
No of levels in the building	5					Required return	7.1%			
Gross area in the building (sq.m)	7395					Discount rate	6.50%			
Gross area in the building (sq.m per level)	1587					npv	€1,602,940.43			
Lettable area in the building	1050									
Lettable area per cluster										
Lettable housing area per cluster	1065									
Lettable office area per cluster	1065									
Expected Return										
Nominal rent Housing: C1 (€ / m2 LFA)	€20.00					**Terminal property value at t=30**				
Nominal rent Housing: C2 (€ / m2 LFA)	€22.00					Potential gross income (PGI)				
Nominal rent Housing: C3 (€ / m2 LFA)	€25.00					Gross exit yield	7.0%			
Nominal rent Housing: C4 (€ / m2 LFA)	€28.00					Terminal property value at t=10				
Nominal rent Services housing										
Nominal rent Office: C1 (€ / m2 LFA)	€25.00									
Nominal rent Office: C2 (€ / m2 LFA)	€25.00									
Nominal rent Office: C3 (€ / m2 LFA)	€28.00									
Nominal rent Office: C4 (€ / m2 LFA)	€30.00									
Nominal rent Services offices										
Nominal rent Services Commercial	€25.00									
Expenses Incurred										
Purchase price (land)	€ 500.00	-€	3,697,500.00							
Cost of demolition	-€ 525,045.00									
Cost of transformation	€ 15,233,700.00		**cost per sqm**	**€**	**2,060.00**					
Management+ consultants fees	**3%**									
Architect's fees	**6%**									
Transformation cost per sqm after 20 years	**€ 400.00**				60-70% lower transformation costs					
Recurring cost										
Insurance (€ / m2 GFA)	€8.80									
Taxes (€ / m2 GFA)	€9.00									
Property Management (Operation)(€ / m2 GFA)	€4.80									
Repair and Maintenance (€ / m2 GFA)	€24.90									
Total recurring costs	€47.50									
Total operation and maintenance costs	15%									
Inflation	2.2%									

[25] *"A deterministic model had no randomness involved in generating it future output values. (Leung, 2014)"* (van Eerden, 2018)

Period		0	1	2
Vacancy Residential			10%	8%
Vacancy Offices			10%	8%
Vacancy Commercial			10%	8%
Inflation value			€ 500.00	€ 511.00
Operating income and expenses				
Potential gross Income-Housing				
C1			€255,600.00	€261,223.20
C2			€281,160.00	€287,345.52
C3			€319,500.00	€326,529.00
C4			€357,840.00	€365,712.48
Vacancy			-€121,410.00	-€99,264.82
Gross income Housing			€1,092,690.00	€1,141,545.38
Potential gross Income- Office				
C1			€315,000.00	€321,930.00
C2			€0.00	€0.00
C3			€0.00	€0.00
C4			€0.00	€0.00
Vacancy			€0.00	€0.00
Gross income Office			€315,000.00	€321,930.00
Potential gross Income- Commercial				
Gross Commercial Income			€0.00	€0.00
Effective Income			€1,407,690.00	€1,463,475.38
Operating expenses				
Operating expenses			-€126,692.10	-€131,712.78
Net Operating Income			€1,280,997.90	€1,331,762.60
Transformation costs inex			€ 400.00	€ 408.80
Investment				
Land cost		-€ 3,697,500.00		
Demolition cost		-€525,045.00		
Transformation		-€15,233,700.00		
Management + Design		-€1,371,033.00		
Total		-€20,827,278.00		
Return Analysis				
Net property cash flow		-€20,827,278.00	€1,280,997.90	€1,331,762.60
		-€20,827,278.00	€1,202,814.93	€1,174,160.86

€2,341,959.20	€2,391,140.35	€13,710,486.66
€523,010.56	€506,155.24	€2,750,927.10
	NPV	€5,914,399.11
	Value of the prop	€26,741,677.11

