FACULTY OF TECHNOLOGY

REGENERATIVE MAINTENANCE IN BUILDINGS

ENVIRONMENTAL ENGINEERING

Bachelor´s Thesis

August 2019

Mira Lindholm

FACULTY OF TECHNOLOGY

REGENERATIIVINEN KIINTEISTÖJEN YLLÄPITO

Mira Lindholm

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Tiivistelmä

Suomen Yliopistokiinteistöt Oy on mukana eurooppalaisessa COST RESTORE -verkostohankkeessa, jossa kartoitetaan vahvan ja uudistavan kestävän kehityksen haasteita rakennetussa ympäristössä. Keskeisenä lähtökohtana on näkemys, että rakennettu ympäristö ei ole kestävä olemalla ”vähemmän huono” eli esimerkiksi vähemmän energiatehokkaampi kuin aiemmin. Sen sijaan rakennetun ympäristön on oltava tulevaisuudessa ”enemmän hyvä” ja sen on pyrittävä sekä vahvistamaan että uudistavaan kestävyyteen.

Tämän työn päätavoitteena on tehdä kattava kirjallisuuskatsaus kestävän kehityksen evoluutiosta kiinteistöpalveluissa ja kiinteistön ylläpidossa. Kokonaisuutta lähestytään kaupunkiympäristön kontekstissa, kiinteistön sijainnin tasolla ja kiinteistön tasolla. Ensiksi työssä keskitytään ympäröivään luontosysteemiin, toiseksi regeneratiiviseen rakennukseen ja kolmanneksi regeneratiiviseen ylläpitoon. Työssä keskitytään toimi- ja liiketiloihin sekä kampusalueisiin, mutta työssä esiteltävät keinot ovat sovellettavissa mahdollisesti laajemminkin.

Muita tietoja

ABSTRACT
FOR THESIS

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Abstract

University Properties of Finland is involved in European Cost Restore – project, where the main point is to survey strong and regenerative sustainable development´s challenges in built environment. Starting point of the project is view, where the built environment is not sustainable just being "less bad", for example more energy efficient, than before. Instead built environment must be in the future "better" and it must aim at strengthened and regenerative sustainability.

The aim of the work is to do comprehensive literary survey of evolution in real estate service and maintenance of the properties. The whole is approached first as a level of whole surrounding natural system, second as a level of location of property and third as a level of the property. First this work concentrate surrounding natural system, second regenerative building and last regenerative maintenance. The focus before anything is at campus areas, commercial and office premises, but the views might be applicable more widely.

Additional Information

OPENING WORDS

The main task of this thesis is to do an exhaustive literary survey about the evolution of sustainable development at services and maintenance of real estate. I approach this from the perspective of buildings, neighbouring areas and urban communes. First this work concentrates on surrounding natural systems, second on regenerative buildings and finally on regenerative maintenance.

I want to thank University Properties of Finland for the amazing and inspirational summers of 2018 and 2019. During those summers I got very interested about learning and working spaces and how to maintain them ecologically beneficially. My greatest thanks to Ari-Pekka Lassila and Suvi Nenonen for providing me with this interesting assignment and for being my supervisors. I also want to thank Markus Saari for being my supervisor at the University of Oulu.

In Oulu, 9.9.2019 Mira Lindholm

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CONCEPTS

COST network has defined a few concepts in RESTORE booklet (2018):

"Sustainability: The balance point where we give back as much as we take

Restorative: Restoring social and ecological systems to a healthy state

Regenerative: Enabling social and ecological systems to maintain a healthy state and to evolve.

Health and wellbeing: Sustainability is now longer concerned only with resources and energy, but increasingly and significantly human-centric.

Place: Our relationship with place, ecology, nature, soil, bio-climate

Energy: Working towards restorative and regenerative energy, net-zero, carbon-neutral approaches and energy storage

Water: Understanding net positive water, building influence, floods, drought, water stress

Wellbeing: Provision of buildings and facilities that foster health, happiness, salutogenesis, biophilia, mindfulness, air, light, comfort

Carbon: Reimaging Carbon with science based targets, 350ppm, 2Deg, social impact

Resources: A future of healthy and responsible materials, responsible, transparency, conservation circular economy

Equity: Working towards equity, fairness, inclusion, respect"

Facilities management: “the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities” (The European Committee for Standardisation’s (CEN) EN 15211-1)

Sustainable facility management: “illustrates how it offers the opportunity to engage users, operationalise strategic energy goals and link decision making to the global and local climate as well as the eco-system” (COST 2019; Nielsen et al, 2016)

Regenerative facility management: “targets to achieve healthy state of people´s environment in short and long term by pushing solutions and resources beyond sustainability” (COST, 2019)

1 INTRODUCTION

Green values and sustainable development have been buzzwords throughout different industrial sectors for decades. However, in construction industry attention is drawn even further this line of thought as concepts of restorative and regenerative development are being merged into design of urban environments. In this context, restorative means that social and ecological systems are restoring to a healthy state. That is not considered to be enough anymore and that is why shift towards regenerative development is in demand. Regenerative means that social and ecological systems are able to maintain a healthy state and can evolve. For example, instead of speaking how energy-efficient building is, the talk should be on how much energy building can produce to energy grid and thus benefit the surrounding environment.

