CHALMERS
UNIVERSITY OF TECHNOLOGY

The Potential of Biophilic Urbanism in the Living Lab Concept

Including Nature in the Built Environment – A Case Study on the Greater Curtin Master Plan

Master's Thesis in the Master's Programme Infrastructure and Environmental Engineering

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Department of Civil and Environmental Engineering
Division of Water Environment Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
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Master's Thesis BOMX02-16-47

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Cover:
Nature in the built environment, Perth Western Australia (Gustafsson & Haag, 2016). Upper left picture is at Fremantle and remaining pictures at Curtin University.
Department of Civil and Environmental Engineering
Göteborg, Sweden, 2016

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ABSTRACT

Biophilic urbanism implies that Nature is incorporated in the built environment, this as it enhances human health and well-being, and supports the local ecosystems to be resilient for future climate changes. A living lab is an innovative physical environment where business, society, academia and users come together to test and develop innovations in a real-life context.

This Master's thesis is a case study performed on Greater Curtin, an expansion area located in Perth, Western Australia. The aim of the thesis was to assess the potential of biophilic urbanism in the living lab concept. To assess the potential, a scientific basis on the two concepts, a case study and an analysis were performed. The case study included a review of Greater Curtin Master Plan and eight semi-structured interviews with stakeholders involved in the master plan. The qualitative data obtained from the interviews was thematically analysed. The analysis aimed to seek patterns and understanding of the reviewed concepts and to find natural design attributes possible to implement in the Curtin Living Lab: The Solar Studio.

The analysis revealed a collective understanding of benefits that Nature in the built environment provide to the human. However, Nature in the built environment is not a natural part of the urban development. To implement the concept of biophilic urbanism, it is suggested that benefits and practical implementations of Nature are demonstrated. A living lab has the potential to meet these needs. Related to the living lab concept, user involvement and co-creation for innovation were occasionally understood by the group.

A potential of biophilic urbanism in the living lab concept was identified through the case study. The ambitions for sustainability innovations within Greater Curtin Master Plan relate to the living lab concept and the concept of biophilic urbanism. Additionally, several natural design attributes were identified possible to implement in the built environment and consequently in a living lab. The articulated need for a testing environment of natural design attributes implies a potential for biophilic urbanism in the Curtin Living Lab: The Solar Studio.

Key words: Biophilic urbanism, Living lab, Nature, The built environment

Potentialen av att inkludera Biophilic Urbanism i ett Living Lab koncept
Att Inkludera Natur i den Bebyggda Miljön – En Fallstudie av Greater Curtin Master Plan

Examensarbete inom masterprogrammet

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SAMMANFATTNING

Biophilic urbanism innebär att Natur inkluderas i den bebyggda miljön då det förbättrar människans hälsa och välmående samt att lokala ekosystem kan hantera framtida klimatförändringar. Ett living lab definieras som en innovativ och fysisk miljö där parter från den privata, kommunala, akademiska och användande sektorn möts för att utveckla innovationer i en verklig kontext.

Denna uppsats är en fallstudie av Greater Curtin, ett expansionsområde i Perth, Västra Australien. Syftet med uppsatsen är att bedöma potentialen av att inkludera biophilic urbanism i ett living lab koncept. Potentialen bedöms med hjälp av en vetenskaplig grund baserad på de två koncepten, en fallstudie och en analys. Fallstudien baseras på en genomgång av Greater Curtin Master Plan, en översiktsplan för expansionsområdet, samt åtta delvis strukturerade intervjuer med parter anknutna till planen. En tematisk analys användes för att analysera kvalitativ data erhållen från intervjuerna. Syftet med analysen var att finna mönster och förståelse för de koncept som granskats, samt att ta fram naturliga designattribut som kan implementeras i Curtin Living Lab: The Solar Studio.

Analysen påvisade en samlad förståelse för att Natur i den bebyggda miljön bidrar till fördelar för människan, men trots detta är inte Natur ett givet inslag i utbyggnaden av den urbana miljön. För att biophilic urbanism ska bli ett vanligt förekommande inslag krävs att fördelarna och praktiska tillämpningar av Natur demonstreras. Ett living lab har potentialen att möta dessa behov. Enstaka delar av gruppen förstår vikten av att involvera användare och att ”samskapa” en innovation i ett living lab koncept.

Genom fallstudien har potentialen av att inkludera biophilic urbanism i ett livning lab koncept identifierats. I Greater Curtin Master Plan har de studerande koncepten identifieras i ambitioner för hållbara innovationer. Dessutom har det identifierats naturliga designattribut som kan implementeras i den bebyggda miljön och därmed också i ett living lab. Det uttrycks även ett behov av en plats där naturliga designattribut kan testas, vilket styrker potentialen att inkludera biophilic urbanism i Curtin Living Lab: The Solar Studio.

Nyckelord: Biophilic urbanism, Living Lab, Natur, Den bebyggda miljön

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Preface

This Master's thesis has assessed the potential of biophilic urbanism in the living lab concept through a case study at Curtin University in Perth, Western Australia. The work has been carried out between January to June 2016 as a part of our Civil Engineering degree and master's degree in Infrastructure and Environmental Engineering at Chalmers University of Technology. The work took place at the department of Civil and Environmental Engineering, Water Environment Technology, and at Curtin University Sustainability Policy institute in Perth, Western Australia.

The case study was formed by eight semi-structured interviews with PhD students and academic experts from Curtin University Sustainability Policy institute, and property developers from Curtin University. These persons have been essential for the work with the thesis. Curtin University Sustainability Policy institute has embraced us with open arms and enabled the work with the thesis. Another important actor for the work was ÅForsk who allocated a travel grant for the travel and living in Perth. Without these money a case study in Perth would have been impossible.

A special thank is addressed to our supervisor at Curtin University Sustainability Policy institute, Professor Greg Morrison, who made the thesis possible and helped us in all stages of the work. We also want to thank Associate Professor Sebastien Rauch at WET for being our supervisor at Chalmers.

Lastly we would like to thank our families, partners and friends who have supported us in our choices and studying hours of becoming Civil Engineers.

Göteborg, June 2016

Camilla Gustafsson and Annamaria Haag

Notations

Following section present the List of figures and List of tables. Each figure or table is attached with chapter number followed with numerical order, the description and the page number where the figure/table can be found.

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1 Introduction

The introduction includes Background, Aim, Objectives, Limitations and Outline of the master thesis *"The Potential of Biophilic Urbanism in the Living Lab Concept, Inculding Nature in the Built Environment – A Case Study on the Greater Curtin Master Plan"*. The thesis is a part of the master program Infrastructure and Environmental Engineering at Chalmers University of Technology in Gothenburg, Sweden 2016. The case study is performed on the Greater Curtin expansion area in corporation with Curtin University in Perth, Western Australia.

1.1 Background

Consumption of resources as energy, material, water, land and nutrients are increasing (Kalmykova, et al., 2015). Human well-being is related to the use of natural resources since increased use of these resources improve the economic development (Fisher-Kowalski, et al., 2011). Nevertheless, increased consumption of natural resources results in undesired environmental impacts. The undesired impacts are related to waste and emissions which counteracts the sustainable development goals for 2030 set by the United Nations (UN Department of Economic and Social Affairs, u.d.). The goals aim to provide a sustainable development and are described by 17 targets. The targets related to sustainable consumption of natural resources promotes improved human well-being together with sustainable economic growth.