Appendix 2

	Strategy		*Suggested by*
1	Integrate the design of installations systems into the structural building design		(Geraedts, 2001)
2	Avoid running installations through structural sections		(Geraedts, 2001)
3	Separate the structural and infill elements of a building		(Crowther, 2005; Geraedts, 2001; Guy, 2002; Kendall, 1999; Keymer, 2000; Webster et al., 2005a)
4	Restrict distribution of function and facilities		(Geraedts, 2001, Vakili-Ardebili and Boussabine, 2006)
5	Increase physical adjacency of access point		(Guy, 2002, Keymer, 2000)
6	Improve phase system installation		(Crowther, 2005, Keymer, 2000, Slaughter, 2001)
7	Provide sufficient information about disassembly process		(Chini, 2002)
8	Apply mechanical methods of water protection instead of chemical sealants and adhesives		(Guy, 2002)
9	Limit number of components		(Webster et al., 2005a)
10	Use flexible building interfaces		(Crowther, 2005; Durmisevic, 2006; Geraedts, 2001; Guy, 2002; Macozoma, 2002; Sassi, 2008; Webster et al., 2005a)
11	Simplify demolition	Ensure transparency and ability to access building components that need to be removed	(Crowther, 2005; Fletcher et al., 2000; Geraedts, 2001; Keymer, 2000; Morgan and Stevenson, 2005; Slaughter, 2001)
		Clearly identify process of disassembly	(Crowther, 2005)
		Provide sufficient information to let the deconstruction happen in an efficient and safe way	(Crowther, 2005; Durmisevic, 2006; Macozoma, 2002; Sassi, 2008; Webster et al., 2005a)
		Define the hierarchy of disassembly according to expected life span of the components	(Chini, 2002)

Figure 41: Strategies for adaptability, adopted by Sadafi, 2014

Appendix 3

The first question of the Delphi panel is to put all of these drivers in an order based on their importance for you:

Which of the following indicators are more important when deciding If the transformation will go into creating an adaptable building or If you will go for a standard transformation/conversion?

Drivers for adaptability, used in the Delphi research.

Secondary Location: Dependent on the type of real estate sector. For offices, a secondary location could be out of the Central Business District (CBD), or in an area with bad infrastructure and bad accessibility. Generally, a secondary location in the Netherlands is out of the Randstad and/or away from the city Centre (Bouwinvest, 2016; CBRE, 2018; Dynamis, 2018).

Market Uncertainty and Market oversupply: This driver is about the real estate market. Market Uncertainty is raised during a crisis and market oversupply results when demand is lower than supply, resulting in a surplus. So, the question for this driver is A) If you are re-developing an asset now, when the market is not that uncertain are you willing to make a slightly higher investment in order to be ready for the next real estate downturn and an uncertain market? B) Nowadays the office market is booming, but in the next crisis there is a big possibility to phase again high vacancies in the commercial sector, because of the oversupply or the smaller demand (Schmidt III, 2014; Remoy, n.d.) (Kincaid, 2002). Do you try to re-develop an asset with a certain adaptive capacity in order to be able to deal with an uncertain market?

High building vacancy: The building that you are going to transform was bought after being vacant for more than 3 years (this can be described as structural vacancy). Main drivers for structural vacancy are the functional and technical obsolescence. So, when you are re-developing the asset do you try to make it adaptable in order to confront a next functional or technical obsolescence. Functional obsolescence is when the building cannot be used anymore in its current function, or when there is a small demand in the market for the current function. Technical obsolescence can occur when the building cannot adapt to new technologies, new installation and services that are required by the user (Geraedts, et al., 2014; Remoy, n.d.) (Kincaid, 2002).

Environmental (energy) legislation: After the Paris agreement in 2015, many things changed concerning environmental laws. An example is that all the office buildings in the Netherlands should have at least label C to continue operating after 2023 (JLL, AKD, 2018; Schmidt III, 2014; Deutsche Asset Management, 2018). So, concerning the possibility of more environmental restrictions do you try to re-develop an adaptable building that can be adjusted to the future governmental requirements?

Municipality's Vision: At the moment that you are in the designing phase or re-developing a building you know that the Municipality will release a vision for the specific area (Remoy, 2010; Remoy, n.d.; Brink Groep, 2014). Example: The neighborhood to be an Innovation District or High-Quality Mixed-Use area. On the other hand, the current Municipal authorities have a certain perspective on the area-redevelopment. Considering that this area project will take around 20 years to be finalized and that many authorities can possibly change till then, do you try do make your project more adaptable in order to be sure that it will match the Municipality's vision. This is not a question only about the permits, but also in the efficient functioning and use of your building.

Zoning legislation: After the completion of your projects you are informed that the Municipality wants to transform the area the building is located to another function or that the Central government add some extra restrictions on the zoning requirements and your building cannot function anymore on its current use (Schmidt III, 2014; Remoy, n.d.; Deutsche Asset Management, 2018). Is that a driver in order to decide for a more adaptable transformation?

Sustainability: Sustainability is a concept that gains importance in the real estate sector, mainly for social and environmental issues (Remoy, n.d.). It has to do with the materials selection, the way you built and the way that you integrate social cohesion into your project.