University Properties of Finland is involved in the European Cost Restore – project, where the main point is to survey strong and regenerative sustainable development´s challenges in built environments. The starting point of the project is to view, where the built environment is not sustainable just by being "less bad", for example more energy efficient, than before. Instead built environments must be "better" in the future and they must aim at strengthened and regenerative sustainability. Figure 1 highlights the steps towards regenerative development.

Figure 1. Built environment must aim towards regenerative (COST 2018, p 8).

The aim of the work is to do comprehensive literary survey of evolution in real estate service and maintenance of the properties. The literature review is implemented by using keywords green, sustainable, regenerative, restorative and facilities management. The main emphasis is in search results, which have been published in the twenty-first century, but there are also results, which have been published in twentieth century.

The search for these articles took place between September 2018 and July 2019. The articles were searched mainly from Scopus and Web of Science.

The concept of regenerative development is approached first at the level of whole surrounding natural systems, second at the level of locations of property and third at the level of the properties. First this work concentrates on surrounding natural systems, second regenerative buildings and finally on regenerative maintenance. The focus before anything is on campus areas, commercial and office premises.

Key issues of the thesis are how to observe ecological, economic and social sustainable development in property maintenance? How restorative and regenerative can be carried out in property maintenance? What do restorative property goals mean in real life? Who plays a central role and what effects do they have in restorative and regenerative solutions in maintenance? What are the certifications, standards and norms in restorative and regenerative maintenance? How can technology support restorative and regenerative solution in maintenance? The most important concepts are sustainability, restorative and regenerative.

2 LITERATURE

2.1 Surrounding natural system

Current green approaches to building retrofits are a result of thinking that we must reduce buildings negative impacts. Although that is important, we must do things better (Procedia Engineering, 2017, p 658). We need a fundamental shift towards regenerative development, because the most of buildings, which will exist in 2050, have already been built (United Nations Environment Programme, 2009, p 6). This requires a positive model, when humanity is part of a larger community of life. That's why a single building retrofit must positively interact with its surrounding natural and human systems to shift regenerative (Procedia Engineering, 2017, p 659).

One tool towards to regenerative development might be a "proactive" retrofit, which aim to integrate restorative, net-positive and regenerative design concepts into building retrofits. This model considers key interactions between environment and human, physical and natural systems in built environment. (Procedia Engineering, 2017, p 659) The first step towards regenerative development is change of thinking, not change of techniques (Mang and Reed, 2012, p 26).

Figure 2 shows the four levels of work, where each living system must continually engage to increase its viability, vitality and capacity for evolution. Above the line you can see concepts "regenerative" and "improve", which explore the potential and creativity to the larger system. Below the line are the concepts "maintain" and "operate", which handle only with what is in existence. In other words, they simply react to negative events. Although this is important, we must take account "proactive" building, because it seeks to integrate concepts restorative, regenerative and net-positive by interacting with its surrounding environment. It´s important to capacity for evolution to work at all four levels. (Procedia Engineering, 2017, p 660)

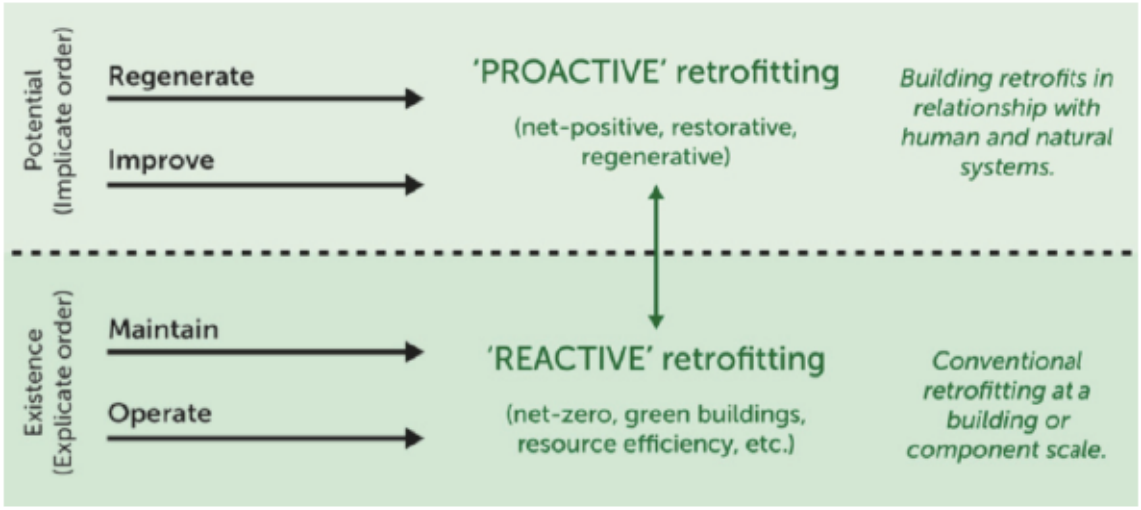

Figure 2 Four levels of work (Procedia Engineering, 2017, p 661).