An important factor to decrease the use of resources and the environmental impact is reduction of resource consumption in the built environment (Hagy & Balay, 2014). A living lab is a physical environment where research is brought into reality to meet needs of the market. Thereby the living lab act as a platform for implementation of sustainable technologies to enable sustainable living. A living lab can be defined as[1];

"A Living Lab is a real-life place for user co-creation of innovations in knowledge, products, services and infrastructures."

In a living lab the user is defined as the different stakeholders involved from business, society and academia, but also those using the products, services and concepts developed in the lab[2]. The users are involved in the co-creation process induced by the living lab. Co-creation is as a tool to facilitate innovation (Hagy & Balay, 2014).

Curtin University, is located six kilometres south-east of Perth CBD (Central Business District) (Curtin City Project Group, 2014 b). Perth is the capital city in the territory of Western Australia (WA). Curtin University initiated the development of the Greater Curtin Master Plan with the aim to provide spatial strategies to support the vision of the university, but also directions set for the city of Perth and the territory of Western Australia. Common achievements being to

[1] Curtin Living Labs: The Solar Studio, version 19, Appendix 3, 8.1 Business models for sustainability in Living Labs.
[2] ibid

support innovation, collaboration and creativity. The vision for Curtin University is formulated as;

"To be an international leader in research and education – changing minds, changing lives and changing the world."

The location of the Greater Curtin expansion area in relation to Perth in Western Australia is visualised in Figure 1-1.

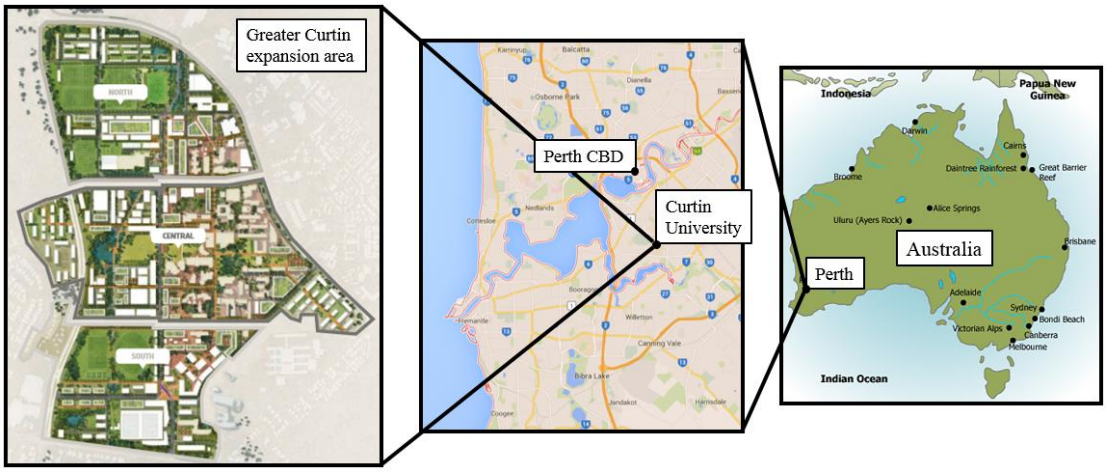

Figure 1-1. Greater Curtin expansion area located in Perth, Western Australia.

In the area covered by the Greater Curtin Master Plan, a living lab is planned; Curtin Living Lab: The Solar Studio[3]. Here continuous research on sustainable development is possible to perform in an Australian context. One of the sustainable development goals promote access to sustainable energy why implementation of solar energy in The Solar Studio is motivated (UN Department of Economic and Social Affairs, u.d.). Furthermore, Greater Curtin Master Plan has identified strategies for the development of a sustainable infrastructure network (Curtin City Project Group, 2014 b). These strategies comprise service systems connected to energy and water where objectives have been identified. The energy objectives promote energy efficiency and self-sufficiency, and integrated energy education in the Curtin area.

Biophilic urbanism implies implementation of Nature in the built environment at different spatial scales (Beatley, 2011).The concept describes why and how nature can be included in the urban environment. It is shown that humans have an emotional affiliation to Nature, which is described by the term *Biophilia* (BiophilicCities, n.d). Historically the implementation of Nature in the urban environment has not been prioritised but is today considered to be essential to gain both emotional and physical benefits for the human well-being. Additionally, potential benefits come from ecosystem services provided by Nature. Examples are urban cooling effects, reduction of energy consumption for thermal control in buildings, enhancing biodiversity, and regulation of the hydrogeological cycle (SBEnrc, 2012).

[3] Professor Greg Morrison (2016), *Curtin Living Labs: The Solar Studio, version 19* (Unpublished)

The interest for biophilic urbanism in Australia is driven by the climate changes and densification of cities (SBEnrc, 2012). The climate change is driven by greenhouse gas emissions and will result in a temperature increase of around 1.0°C in Australia 2030. The climate is expected to be extreme in the sense of weather conditions as rain, droughts, tropical cyclones and heat waves. The precipitation in Perth, Western Australia, is expected to decline and the risk for droughts will increase. With densification of cities, caused by urbanisation and increased population, higher pressure is put on energy, water supply, infrastructure, food and environment.

How Nature can be included and implemented in the built environment is clearly described by Kellert (2008). Although there is a great range of guidelines on how Nature can be implemented and examples of natural design attributes, it exists a gap in literature on biophilic urbanism in the living lab concept. The potential for biophilic urbanism in the living lab concept is therefore unknown.

The implementation of biophilic urbanism in the Curtin Living Lab: The Solar Studio is motivated as it follows the sustainable development goals for 2030 (UN Department of Economic and Social Affairs, u.d.). The implementation relates to the goals describing the need for resilient infrastructure and cities, and halting the biodiversity loss by promoting sustainable use of ecosystems. However, the actual potential for biophilic urbasnism in the Curtin Living Lab: The Solar Studio is undefined.

1.2 Aim

The aim of the master thesis is to identify the potential of biophilic urbanism in the living lab concept. The potential is assessed through a case study on the Greater Curtin Master Plan. The thesis will act as a starting point for the work with biophilic urbanism connected to the living lab concept, and for further research within the concepts.

1.3 Objectives

Three objectives are formulated to further define the aim; Scientific basis, Case study, and Analysis. The scientific basis is formed by a literature review and aims to create a foundation for the case study.

The case study is formed by a review of the Greater Curtin Master Plan and semi-structured interviews with stakeholders involved in the master plan. The aim with the interviews is to establish a discussion on ambitions for sustainable innovations within Greater Curtin Master Plan, the living lab concept, and the concept of biophilic urbanism. Additionally, it aims at discussing natural design attributes possible to implement in the built environment.

The scientific basis and the case study are combined to form the analysis. The analysis aims to assess the discourse of the concepts; ambitions for sustainability innovations within the Greater Curtin Master Plan, living lab, and biophilic urbanism. Furthermore, the analysis aims to find natural design attributes possible to implement in the built environment. Combining the discourses and

identified natural design attributes will assess the potential of biophilic urbanism in the living lab concept.