Lack of good infrastructure: Infrastructure is the system of land-based physical assets and technology which collectively provide the enabling environment and deliver the services required to enhance economic growth and the quality of human life in the society (Remoy, 2010; Van Eerden, 2018). Is the lack of infrastructure a good reason to go for an adaptable transformation? This has also two perspectives. A) You expect that in the future the infrastructure will be upgraded so you want your building to accommodate higher densities or another function. B) You do not believe that the existing situation will change and you want to be ready to react If you have high vacancy after the completion of the project.

No parking facilities: Highly connected to infrastructure, the lack of parking facilities could be a main reason for vacancy in residential or commercial buildings (Remoy, 2010; Van Eerden, 2018).

Become a frontrunner: Dependent on your expertise, which means that you want to be a frontrunner as a company or you want to have a building which has the image of Front-runner. If so, is that an important driver to design a building that can adapt to the changing technologies, innovations and/or standards in a long-term perspective (JLL, 2013)?

Low aesthetical quality: The building's aesthetics do not match anymore with the environment, the current trends or the preference of the users/owners. This does not mean that the existing building is not beautiful, we do not care as this is something that we can change. The question here is If you want your transformation project to be adaptive on the preferences of your users, clients or tenants. In long the term the image of what we see as beautiful changes, and a building could be easily characterized as outdated (Baum, 1993; Brand, 1994; Schmidt III, 2014; Schnädelbach, 2010).

Appendix 4

List of Participants in the Delphi Research and Interviews Sessions

Frank	Bijdendijk	Investors
Ronald	Schleurholts	Architect
Oresti	Sarafopoulos	Architect
Roderik	Mackay	Developer
Jurre	Blauw	Developer
Tom	van Eerden	Consultant
Evi	van Rijn	Consultant
Melike	Catagol	Investor
Jan	Bruil	Investor
Silvie	Bruijning	Developer
Joelle	Lockhorst	Developer
Hilde	Remoy	Academic
Arnold	Hobma	Architect
Tijmen	Schrauwers	Contractor
Robert	Schmidt	Academic
Peter	de Jong	Academic
Joost	Ektor	Architect

Appendix 5

Interview Questionnaire

Author: Kougea Charitini
Last edited: 29/1/2019

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1. How many years to you work in the sector of architecture/real estate development/real estate consultancy?

- Less than 5
- Less than 10
- More than 10

2. Which are the main uncertainties to deal with when designing a project (transformation or not)?

- Future trends
- Future users' requirements – life style or working style?
- A new financial and real estate crisis?
- The building to be quickly (after 10 years) functional or technical obsolete?

3. Which are the drives in your decision-strategy or design-making process when you are dealing with re-design or new construction projects? Are there any new concepts that you added to your agendas the last 2-3 years? (like sustainability-energy positivity-circularity)

4. Which are the other actors that highly influence your strategy? Who is the final decision? maker? (Owner-Investor-Architect-Consortium)

5. Many buildings usually undergo the following changes. What are the major cost considerations to be considered in these changes?

•Small changes with some improvements in existing buildings to continue the same use
•Large changes with major refurbishments to continue the same use
•Large changes to adapt for new/different use
•Demolition and new built

……

6. How often do you work in transformation projects?

……

7. Depends on the frequency of transformation projects: What is the main reason to transform real estate?

- Vacancy
- In-efficiency
- Different Market demand
- Obsolescence
- Depreciation
- New energy requirements
- Other

…….

8. Is Adaptability or flexibility a concept that you are familiar/work with? (Yes/No)

9. Do you think that through adaptability the life cycle of a building will be expanded, or Can adaptability support your vision-concepts etc? Do you work with layers?

10. Which of the main characteristics of adaptability are more important for you?

Change of Use
Ability to remain Fit
Value
Time

11. Can you please prioritize?

(I will the list to the interviewee printed)

12. Which are the main design parameters that you follow in order to extend the life-cycle or the adaptive capacity of a project? Do you consider the layers of Brand (six S model) while you are designing a project?

A. ……..
B. ……..
C. ……..

……
……

13. What are the expected difficulties/risks to design (use the information that mentioned above) a transformation project to respond the future potential change of use? (max 5)

14. If it is financial: Are the investors, or client, aware about the benefits of an adaptable design? (awareness is one of the two top factors that affect flexibility). Did the financial crisis of 2008 was a factor that affected them?

Appendix 6

Consent form
Author: Kougea Charitini
Last edited: 15/1/2019

I would like to thank you for accepting my invitation for this interview designed for my Master Thesis in TU Delft, Management in The Built Environment Track. The objective of this interview is to explore the fundamentals of adaptable design, the obstacles, the risks and the benefits of it. The focus is on transformation projects, mainly on vacant office buildings built in the decades of 1970 and 1980, a building type that is spread globally.