First, we must understand, how using physical built environments improve resource efficiency and how we can improve social connections and a connection to nature. Only after that we may achieve proactive retrofit outcomes. The image below (Figure 3) shows us how an energy efficient building retrofit can improve occupant wellbeing and health, as well as enhancing and restoring local ecosystems. (Procedia Engineering, 2017, p 661) The difference between regenerative and restorative design is that regenerative design creates better conditions to support ecosystems and restorative designs reverse damages (Nugent et al, 2016).

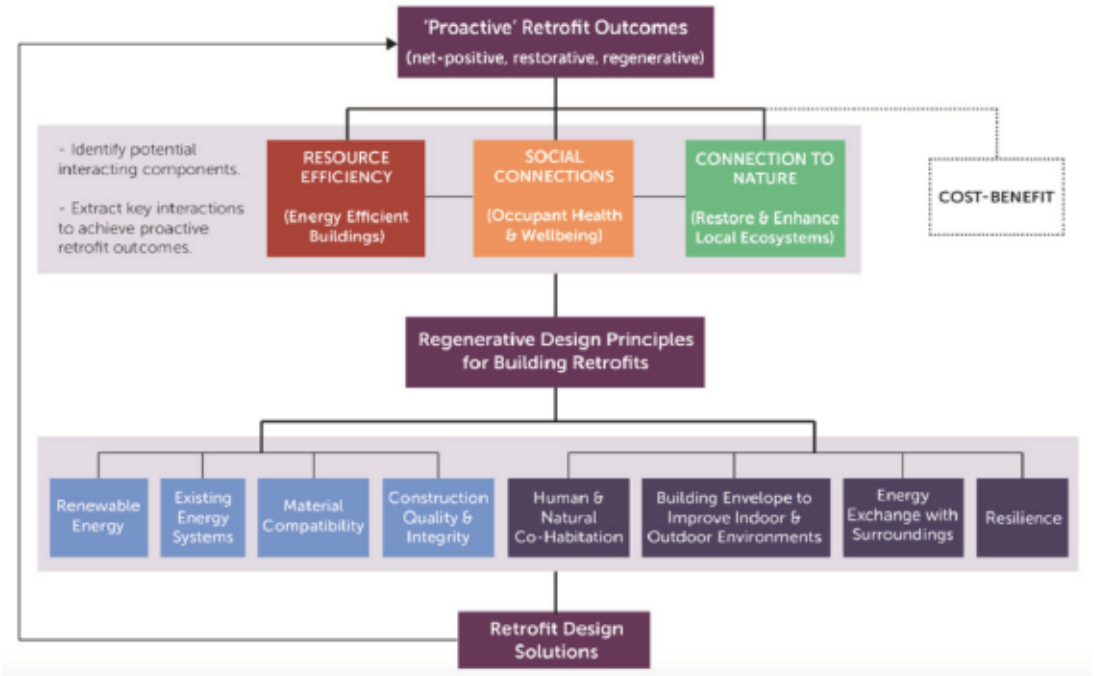

Figure 3 Energy efficient building retrofits' impacts on occupants and local ecosystems (Procedia Engineering, 2017, p 662).

Figure 4 shows regenerative building retrofit possible components between surrounding natural systems (green), human systems (orange) and physical environments (green). Human systems and physical environment are a part of building scale in the figure 4. Although, for example, the use of renewable energy systems is a part of building scale, it benefits beyond its site boundaries. If we want to ensure a proactive retrofit outcome, we must extract and identify the key interactions, which should cross all three dimensions. To explore the potential interactions between all the components, each dimension can spin on a central pivot. This helps the designers question the interconnectedness between different components. For example, how could the choice of material improve indoor environmental qualities? Extracting and identifying the key interactions between different systems helps taking a step towards regeneration. (Procedia Engineering, 2017, p 661-662)

Figure 4 Regenerative buildings retrofits possible interacting components (Procedia Engineering, 2017, p 663).