1.4 Limitations

The potential of biophilic urbanism in the living lab concept is assessed through a case study on the Greater Curtin Master Plan. Greater Curtin is an expansion area located in Perth, Western Australia. The case study implies that the assessment is based on the climate and environment of Perth, both present and in future. The climate in Perth is considered as tropical to subtropical with high temperatures during summer and intense rain events during winter.

The living lab concept is mentioned in the Greater Curtin Master Plan. However, it is not decided in what form the concept will be applied. There is an ongoing process where the concept is to be applied in a physical building, currently referred to as the Curtin Living Lab: The Solar Studio. The living lab remains in a planning stage at the time of this thesis which implies that no spatial data is available for the building. For the scope of this thesis the living lab is therefore considered a physical building with unknown location.

The study of the potential of biophilic urbanism in the living lab concept is driven by the need for including Nature in the built environment. In Australia the need is also driven by the climate changes. A living lab may have the potential to demonstrate the implementation of Nature in the built environment. For further planning with Curtin Living Lab: The Solar Studio it is important to consider solar power in combination with biophilic urbanism and the living lab concept. However, in the scope of this thesis the understanding of solar power in combination with biophilic urbanism and the living lab concept will not be assessed.

The potential of biophilic urbanism in the living lab concept is assessed through eight semi-structured interviews with stakeholders involved in the Greater Curtin Master Plan. The group of interviewees represents Curtin University as property developers, researchers and academic experts. However, the interviewed group implies limitations in representation of the general society. Furthermore the amount of interviewees cannot be considered as statistically representative.

The interviews were performed as semi-structured to retrieve in-depth responses. The questions presented in Table 2-1 were prepared before the interviews took place. But the time and direction of discussion decided which questions were asked and if a following-up question were required. The aim was to ask at least one question related to each of the focus areas. To not ask the same questions to each interviewee provide inconsistency, but has potentially provided in-depth answers with possibilities to further elaborate when required. The choice of following up-questions were based on the on-going discussion and are therefore not consequently the same which imply objectivity.

1.5 Outline of the Thesis

The master thesis *"The Potential of Biophilic Urbanism in the Living Lab Concept, Including Nature in the Built Environment – A Case Study on the Greater Curtin Master Plan"* follows the structure of a technical report. In chapter 1 the

Background to the research is presented, and the Aim and Objectives are presented with its limitations. Chapter 2 present the Methodology chosen to deliver the Aim. The Methodology is outlined with a Scientific Basis, presented in chapter 3, a case study, presented in chapter 4, and an Analysis, with its result presented in chapter 5. The results, the reliability of the results, and suggestions for future research are discussed in chapter 6. The Conclusions retrieved from the research are presented in chapter 7.

2 Methodology

The structure of the methodology is in accordance with the three objectives; Scientific basis, Case study and Analysis. The parts included in the methodology are visualised in Figure 2-1 and further explained in sections related to each objective.

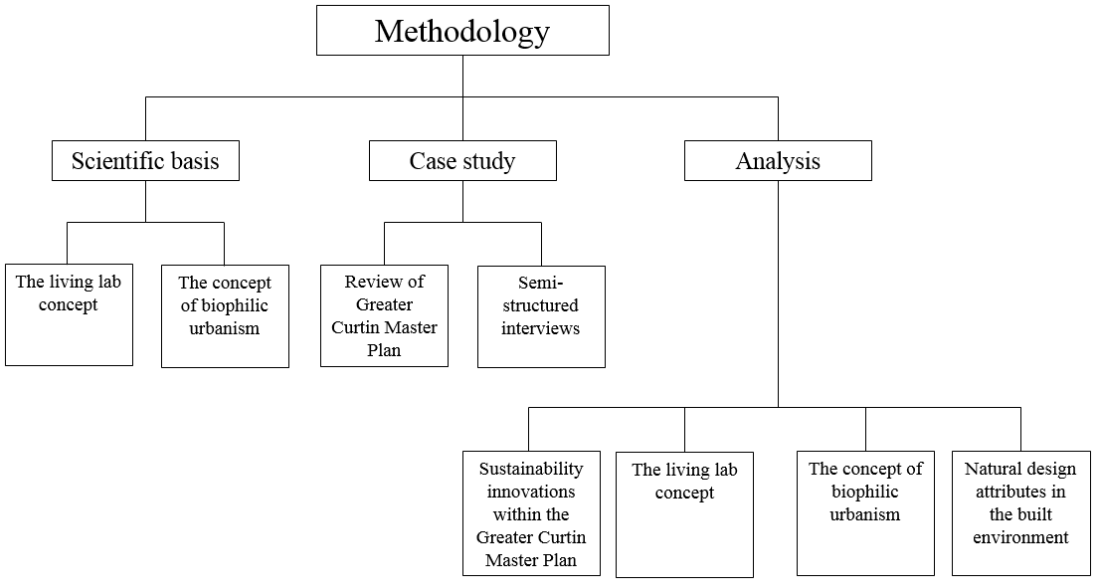

Figure 2-1. Parts involved in the methodology of the thesis

2.1 Scientific basis

A literature review was carried out on the living lab concept and the concept of biophilic urbanism. A literature review was done on the living lab concept and definitions related to the concept. The main findings are presented in chapter 3.1 The Living Lab – A Real-life Testing Environment. Furthermore a literature review was carried out on biophilic urbanism connected to urban ecology, biodiversity, resilience and ecosystem services. Also here the main findings are presented in chapter 3.2 Biophilic Urbanism – Including Nature in the Built Environment. The studied materials were books, reports, articles, master and PhD theses connected to the topics.

2.2 Case study

The case study constituted of a review of Greater Curtin Master Plan and semi-structured interviews with stakeholders involved in the master plan. The review was done to identify how the living lab concept and the concept of biophilic urbanism were considered in the master plan. The review implied a study of four documents; Creating the city of Innovation – The Vision, Drivers for Change (Part A), Master Plan (Part B), and Delivering the Vision (Part C). The main findings from these documents are presented in 4 Case Study – Review of Greater Curtin Master Plan.

2.2.1 Interview Methodology

Based on the review of Greater Curtin Master Plan and the literature review done on the two concepts, material could be prepared for semi-structured interviews. The interviews were focused on how stakeholders involved in the Greater Curtin Master Plan perceive three areas; ambitions for sustainable innovation within Greater Curtin Master Plan, the living lab concept, and the concept of biophilic urbanism. They were also focused on natural design attributes possible to implement in the built environment. The spatial scale of the natural design attributes was directed towards building, property and urban level.

The interview questions are presented in Table 2-1. On occasions, the answer given to a question triggered the moderator to ask a following up question to further encourage the interviewee to expand their reasoning. These questions are not presented in Table 2-1.

Table 2-1. Interview questions for the semi-structured interviews.

Focus areas	**Question**
Ambitions for sustainability innovations within the Greater Curtin Master Plan	What do you identify as the ambitions for sustainability innovations within the Greater Curtin Master Plan?
	Why do you think ambitions for sustainability innovations are included in the Greater Curtin Master Plan?
The living lab concept	What does a living lab imply for you?
	Which main stakeholders should be involved in order to successfully implement the living lab concept?
The concept of biophilic urbanism	Why to include Nature in the built environment? What benefits are provided?
	How can Nature be implemented in a sustainable way?
	If Nature is implemented in/on/around a built, could it provide benefits for a larger area?
Natural design attributes in the built environment	How can Nature be applied in/on/around a built? Design?
	Can you think of any innovative ways to incorporate Nature in the built environment?
	Which natural design attributes are interesting to incorporate in a living lab? Why?
	How can Nature be applied in an urban area? Design?