The first part (30 minutes) is the first round of the Delphi panel. This consists of a discussion about design parameters and indicators for an adaptable design. In the end, I will ask you to evaluate this list based on the importance of the indicators and how easy or not is their applicability. After a few weeks, I will send you back the grading alongside with the average scores given by the panel. At that moment, you can revise or not your own grading.

The second part of the interview (30 minutes) is structured as an exploratory discussion on the real estate strategies or goals for the adaptive re-use of existing buildings. What I expect is to understand the perspective of an architect concerning the decision making for developing a transformation project; why should or should-not go for a building that can adapt to the changing future (users' or owners') demand. Moreover, the topic will be shifted to more practical issues as the "grade" of adaptability, the decision making and the financial feasibility of the design. In order to simplify and make more feasible my note-taking, I would like to audio tape our conversations today. Please sign the release form. For your information, only researchers on the project will be privy to the tapes which will be eventually destroyed after they are transcribed. Before we start, you must sign a form devised to meet our human subject requirements. Essentially, this document states that: (1) all information will be held confidential but will be used to draw an understanding of the stakeholders' management perspective and decision making, (2) your participation is voluntary, and you may stop at any time if you feel awkward3) I do not intend to inflict any harm.

Thank you for your agreeing to participate and for the time you are willing to share.
Kougea Charitini
4/2/2019

Consent Form for Qualitative Interview and the Delphi Method
Please tick the appropriate boxes **Yes No**
Taking part in the study
I have read and understood the study information dated [03/12/2018], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.
I understand that taking part in the study involves sharing knowledge about the respective investor firm's perspective. This is conducted through an audio-recorded interview followed by feedback based on the finding as a result of the study. The audio recordings will be transcribed as text and the recordings would be destroyed.
I would be willing to receive the transcript of the interview and would be interested to make

the revisions if needed.

I understand that if there are any modifications to be made to the interview response, I would be able to and am willing to change it in the transcript provided post the interview. This is done to maintain maximum transparency and to provide an opportunity to reflex on the response made.

Use of the information in the study

I understand that information I provide will be used for the following

reports, presentations using the same terms as you used in the study information sheet. Consider any secondary use and whether knowledge sharing and benefits sharing needs to be considered, e.g. for indigenous knowledge.

I understand that any personal information collected about me that can identify me, such as [e.g. my name & company profile], will not be shared beyond the study team.

If you want to use quotes in research outputs then add extra question: I agree that my information can be quoted in research outputs

If you want to use named quotes, then add extra question: I agree that my real name can be used for quotes

If written information is provided by the participant (e.g. diary) then add extra question: I agree to joint copyright of the [specify data] to [name of researcher]

Future contact for the study

I understand that in case any additional information is required in the future I am willing to participate and share

If any additional research is required during the process, I would be willing to be contacted again to participate. (In case if need)

Interviewee's Personal details

Name:

Company Name:

Size of Company:

Signatures

_____ _____ _____

Signature Date

I have accurately handed out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Charikleia Christina Kougea _____ 5/2/2019

Signature Date

Contact Details

Kougea Charitini

Kougea@gmail.com

+31 626766225

Glossary

Adaptability:

*"**The capacity to change** the building's built-environment in order to **respond and fit to the evolving demands** of its users/ environment **maximizing value** throughout its **lifecycle**."* (Schmidt III, 2014)

Characteristics of adaptability in Real Estate:

- **Capacity for change**, which can be translated in many things like change of the size, function, location.
- **Remain "fit"** or "reduce in mismatches", which is about the connection and the relation between the user and the building.
- **Value**, which can be translated as "maximizing the productive use", "to fit both the context of a system's user and its stakeholders' desires", "at minimum costs".
- **Time,** which indicates the speed of change and the life cycle commitment; long term changes and "extension of use"

Adaptive Reuse:

Adaptive reuse is a revival strategy through which existing buildings (mainly vacant or inefficient)
are converter to accommodate a new function.

Adaptability Types:

Adjustable: Change of Task
Versatile: Change of Space
Refitable: Change of Performance
Convertible: Change of Function
Scalable: Change of Size
Movable: Change of Location

Objectives of the Interview and Delphi Research

I. To identify factors for the change of use and adaptation potential
II. To identify and evaluate design parameters which enhance adaptability
III. To evaluate the importance and the added value of these parameters
IV. To evaluate the economic consideration and the financial impact of the design parameters for adaptability