2.2 Regenerative building

The buildings are often built to serve the needs of the construction time. That's why they usually need, for example, replacements or remodelling, when circumstances change. That is usually expensive and harmful to the environment. On this account, sustainable designs have intervened in this intolerable situation. (Nugent et al, 2016)

2.2.1 What is regenerative building?

The most important quality relative to real estate management is that regenerative buildings are flexible to change when the time and conditions change. They capture and treat all water they need and produce their own energy. Regenerative buildings may even share the energy to the neighbouring area, when they have a net-positive impact on the surrounding area. In that manner buildings, for example, give opportunities for urban agriculture (for example gardening on roofs). (Nugent et al, 2016)

Overall, regenerative buildings restore their surrounding areas by, for example, providing lost plants and wildlife while also restoring natural hydrology. They are designed to improve their surrounding environment by increasing the quality of life for abiotic and biotic parts of the environment. Buildings are also integrated into the environment. They neither cause health impacts or emissions. (Nugent et al, 2016)

2.2.2 Meaning of place

It is not enough if we only think of regenerative development at the level of the surrounding environment. We must also consider the building's location. A regenerative place is, according to Procedia Engineering, 2017 (p 662), "a concept that emerges from the whole network system and the complex interactions between these systems". So, when thinking of a regenerative place, the definition is much more than just, for example, tectonic form, light, climate and topography (Hes and Plessis, 2015). Before we can think what a building can generate, we must ask the following questions, which are presented in Procedia Engineering, 2017 (p 662):

1. "What patterns, dynamics and relationship between human, physical and natural systems characterize this specific place? Do they add positive value to the whole system?
2. What is the existing role of this building? Does it diminish or enable the ability of others to play their role? Does it need to change?
3. What are major issues preventing the building from improving its own performance and its ability to add positive value to its occupants and the local ecosystem?"

In general, stories give us a possibility to imagine the future differently and share and understand complex wholes. Stories are a good tool for a deeper connection to a place and to grow harmonious with a place. First, understanding the story of a place enables understanding how living systems work in a place and give us greater intelligence about how humans can align themselves with a way of working, which benefits all. Second, the spirit of caring must come from a deep connection to a place or the society does not do the needed changes, as history has shown. The Story of Place provides also a framework for an on-going learning process (Mang and Reed, 2012, p 28-30).

One important question is, how can we enlarge a regenerative process over the design phase or construction phase of a project? One solution might be the concept of story fields. If the conversation around the project produces a storying process it can come out of the project across and into the community, meanwhile sourcing a new story field, which Atlee (2007) calls it (Mang and Reed, 2012, p 30).

2.2.3 Proactive and reactive design

In figure 5 we can see examples of proactive and reactive designs. The proactive retrofit includes principles, which have positive impacts to its surroundings. Reactive retrofits focus is on more ordinary building retrofits. Although we concentrate on the proactive view, we must remember that the reactive view gives us a basis, which we can expand with the proactive view. We must also increase a human's physical and visual connection to nature. The key to that is to provide intervention strategies, which support natural- and human co-habitation. This includes, for example, alteration or provision of shared spaces to incorporate facilitate and nature opportunities for social interaction. (Procedia Engineering, 2017, p 663)

Figure 5 Concrete examples of proactive and reactive design (Procedia Engineering, 2017, p 664).

2.2.4 Regenerative initiatives for measurement

There are various certifications, which can be used when measuring regenerative development. A few of those are introduced below.

ISO 14001 Environmental management system

With ISO 14001 Environmental Management System, a company can get certification, which tells the organization's services', products' and processes' environmental impacts. ISO 14001 helps companies to, for example, demonstrate full environmental legal compliance, to minimize their environmental footprints, offer operational improvements and develop companies in sustainable manners. (Certification Europe, 2019)

One Planet Living

Bioregional created with WWF One Planet Living framework to reduce over-consumption and therefore to reduce ecological footprint. This framework consists of

ten principles. It also includes detailed guidance and goals. Ten principles are described in the figure below (Bioregional).

Figure 6 Ten principles at One Planet Living framework (Bioregional).

Living Building Challenge

"The living Building Challenge is a green building certification program and sustainable design framework that visualizes the ideal for the built environment." (Living Future, 2019) The main idea is that Living Buildings create a positive impact on natural and human systems while interacting with them. Buildings do not take more than they give. The Living Building Challenge pays attention to regenerative spaces,

where occupants are connected to air, light, community, food and nature. The buildings remain within the resource limits of their sites and are self-sufficient. Living buildings treat and collect all water on the spot and produce more energy than they use. The Living Building Challenge also pays attention to healthy and beautiful. (Living Future, 2019).

To become a Living Building, the buildings must meet two core conditions:

1. "All Imperatives assigned to a Typology are mandatory
2. Living Building Challenge certification requires actual, rather than anticipated, performance demonstrated over twelve consecutive months" (Living Future, 2019)"

The Living Building Challenge has divided the subjects to seven Petals, resembling a flower. Each building's function should work as cleanly and efficiently as the flower works. The Petals are place (limits to growth, urban agriculture, habitat exchange and human-powered living), water (net positive water), energy (net positive energy), health and happiness (civilized environment, healthy interior environment, biophilic environment), materials (red list, embodied carbon footprint, responsible industry, living economy sourcing, net positive waste), equity (human scale and human places, universal access to nature and place, equitable investment, just organizations) and beauty (beauty, spirit, inspiration and education). (Living Future, 2019)

2.3 Regenerative maintenance

2.3.1 Sustainable facility management

Facility management is an important piece of sustainable development of economy. That's why it is important to evolve better management technologies. In addition, facilities management can benefit development of the built environment. (Junghans, 2011)