The interviews were semi-structured to allow open discussions on the focus areas. An open discussion meant that the data obtained from the interviews had a qualitative character. The open discussion aimed at assessing the deeper understanding of a concept rather than identifying specific words related to the concept in the answer.

In the case study 10 persons were interviewed. These persons were chosen due to their involvement in Greater Curtin Master Plan. The group of persons were all representatives of Curtin University and can be considered as academia. Three interviewees were professional staff at Curtin Properties which were interviewed together due to lack of time. Curtin Properties is the ones who has developed the master plan and is property developers for Curtin University. Five PhD students

at Curtin University Sustainability Policy Institute (CUSP) were interviewed since their research areas were connected to the master plan. Two interviews were held with academic experts (professor and doctor) based on their expertise in the area of biophilic urbanism and Nature in the built environment. The interviews held with the PhD students and the academic experts were individual to increase the possibility for in-depth answers. In total eight interviews were performed and the interviewees are intentionally kept anonymous.

In conjunction to the interviews, a small presentation on the background and aim of the thesis was held together with the focus areas of the interviews. The interviews were audio recorded and summarised accordingly. The summary of each interview was sent to the interviewee for acceptance. If no reply for acceptance was received in two weeks the summary was considered approved. The summaries formed the foundation of the analysis.

2.3 Analysis

The outcome from the in-depth interviews was series of qualitative data. Transformation of the data was required to enable a thematic analysis, a search for common themes and patterns in the answers. Themes were searched for in the answers, this to evaluate the discourse and the understanding of the three concepts; ambitions for sustainability innovations within Greater Curtin Master Plan, the living lab concept, and the concept of biophilic urbanism. Described by Massey (2011) the identification of themes has occurred with little guidance. For the analysis to be consistent and explicit, the method developed by Massey (2011) for thematic analysis of qualitative data obtained from focus group interviews was used.

2.3.1 Description of Thematic Analysis

Evaluation research is the learning about how well a practice, policy or program works (Connelly, 2015). The learning can help decision makers to understand if the practice, policy or program should continue, end, or be modified. From the evaluation research, evidence can be provided to why a decision is made or not made.

Massey (2011) has developed a model for the thematic analysis of qualitative data obtained from focus group interviews. In a focus group interview the group is led by a moderator which drives the discussion. The discussion is based on questions relevant for the purpose of the evaluation research and are prepared by the moderator.

Described by Massey (2011) the thematic analysis is one out of three approaches to analyse qualitative data obtained by focus group interviews. It is the most common analysis and implies a search for common themes and patterns in the answer. However, the analysis has been done with little guidance and with restricted connection to specific techniques. Usual practice is grouping of comments or by selecting interesting quotes. With this background, Massey (2011) developed a model to help the transformation of latent data into something understandable. Latent data is a term described in Appendix I.

The method explains how raw data from transcripts can be sorted into three levels; articulated, attributional, and emergent, demonstrated in Figure 2-2 (Massey, 2011). Articulated data represents the direct response to a question and the conversation around the topic of the question. The articulated data provides understanding of how a question is interpreted and reveals experiences, opinions and preferences. Patterns may exist in this type of data why organisation of the data is possible. Limitation with the data is its dependency to the question asked. Therefore clear and relevant questions are necessary to decrease the risk for confusion.

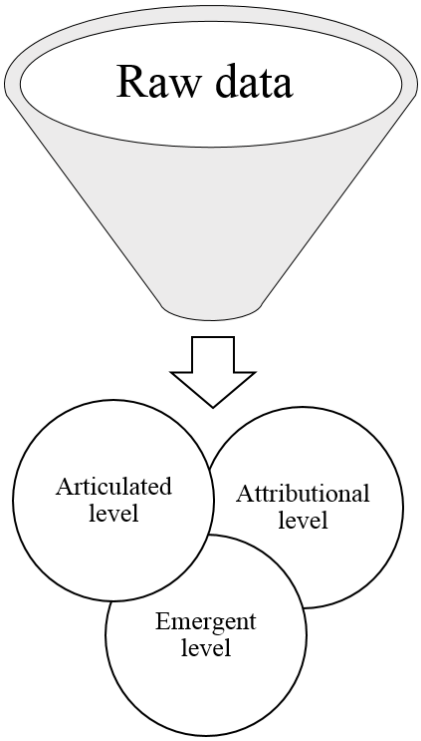

Figure 2-2. Symbolic visualisation of how raw data from transcripts is sorted in three levels

When data fits into predefined hypothesises, themes or theories developed by the researcher it is classified as attributional data (Massey, 2011). It is the search for responses or lack of responses to pre-defined themes relevant for the purpose of the research. The question need to be formulated in a way to reveal the deeper understanding of the themes. Important for the relevance, support and motivation of the data is to describe the themes. To support the data, it is also important that the evaluator explain why the data belongs to the theme. The limitation with this data is connected to the risk of forcing data to fit a theme when the data is not detailed enough to be thematised.

Massey (2011) describes the last level of data as the emergent data, the data that adds new insight and hypothesises, themes or theories. The data can also provide explanations of articulated data, not possible to fit any themes. Important to keep in mind is that not all answers have emergent data. The time in focus group interviews is often limited and it may be hard to capture the evolving discussion. This level of data has the largest risk for subjectivity, and the consistency in

judgement is decreased (Massey, 2011). Due to these limitations the data requires further verification in another evaluation research.

2.3.2 Motivation for the Analysis Methodology

Both individual in-depth and focus group interviews are qualitative research techniques (Boyce & Neale, 2006). However, the data obtained from the two methods differs in its content (Massey, 2011). Described by Massey (2011) is that the focus group interview provides data from the individual but also the individual in a group. In this way the in-depth interview lacks the social context (Massey, 2011) but it most likely gives a deeper understanding of the questions asked (Boyce & Neale, 2006). The level of detail in the data is increased and the atmosphere may be more relaxed in the in-depth interview.

Even though the data differs between the two interview methods, the aim of the research can be the same. A search for common patterns and themes in focus areas was the purpose of this study and the method developed by Massey (2011) was then considered a suitable method for the analysis. The reason for this was because the questions asked were interpreted in a certain way, which was possible to evaluate with the articulated level of data. It was of high priority to assess how the interviewees understood certain concepts with pre-defined themes, possible to assess with the attributional level of data. The emergent level of data could address new insight, not possible to predict before the research. Evaluated by the review of the concept was that the method developed by Massey (2011) does not need to be restricted to qualitative research techniques of focus group interviews.

2.3.3 Application of Analysis Methodology

The analysis methodology developed by Massey (2011) was used to analyse the qualitative data summarised from the interviews. A complete analysis, which includes all three levels of data, was applied to the focus areas; ambitions for sustainable innovations within Greater Curtin Master Plan, the living lab concept, and the concept of biophilic urbanism.

The answer to each question was considered to fit one or more of the three levels of data. Data considered a direct reply to a question was categorised as articulated data. The attributional data was categorised according to the themes established through the literature review and the review of Greater Curtin Master Plan. The themes and a description to these are presented in 5.1 Themes for Identification of Attributional Data. Related to each focus area was one general question related to the area and one or two following up questions, see Table 2-1 for the questions asked. The general question was related to all defined themes but the following up questions did not have a relevance to all themes. The themes relevant for the following up question are presented in the attributional data in chapters 5.2.2 The Reason for Including Ambitions for Sustainability Innovations, 5.3.2 Stakeholders Involved in the Living Lab Concept, 5.4.2 Sustainable Implementation of Nature, and 5.4.3 Generated Benefits beyond Building Scale. If the answer involved parts possible to fit with a relevant theme it was categorised accordingly together with a description of the reason, this to ease the upcoming analysis. If an answer did

not directly respond to the question and did not fit a theme but still evolved from the concept, it was considered as emergent data.

On occasions, the answer given to a question triggered the moderator to ask a following up question. The reason was to further encourage the interviewee to expand their reasoning or possibly develop an emergent answer. The answer to these questions was commonly treated as an emergent reply or for a few cases as a direct response to the previous question, this in the case where the question lead to expansion of the previous answer. It is however important to understand that the following up questions could lead the interviewee in a specific direction, indicated by the question. Nevertheless, if the following up question was not asked, such reply may not have been revealed.

The analysis was done for the group as whole. The articulated and emergent data were analysed in accordance to its discourse and categorised in patterns. Often the emergent categories were related to articulated categories. The attributional data was analysed both in accordance to its discourse and the level of understanding in the group. To attain an indication on the level of understanding the amount of interviewees discussing each theme was considered. If the theme was discussed by half or more of the group it was classified with a collective understanding. If less than half of the group discussed a theme it was classified with an occasional understanding. If the theme was not discussed by any in the group this was highlighted. Important to highlight is that the interview with Curtin Properties was considered as one response, not by the amount of individuals in the group interview. The indication of the understanding should not be considered as statistically representative. The results of the thematic analysis are presented in 5.2 Analysis of Ambitions for Sustainability Innovations within the Greater Curtin Master Plan, 5.3 Analysis of the Living Lab Concept, and 5.4 Analysis of the Concept of Biophilic Urbanism.

The aim with the fourth focus area; Natural design attributes in the built environment, was to reveal the interviewees' knowledge on natural design attributes at different scales of a building. Furthermore, the aim was to determine which of the design attributes that can be possible to implement in a living lab.

Due to the lack of time no detailed literature review was performed on the focus area why no themes were possible to develop and therefore no attributional data could be identified. With this in mind, the answers to these questions were all treated as emergent responses. Even though the answer may be a direct response to the question it is not important for the result to separate the two levels of data. The emergent data was categorised according to the design attributes' application in scales; in a building, on a building, or surrounding a building. If the answer was elaborating on something else than the design it was categorised as an evolving discussion. The results from the analysis are presented in 5.5 Analysis of Natural Design Attributes in the Built Environment.

3 Scientific Basis – Living Lab and Biophilic Urbanism

The scientific basis comply the living lab concept and the concept of biophilic urbanism. The living lab concept is described with a variety of living lab definitions. The concept of biophilic urbanism is described with urban ecology, biodiversity, resilience and ecosystem services. The scientific basis aims at together with the case study form a foundation for the thematic analysis.

3.1 The Living Lab – A Real-life Testing Environment

In this chapter the living lab definition will be elaborated on in order to reveal the meaning of the definition and hence the implementation of the living lab concept. The implementation of the living lab concept will be described by further explanation of the compounds involved in a recent definition of the living lab.

3.1.1 The Living Lab Definition

The living lab concept emerged about 25 years ago at Massachusetts Institute of Technology (Hagy & Balay, 2014), and has been studied more frequently in Europe during the last 10 years (Bergvall-Kåreborn, et al., 2015). The living lab is referred to a laboratory in a real-life and full-scale context (Hagy & Balay, 2014). Here new innovations are tested and developed in a real-life setting which makes it possible to faster launch the innovations on the market (Westerlund & Leminen, 2011).

A variety of living lab definitions exist in literature (Dell'Era & Landoni, 2014). This creates a lack of consistency around the living lab concept. Described by Bergvall-Kåreborn et al. (2015) the variety of definitions originates from different living lab projects. The general definition is subjectively formed from a certain living lab. Each living lab takes into account different aspects, for example stakeholder involvement or direction of the research. Similarities in aspects exist between projects but are often different in importance or interpretation together with different combinations of aspects. Even though there is a variety in definitions, common components occur (Dell'Era & Landoni, 2014). In 13 living lab definitions, two common components occurred; a real-life experimentation environment, and users' involvement in the innovation process. As summarised by Hagy and Baly (2014) the living lab is a tool to create innovative products, services and concepts by co-creative research.

For an infrastructure to be considered a living lab it should facilitate co-creation to manage innovation where all stakeholders are engaged in the process (Hagy & Balay, 2014). This means that a place that hosts innovation, experimentation and co-creation may be defined as a living lab.

Another definition is proposed by Bergvall-Kåreborn et al. (2015);

(1) *"A Living Lab is a user-centric innovation milieu built on every-day practice and research, with an approach that facilitates user influence in open and distributed innovation processes engaging all relevant partners in real-life contexts, aiming to create sustainable values."*

This definition states that a living lab is an innovative environment which support an innovative research approach (Bergvall-Kåreborn, et al., 2015). The approach is based on the principles openness, realism and influence which is also described in the definition.

In contrast to Bergvall-Kåreborn et al. (2015) who define the living lab as a physical structure, Dell'Era and Landoni (2014) describe the living lab as a methodology. It is argued that the existing definitions have failed to highlight the methodology for development of new products, services and concepts in the living lab why the following definition is proposed;

> *(2) "A Living lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting."*

The ones involved in the co-creative innovation process is not described by the definition. However, it is described that it is a public-private partnership where public and private actors collaborate for innovation.

In an article by Salter and White (2013) common attributes are presented for living labs. These attributes are user awareness, the real-life context, co-creation for innovation and research. Comparing the two definitions by Bergvall-Kåreborn et al. (2015) and Dell'Era and Landoni (2014) reveal the same common attributes.

Apart from the different ways to define the living lab shape and form, either as a physical building or a methodology, another difference is identified in definition (1) and (2). In definition (1) the living lab is defined as user-centric which means that the users are the source for innovation (Dell'Era & Landoni, 2014). In definition (2) the users are assigned with a more active role in the innovation process, as participatory stakeholders.

By recognising both common and different attributes of definition (1) and (2), direct the focus to recent a definition where the users play a natural role in the co-creation process [4];

> *(3) "A Living Lab is a real-life place for user co-creation of innovations in knowledge, products, services and infrastructures."*

This definition offers a common ground where stakeholders involved in a living lab from business, society, academia and consumers of the living lab are all referred to as users. By doing so a progress in the definition of a living lab is documented where all users are seen as equally important actors to provide innovation, here by user co-creation.