There is two kind of ways, how facility management affects the delivery of construction and procurement; direct and indirect. Direct way is shared to three main areas of responsibility: 1. "support of primary processes" 2. "development of space and infrastructure" and 3. "development of people and organizations". Indirect way is to evolve overall goals of sustainability concerning society, the economy and the environment. (Junghans, 2011)

A Sustainable Facility Management model is presented at Junghans (2011). The model was developed in two phases: First attention was paid to awareness of sustainability and second to integration of sustainability. First means that "to be aware if and how Facility Management impacts are sustainable". Then the organization´s surroundings are observed. What are the impacts on environmental, social and economic criteria? (Junghans, 2011)

The second phase, integration of sustainability, aims to evolve sustainable organizations considering sustainable targets. Now the whole can be more broadly reviewed and it is easier to perceive interact between organization and surroundings. The goal in facility management is to integrate business strategies with environmental, social and economic targets. The sustainable organization is a part of a sustainable society. (Junghans, 2011)

In the picture below is shown how organization interacts with its surroundings. (Junghans, 2011)

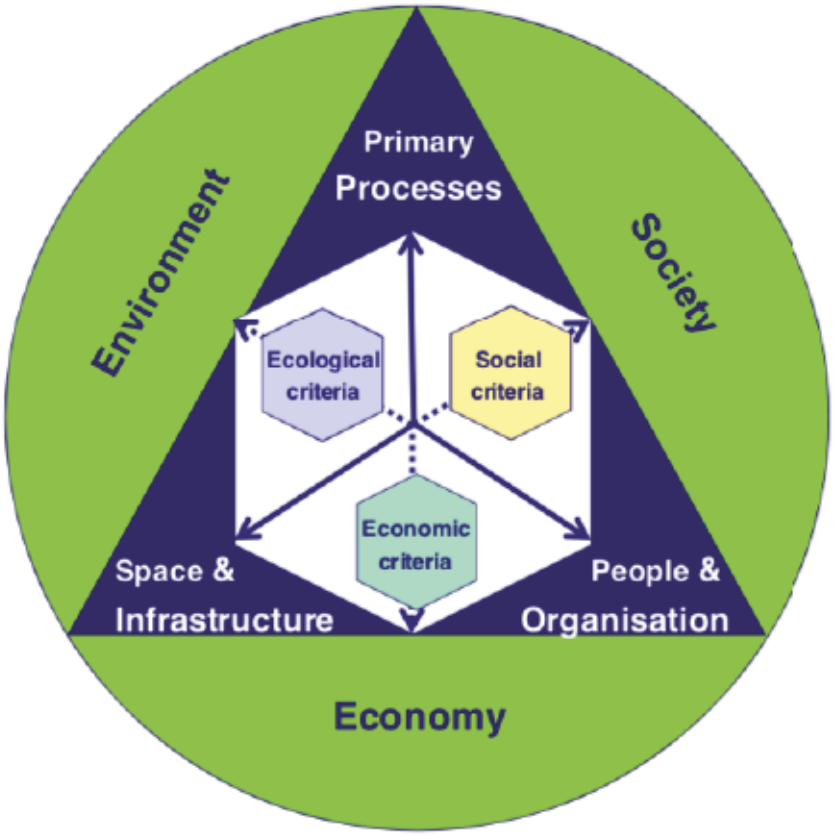

Figure 7 Sustainable Facility Management (Junghans, 2011)

2.3.2 Regenerative maintenance with society, economy and environment

According to COST, 2019, Facility Management influences the economic, social and ecological environment. Additionally, it is important to examine all of these three dimensions as a whole, as shown in figure 7. (COST, 2019, p. 96)

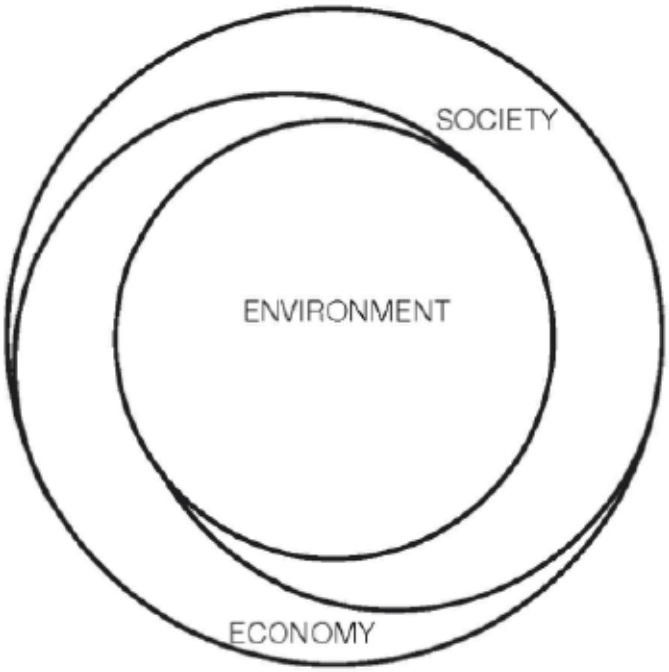

Figure 8 Society, Environment and economy blend into each other. (COST 2019)

Social, ecological and economic targets

Regenerative Facility Management´s social, ecological and economic targets according to COST (2019, p 96-99) are shown in Table 1 below.

Table 1 Social, ecological and economic targets in Regenerative Facilities Management (COST 2019).

Social targets	Ecological targets	Economic targets
➢ Supply of the balanced amount of buildings for work and life, developing mixed-use and hybrid facilities in the context of urban regeneration	➢ Reduction of resources with the focus on circular economy and sharing	➢ Building space optimization for more efficient usage and using digital technology, services and data to monitor effectiveness, collect and provide feedback data about the use patterns – Building information modeling (BIM) and different ways to use virtual and augmented realities as means of visualization can help
➢ Physical and psycho-social wellbeing, alongside compliance with health, safety and security requirements including	➢ Usage of recyclable building material and improvement of multi-project integration in order to recycle materials	➢ Optimization of building life-cycle costs- involving different stakeholders to design, construction, handover, use, maintain and re-develop the buildings in long -term, circular economy perspective
➢ Identification of different social groups and different social groups and provide synergy	➢ Consideration of the separability of used material for re-use and developing new practices and services to make it easy for different stakeholders	➢ Facilitating the most efficient management methods – learn and new innovative models and practices, enhanced by digitalization, ecosystem practices, responsible procurement
➢ Communication of the regenerative values for users – this increases the awareness of regenerative actions."	➢ Reduction of energy consumption and usage of renewable energy sources – inspection of reduction by using digital services and data in an innovative way	➢ Using e.g. green bond as the basis of financial management
	➢ Reduction of space requirements	
	➢ Safeguarding the ability to maintain and de-construct buildings,	
	➢ Prevention of materials that cause harm to people or the environment based on precautionary principle specification	

These defined goals have been considered at a European level. Additionally, national perspectives must be taken into account.

2.3.3 Digitalization and sustainability

There has been interest in the future of facility management since the concept was developed. Nowadays there are two things in facility management; digitalization and sustainability, which generate development trends for the future. Digitalization has three effects, which have been separate from each other in Bröcner et al, 2019: 1. In workplaces there is communication and information technologies as support for work, 2. New ways for designing buildings, 3. Sharing the support for new methods of performance measurement (Bröcner et al, 2019, p369).

Facility management will be based on digitalization in the future. Additionally, facility management needs intelligent data solutions for, for example, control, design, monitoring and management in general. Low-cost sensors and their technology enable better real-time condition monitoring and automated solutions for buildings. Low-cost sensors also give access to "data for key performance facilities management indicators for services and their coordination". It´s also easier in the future for managing facilities to be more efficient, flexible and of higher quality through big data solutions and robotics. Simultaneously that will challenge facility management to focus more on the overall goals for an organization. Additionally, facility management must require more understanding of the needs of clients, users and the society in general (Bröcner et al, 2019, p 376-377).

It is expected, that when data comes more accessible and the facility management use of building information progresses, digitalization will construct new processes and models. These help operations and maintenance to use "shared intelligent models sitting on structured data" when giving more possibilities documentation and asset data. How virtual-reality and augmented-reality technologies influence on facility management is still unknown (Bröcner et al, 2019, p 376-377).

Sustainability and technological innovation will define what type of workspaces, work patterns and workplaces we will have in the future. Even now, digitalisation enables employees to work with different workspace settings, or almost anywhere in the world, as long as they have access to digital network. (Bröcner et al, 2019, p377)

It is important to remember that sustainability and digitalization are not mutually exclusive forces. They both form tomorrow's facility management. (Bröcner et al, 2019, p377)

2.3.4 A Green maintainability

A green maintainability is an essential part of green facility management. (Chew et al, 2017, p57). The concept of "building maintainability" is defined in Chew 2010: it means that a building reaches its optimum performance during the building's trajectory, when life cycle costs are lower. The green maintainability of buildings helps promote the green facility management ideas in support of the sustainable development agenda. It is very important to the economy and the safety of a nation to look at the impacts of life cycle assessment and, particularly, from the view of energy savings and energy efficiency together with the maintainability of facilities. When developing life cycle assessments, also the long-term maintenance and operations must be considered.

The research framework helps in understanding and implementing building sustainability and maintainability. Regarding to Chew et al, 2017, it is pending that the green maintainability protocol can be used with existing assessment systems, for example, with LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Established Environmental Assessment Method). (Chew et al, 2017, p57).