3.1.2 The Living Lab Concept

In the living lab definition (3), four principles are identified to further describe the concept. The principles are; real-life place (Bergvall-Kåreborn, et al., 2015),

[4] Unpublished Springer book on Living Labs, 8.1 Business models for sustainability in Living Labs, nd, M. Burbridge, G. Morrison et al.

users[5]; defined as business, society, academia and consumers of the living lab, co-creation and innovation (Hagy & Balay, 2014).
A place is an environment where human activity and social interaction form the place which is identified by its physical environment and by the events that people experience there (Bergvall-Kåreborn, et al., 2015);

"It is through our actions, behaviour and the meaning attributed to a situation that a space transforms to a place"

A real-life place is related to realism which in the context of a living lab refers to the attempt of performing an innovation process in the setting in which it will be implemented (Bergvall-Kåreborn, et al., 2015). This may be achieved by evaluating user tests in real-life contexts, with co-creative activities in the real-world, or by observations of the real world. Implementation and testing innovations in different places have importance to the understanding of the impact and suitability of the innovation in its real environment.

When the innovative approach, described together with the living lab definition (1), is applied in the living lab space it transform into different living lab places (Bergvall-Kåreborn, et al., 2015), as illustrated in Figure 3-1. The innovative approach is based on openness, realism and influence and decides the stakeholders involved, the methods chosen and the facilitation of the activities performed by researchers and project managers.

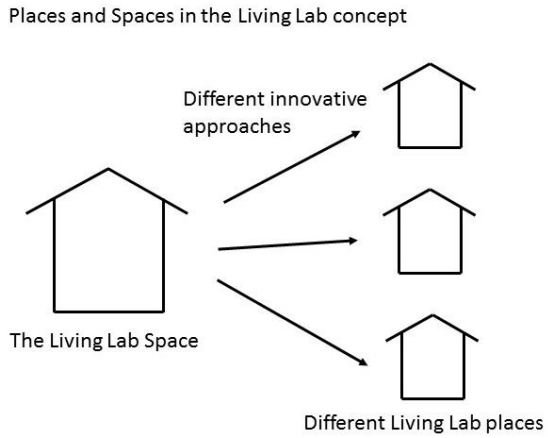

Figure 3-1. Places and Spaces in the Living Lab concept. The Living Lab Space transforms into a Place when different innovative approaches is applied.

The second principle used to describe the living lab concept is the users[6]. In the scope of this thesis the users will be defined as stakeholders including business, society, academia and consumers of the living lab. The consumers refers to the ones using the products, services and concepts provided by the living lab. A living lab can take many shapes and forms, for example a house, a student home, a city, a part of a city; urban spaces or green spaces, rural area or even regions (Dell'Era & Landoni, 2014). Derived from this consumers can be residents of the house, citizens of the city or test persons in general. It is important to involve all the

[5] Unpublished Springer book on Living Labs, 8.1 Business models for sustainability in Living Labs, nd, M. Burbridge, G. Morrison et al.
[6] ibid

stakeholders as they bring their knowledge and experience to the project (Franzén, 2015). The knowledge and experiences provided by the stakeholders facilitates a knowledge transfer; a shift from one technical system to another, which support innovation.

With different stakeholders involved in a living lab project it is important to maintain their motivation in order to achieve a successful collaboration (Franzén, 2015). From the business-stakeholder point of view a consumer-centred approach is said to imply commercial benefits since the risk of failure when launching an innovation is reduced. Highlighting consumers' needs through the living lab provide an opportunity for added value to the innovation (Westerlund & Leminen, 2011). The society and the consumers' involvement in the living lab allow each person to influence the innovation (Franzén, 2015). The outcome of the involvement include learning experiences and accumulated knowledge. However, it might be challenging to maintain their motivation over time and to make them express relevant experience for the purpose of the research. The involvement of academia is apparent as there exist a need to be co-creative in order to foster innovation by transforming the society, e.g. towards a sustainable development.

The innovative approach, proposed by Bergvall-Kåreborn et al. (2015), highlights the importance of influence and participation to support innovation processes. In the living lab context influence mean the consumers' right to impact the innovations developed in the lab which affect them or their every-day life. Depending on the methods chosen or the form that the living lab place take the consumer influence is either enabled or hindered. If a place for influence is proposed in the chosen method to support the consumer influence, the method will support co-creation and hence facilitate innovation. Co-creation is the third principle used to describe the living lab in definition (3) and refers to a living lab as an interactive space for research where all stakeholders is of great importance (Hagy & Balay, 2014).

It has been demonstrated in studies that it is positive with consumer-centred design (Dell'Era & Landoni, 2014). How users are involved in the living lab has shifted from a consumer-centred approach to a participatory approach (Chayabunjonglerd & Torkabadi, 2015). In the latter approach consumers are considered as partners rather than the subject for the design and innovation process (Dell'Era & Landoni, 2014). Consumers are considered equal to other stakeholders and are invited to co-create with designers, researchers and developers, as described in living lab definition (3).

Innovation is the fourth principle described in living lab definition (3). Open innovation is a term used for an innovative environment built on sharing of knowledge and resources between stakeholders (Hagy & Balay, 2014). Therefore open innovation requires co-creation between stakeholders.

Argued by Westerlund and Leminen (2011), there is a nexus between consumer co-creation and open innovation. This connect principle three and four from the living lab definition (3). How consumers are involved in the innovation process result in a degree of openness demonstrated in Figure 3-2. Here the producer-driven phase implies an innovation process driven by the producer. Consumers

lack the possibility to be involved in co-creation and are only considered as buyers. On the other edge is the user-driven phase where the development of innovation is driven by the consumers. The collaboration between producer and consumers is developed and has a long-term perspective.

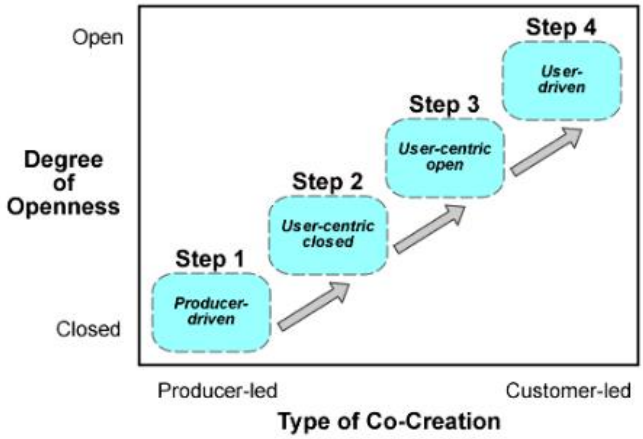

Figure 3-2. The nexus between stakeholder co-creation and degree of openness (Westerlund & Leminen, 2011).

3.1.3 The Living Lab as a Tool for Sustainability

A living lab can take many shapes and forms, this implies that the focus for each living lab may also be different (Salter & White, 2013). The living lab definition (1) by Bergvall-Kåreborn et al. (2015) explains that the goal with their living lab is to create sustainable values. This is however not said to be the goal for all living labs (Vanaker, et al., 2014) but the concept is a useful tool to reach sustainable living (Salter & White, 2013).

The goal for Curtin Living Lab: The Solar Studio is focused on sustainable living and has emerged from the sustainable development goals from 2030 (UN Department of Economic and Social Affairs, u.d.). In Curtin Living Lab: The Solar Studio sustainable living will be combined with the implementation of biophilic urbanism and sustainable energy sources, in this case solar energy[7].

3.2 Biophilic Urbanism – Including Nature in the Built Environment

In this chapter the concept of biophilic urbanism will be presented. The concept is eleborated through urban ecology, biodiversity, resilience and ecosystem services.

3.2.1 Urban Ecology

The Earth consists of components grouped in two categories; biotic and abiotic components (Grunewald & Bastian, 2015). The components are referred to as the natural capital and includes biodiversity, ecosystems and natural resources. The categorisation of biotic and abiotic components is based on living and non-living elements of the Earth. Biotic elements are all living organisms in the biosphere,

[7] Unpublished Springer book on Living Labs, 8.1 Business models for sustainability in Living Labs, nd, M. Burbridge, G. Morrison et al.

and the abiotic components are the non-living physical and chemical elements in the lithosphere, atmosphere and hydrosphere. Holmgren (1995) defines the spheres by separating the components using energy from the Sun to maintain structures and flows and the components not doing it. The biosphere is a part of the ecosphere, the sphere using the Sun for energy. Included in the ecosphere is also the atmosphere and hydrosphere. The sphere not using Sun for energy is the lithosphere, containing the core, the mantle and the crust of the Earth. Here the energy is extracted from radioactive decays by heavy elements in the inner core of the Earth.

Ecology is a way to describe how the Earth and its components work (British Ecological Society, 2015). The structure and functions of ecosystems are studied together with diversity and resilience. Ecosystems consist of biotic and abiotic components in an interrelationship with each other (Grunewald & Bastian, 2015). An ecosystem has infinite numbers of feedback and adaptation processes dependent on the environment the system is situated in (Mitsch, 2012).

Ecosystems are complex systems, always in continuous and changing conditions formed by the feedbacks and adaptation processes. An ecosystem is according to Bolund & Hunhammar (1999) defined as;

"A set of interacting species and their local, non-biological environment functioning together to sustain life"

The ecology in an urban area is studied in different ways (Alberti, 2008). The conventional approach where humans are separated from the ecosystem and act as an external factor, shaping the boundary conditions of the ecosystem. Another approach assesses the urban ecosystem with an interplay between biological, physical, chemical, social and economic systems. An ecosystem is considered as a socio-ecological system of humans and nature in an interaction (Walker & Salt, 2006). The interaction creates feedbacks and changes in the ecosystem (Alberti, 2008). Humans are therefore evaluated as a part of the ecosystem but also as an actor creating feedbacks in the system, as presented in Figure 3-3. The socio-ecological system is constantly changing because of changing boundary conditions, partly caused by human interaction.

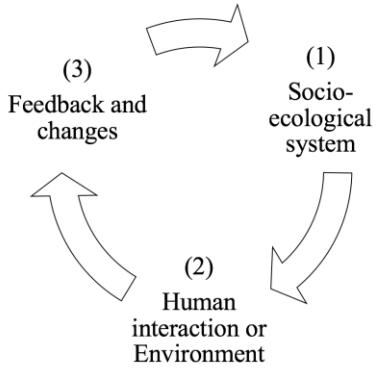

Figure 3-3. Symbolic representation of a changing ecosystem.

A city is composed by multiple ecosystems but it can also be defined as an ecosystem itself (Bolund & Hunhammar, 1999). The urban ecosystem is defined by a high concentration of people with individuals, business and government with

diverse preferences and demands on the city (Andersson, et al., 2016). The large population in cities and their interaction with the ecological system causes increased heterogeneity and transformation in energy and nutrient cycles (Alberti, 2008). The heterogeneity in cities is caused by human activity in the area which can be compared to a rural or natural area with a higher diversity and less human activity. Urban ecology is the study and understanding of the ecology in an urban environment.

Even though urban areas are influenced by human activity (Alberti, 2008), there are green fragments left from the surrounding landscape that may contain biodiversity rich habitats (Andersson, et al., 2016). These rich urban habitats can also contain rare species and their diversity provide benefits to the urban ecosystem. Research has shown that different types of green areas, such as gardens, cemeteries and golf courses contribute to the benefits to the urban ecosystem. To conserve the urban habitats a landscape approach is required when planning the spatial structures of a city. Even if a landscape approach is applied, some of the green areas are too small to be considered and might therefore be left out. This will result in a loss in diversity (Turrini & Knop, 2016).

3.2.2 Biodiversity

The Convention in Biological Diversity (COD) defines biodiversity as genetic diversity within species, diversity between species and diversity of ecosystems (Grunewald & Bastian, 2015). COD is a global legally-binding agreement with an overall aim of encouraging actions for a sustainable future with a focus on biodiversity (United Nations Decade on Biodiversity, u.d. a). Three main goals exist for the agreement;

"…conservation of biodiversity; sustainable use of biodiversity; and the fair and equitable sharing of the benefits arising from the use of genetic resources"

One of the benefits derived from biodiversity is connected to functional diversity. Alberti (2008) concluded from several ecological studies that species perform a variety of ecological functions. If one specie' is lost, ecological functions in the system are also lost. A rich biodiversity therefore mean a variety of ecological functions beneficial for the human well-being and health.

To create sustainable management practice for conservation and generation of biodiversity the focus need to be wide in ecological and social patterns (Hostetler, et al., 2011). The conventional approach of conservation has been directed towards dealing with the symptoms of biodiversity loss rather than the cause of the problem. Discussed by Hostetler et al. (2011) building with green infrastructure in cities is only the first step in conserving biodiversity. The need for a wider perspective is essential. A conserved area, with a rich biodiversity, is not maintained by itself and can be affected by surrounding neighbourhood and its activities.

3.2.3 Resilience

Resilience implies the ability for a system to respond to a sudden impact or disturbance, such as flooding, heat waves, landslides and storms (McPhearson, et

al., 2015). Resilience involves persistence and recovery and the capacity of the system to transform or adapt. Lack of resistance to disturbances in the system, which may be of social, ecological or economical nature, lead to a non-sustainable system.

Based on the ecological definition of resilience, it is the capacity for an ecosystem to maintain its function and structure during exposure for disturbances (Walker & Salt, 2006). The definition is directed towards identifying and understanding the thresholds an ecosystem have to disturbances. When a threshold is crossed, the ecosystem goes through a regime shift and changes both in function and structure. To return to the previous state is hard and expensive. The thresholds are connected to variables affecting the ecosystem and are the boundaries between different states for the ecosystem.

To clarify the terms mentioned above an example is given about an ecosystem going through a regime shift (Walker & Salt, 2006). The ecosystem is a clear lake transformed to a lake exposed to eutrophication due to algae bloom. The variable affecting the system is a constant inflow of nutrients. The lake has a buffer capacity to absorb nutrients in the sediments and therefore make some of the nutrients unavailable for feeding. The capacity for the lake to cope with nutrients without losing the function and structure of the system is described as resilience. After a certain level of nutrient inflow the lake cannot cope with the disturbances and the threshold is reached. This is why the structure and function of the system change to a state with eutrophication and the system goes through a regime shift.