2.3.5 Retrofit of a building envelope

One way to improve an existing building's multiple health benefits for natural and human systems is improving the building envelope. In that way, we could restore the local ecosystem. Additionally, when thinking of a building itself, we could reach many benefits. For example, relative to its internal environment, it can reduce the cooling and

heating loads, improve natural light, air quality and natural ventilation. Relative to the external environment, the envelope might support wildlife habitat connectivity and reduce surrounding urban microclimates. (Procedia Engineering, 2017, p 664)

We have to storage and manage excess renewable energy, if we want to create a positive energy exchange. A two-way exchange with the grid would allow energy sharing with surrounding infrastructure and buildings. In order to guarantee the building account and evolve for future changes in climatic conditions and technology, the retrofitting should be resilient. For example, buildings or building components should be demountable, adaptable, durable and reversible. (Procedia Engineering, 2017, p 664)

2.3.6 Measuring space use real-time

The goal in corporate real estate management is to optimize corporate accommodation to organizational performance. At European universities, the difficulty is to match demand and supply when thinking of the use and allocation of space. The main question is how could universities invest their resources as efficiently as possible? Valks et al. (2018) elaborated this subject in their article. They conducted a survey in thirteen Dutch universities. Their discoveries tell where we are now going on space use real-time and what should be done better (Valks et al. 2018, p 103).

The discoveries of the research tell, that most of the smart tools in universities are in education spaces: in learning spaces or in teaching spaces. The two biggest applications are one that supervisors the use of spaces and one that helps users to find and reserve space. First application helps to supervise the quantity and quality of spaces on a campus. This is a consequence of a growing number of students and employees. When the number of students and employees grow at universities, the spaces must be shared between faculties. Therefore, we need to monitor those spaces. By monitoring spaces, people who set the timetables and campus managers can follow that is the spaces used efficiently and effectively. (Valks et al. 2018, p 107-109)

The second application, which helps users find and reserve spaces, is a solution to shift, where number of employees and students has grown. That is why universities attempt to

give information about free learning spaces. In practice, this has been done using self-booking systems and overseeing the usage of shared desktops. In some universities it is possible to reserve other rooms, for example meeting rooms or classrooms for studying. This helps universities, which lack studying spaces. In addition, there has been some founds of smart tools also. These smart tools have been actualized in a small scale. For example, at one case a faculty or department moved into a shared workplace. (Valks et al. 2018, p 109)

In universities, if measurement is smart it does not have to be real-time. In matter of fact, about half of the smart tools in the study do not gather real-time data on spaces. Instead, they gather data via booking rooms, timetables and manual counts. The interviews, which were done in the study, show that all the smart tools were used to optimize the m^2 footprint, to better support for users or cut down CO2 emissions. The smart tools also add value to other aims on campuses, either directly or indirectly. Smart tools on a campus have an emphasis on functional and strategic goals rather than physical and financial goals. (Valks et al. 2018, p 109-110)

In the study, the researchers asked universities about their future demands. About half of the universities, which use smart tools that measure teaching spaces, are considering or already looking for possible solutions to measure real-time occupancy and frequency of use in the future. This is because students are increasingly taking their own laptops to campuses. Therefore desktop PCs are not used that much anymore, and thus universities are reducing the number of desktop PCs. Thus the students can use the spaces with PCs without using them (Valks et al. 2018, p 110-111).

The problem with booking systems is that they do not reveal actual use. Particularly when the applications, which give information about the availability of big rooms to students via scheduling, are considered. In addition, the study found out a few additional demands. The desire to measure the users' movements on campus arose in the study, as in which users use which facilities. Second, for emergencies, it would be good to have applications, which tell users the evacuation routes. The third thought is the application, which third parties can use to book conference rooms on campus. The study shows that

campus managers are concentrating on the use smart tools on campus. (Valks et al. 2018, p 111)

3 CONCLUSION

Regenerative maintenance is not just a simple concept, but it is much more. In this thesis Regenerative Maintenance is shown as a whole, from many perspectives. This unity is presented in figure 9.

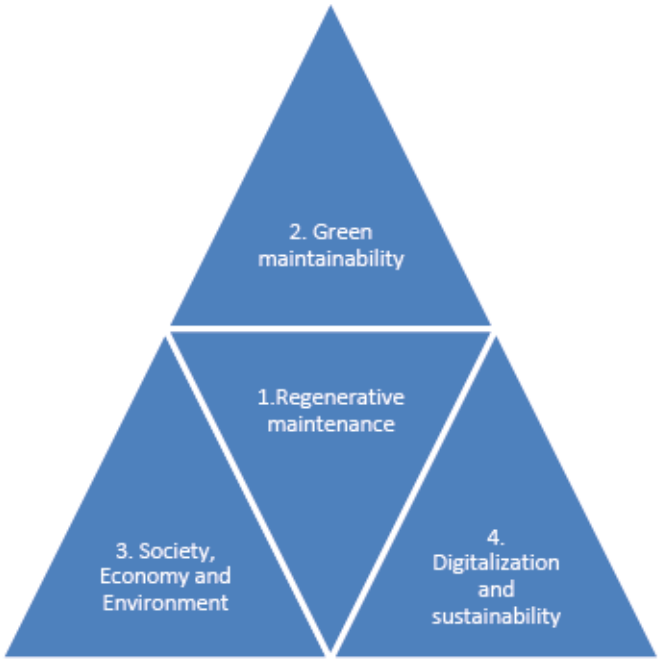

Figure 9 Regenerative maintenance from a perspective of green maintainability, Society, Economy, Environment, Digitalization and sustainability.

1. Regenerative maintenance perspective

There are two kind ways in how facility management affects construction and procurement; direct and indirect. The goal in facility management is integrating business strategies with environmental, social and economic targets. The sustainable organization is a part of a sustainable society. In addition, it is important to recognize regenerative Facility Management´s social, ecological and economic targets.

2. Green maintainability perspective

Green maintainability is an essential part of green facility management. The green maintainability of buildings helps promote green facility management ideas in support of the sustainable development agenda. It is very important for the economy and safety of a nation to look at the impact of life cycle assessment and particularly from the view of energy savings and energy efficiency together with the maintainability of facilities.

3. Society, Economy and Environment perspective

One concrete way to improve an existing building's multiple health benefits for natural and human systems is improving the building envelope. This has various positive impacts, for example, relative to its internal environment it can reduce the cooling and heating loads, improve on natural light, the air quality and natural ventilation. Relative to external environment, an envelope might support wildlife habitat connectivity and reduce surrounding urban microclimates.

As a level of surrounding natural system, regenerative development plays a big role. If society wants to reduce the damage, which has been made, society needs a "proactive" retrofit, which aims to integrate restorative, net-positive and regenerative design concepts into building retrofits. This model considers key interactions between the environment and humans, physical and natural systems in built environments.

There are few things, which are typical to regenerative buildings. First, regenerative buildings are flexible to change themselves as the time and conditions change. Second, they capture and treat all water they need and produce their own energy. Third, regenerative buildings may share the energy to neighbouring areas, when they have a net-positive impact on surrounding area.

Place is also important when thinking regenerative development. The place connects the building to the surrounding area. Good ways to approach the place as a regenerative side is thinking of the place as a story. Stories enable deeper connections to a place and to a grow harmony with place. One goal is to shift from reactive to proactive. We must

increase a human's physical and visual connection to nature. The key to that is to provide intervention strategies, which support natural- and human co-habitation. This includes, for example, the alteration or provision of shared spaces to incorporate facilitate and nature opportunities for social interaction. In addition, there are a few tools, which helps when measuring regenerative development. For example, ISO 14001, Living Building Challenge and One Planet Living gives a good signal about regenerative development, although they don't directly measure it.

4. **Digitalization and sustainability perspective**

Digitalization and sustainability are also important parts of regenerative facility management. Digitalization has three effects: in workplaces there is communication and information technologies supporting work, such as new ways for designing buildings, and sharing support for new methods of performance measurement. Facility management in will be based on digitalization in the future. Additionally, facility management needs intelligent data solutions for, for example, control, designing, monitoring and management in general. Low-cost sensors and their technology enable better real-time condition monitoring and automated solutions for buildings. Sustainability and technology innovation will define the workspaces, work patterns and workplaces we will have in future.

4 SUMMARY

Most of the buildings, which will exist in 2050, have already been built. That's why the real estate management field needs to shift toward a regenerative concept. In this work, the totality was approached first from the perspective of the whole surrounding natural system, then from the level of the property's location and finally from the level of the urban environment. In the first phase this work concentrated on surrounding natural system, then on regenerative buildings and finally on regenerative maintenance. The main focus was on campus areas, and on commercial and office premises.

The goal of corporate real estate management is to optimize corporate accommodation to organizational performance. In European universities, the main challenge is to match demand and supply, while considering the allocation of space. The problem with booking systems is that they do not reveal actual use. Overall, studies show that campus managers are increasingly using smart tools on campuses.

It may be concluded, that the main responsibility of shifting towards regenerative development falls on the property owners - but the tenants are also responsible for it. They can vote with their feet, and wallets, and favour regenerative buildings. Reducing taxation might help, when moving towards more regenerative future.

The goal of this thesis was to do an exhaustive literary survey on the evolution of sustainable development of services and the maintenance of real estate. Key issues of this thesis were to identify restorative and regenerative solutions in maintenance. The issues standardizations, technology and sustainability played a key role. The most important concepts were sustainability, restorative and regenerative development.

Literature review indicated that regenerative maintenance approach demands systematic thinking. It is not just matter of one building but also it is connection to environment and surroundings. The thesis succeeded in answering all these given questions and the result can be used within the construction industry as information towards more regenerative vision. Overall, there was not much information about regenerative

buildings and maintenance to be found. There was not so much information about regenerative maintenance either and the concept was very vague. This indicates novelty of the topic and demand for future research. One could improve the results by specifying the concept of regenerative maintenance. Additionally, the effects of digitalization to regenerative buildings and their maintenance should be studied further.

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