Resilience in an ecosystem is shaped and created by adaptability of biotic and abiotic elements (Walker & Salt, 2006). Adaptability can also be shaped by human interaction in the system. The adaptability can be achieved in three separate ways connected to the threshold of variables. The first approach is to move the threshold for the variable and the second is to move the state of the system away from the threshold. An example of the latter approach is to add zooplankton to the example of the lake. This can generate a change in the system because zooplankton feed on algae. The third approach is to make the threshold more difficult to reach. An example connected to the lake is to install riparian vegetation. By this, less nutrients will reach the lake. However, ecosystems are complex system, always adapting and creating feedbacks (Alberti, 2008). Evolved from this, changes can be harder or easier to predetermine but are always to a surprise (Walker & Salt, 2006).

The resilience towards unforeseen disturbances is linked to biodiversity (Walker & Salt, 2006). The biodiversity creates a variability for the ecosystem to respond when it is exposed for unknown disturbances. Described by Alberti (2008) different species have different functions and a diverse ecosystem can therefore generate alternatives in response to disturbances.

3.2.4 Ecosystem Services and Biophilc Urbanism

Derived from the meaning of urban ecology and, the importance of biodiversity and resilience, it is established that humans need daily interactions with Nature (Beatley, 2011). The need of daily interaction with Nature is a result from the

evolutionary process where humans have evolved connected to Nature (Kellert, 2008). Humans need for Nature in combination with an increased densification of cities creates a necessity for Nature in built environment (Sustainable Built Environment National Research Centre , 2012).

Daily contact with Nature is proved to reduce stress, improve cognitive skills, and improve academic performance and even lowering the effects of ADHD and Autism (Beatley, 2011). This means that Nature will induce humans to be healthy and productive individuals with the effect of enhanced positive mental health. There are research that shows that the incorporation of green infrastructure in urban areas serve as "pull-factors for physical activity".

Humans are dependent on the benefits derived from Nature to improve air quality, by reducing pollutants (Beatley, 2011). Furthermore, natural features regulates storm water and urban runoff, provide shade and natural air conditioning and can be used to produce water and food. The importance of these benefits is large in cities and urban areas where most of the human population exist (Andersson, et al., 2016). Global urbanisation means a large demand of the benefits that Nature provide which is the driver behind the global climate changes of today.

Including Nature in the built environment is argued to be prioritised to enhance human health and well-being and to ensure liveable and sustainable cities (McPhearson, et al., 2015). This is performed by applying either of the concepts; ecosystem services (McPhearson, et al., 2015) or biophilic urbanism (Beatley, 2011), which will be elaborated in this chapter. Ecosystem services refer to the benefits human population derive from ecosystems (Bolund & Hunhammar, 1999). The concept implies that humans are dependent on the services that Nature provides for their survival. Biophilic urbanism means including Nature in the built environment as it enhances human health and well-being (Beatley, 2011). A biophilic city is sustainable and resilient and is able to face climate changes and natural disasters (Beatley & Newman, 2013) due to its abundance with Nature and ability to repair and restore itself and its biodiversity (Beatley, 2011).

3.2.4.1 Anthropocentrism and Biocentrism

Biophilic urbanism and ecosystem services describe a motivator to include Nature in the built environment, to enhance human well-being ((Sustainable Built Environment National Research Centre , 2012): (Grunewald & Bastian, 2015)). As described, the biophilic urbanism approach is based on including Nature for the benefits generated by Nature (Sustainable Built Environment National Research Centre , 2012). The same argument underpins the reason for including Nature in the concept of ecosystem services (Grunewald & Bastian, 2015). In these concepts Nature preserve a value for the human in its function and use but not by itself. In other words nature provide instrumental values for humans.

There are defined environmental ethical views related to what has a value in itself, an intrinsic value (Hedenus, et al., 2015). In the ethical view of anthropocentrism humans have an intrinsic value and everything else serves as instrumental values for humans. Biocentrism is an ethical standpoint where living organisms (biotic components) have an intrinsic value. These definitions imply that biophilic

urbanism and ecosystem services are both founded on the ethical view of anthropocentrism. Kellert (2005) describes the argument on why Nature should be conserved based on the anthropocentric ethical standpoint;

"...it represents an argument for conserving Nature based on a long-term self-interest."

3.2.4.2 Ecosystem Services

Ecosystem services is an anthropocentric concept based on the human rights of having access to food, clothing and housing stated, which is stated in Article 25 in The universal declaration of human rights (United Nations, u.d.). The human rights are also supported by the Sustainable development goals set for 2030 which declare to end hunger, assure availability to water and sanitation and access to sustainable energy (UN Department of Economic and Social Affairs, u.d.). According to Bolund & Hunhammar (1999) the concept of ecosystem services refers to;

"*The benefits human populations derive directly or indirectly from ecosystem functions".*

Even though humanity is increasingly urban it is still dependent on the benefits of Nature for its survival (Bolund & Hunhammar, 1999). Urbanisation means higher population density and increased dependence of infrastructure (McPhearson, et al., 2015). This lead to a lower ability to adapt to disturbances and disasters. Resilience of a city can be achieved by adapting the concept of ecosystem services as a way to use the benefits that Nature provide to cope with unexpected events.

The benefits from Nature are found both within a city and beyond its limits, and are referred to as ecosystem services (Bolund & Hunhammar, 1999). A city claim ecosystem support of a larger area than the area of the city itself, which imply the importance of the spatial cover for ecosystem services. The services generated within the city are referred to as locally generated ecosystem services or direct ecosystem services. The services generated beyond the limits of the city, not directly consumed by the residents are referred to as indirect ecosystem services. Research show that locally generated ecosystem services has an impact on the quality of life in an urban area. Examples of these are; air filtration, noise reduction, rainwater drainage, and sewage treatment. Nevertheless, the indirect services are needed to sustain the ecosystems of the city with pollination of flowers and cycling of nutrients.

Urban ecosystems are described as diverse due to the high concentration of people with diverse preferences and demands on the city and the ecosystem services generated by the city (Andersson, et al., 2016). This diversity cause tension on the urban ecosystem, this as ecosystem services are generated by;

"... complex interactions between ecological processes and human activities and organisation"

This indicate complex interactions between ecosystems which generate the ecosystem services (Andersson, et al., 2016). This illustrates the importance of biodiversity in an ecosystem and among multiple ecosystems.

Urbanisation sets a high demand on the ecosystems of the planet to provide ecosystem services, which affects the resilience of the entire planet (Andersson, et al., 2016). An urban ecosystem services approach to planning would reduce the tension between conservation of biodiversity and urban expansion. This approach would provide a shifting of the urbanisation patterns towards a sustainable city development. This means that the locally produced services are increased, which lower the demand on external services and in turn decrease the global footprint of the city (McPhearson, et al., 2015). To cope with the future disturbances a resilient approach is required when planning a city. A resilient approach can be fostered by incorporating the concept of ecosystem services. But the city also need to assure a resilient supply of ecosystem services to ensure well-being of the residents.

3.2.4.3 Ecosystem Services and Connectivity

In an urban area vegetated green infrastructure produce locally generated ecosystem services such as air filtering, micro climate regulation, and storm water management (Bolund & Hunhammar, 1999). Green infrastructure provide well-being for humans though cultural services such as recreation and health but also provisioning services like food production (Andersson, et al., 2016). Urban areas with a high amount of vegetated area enhance higher diversity and abundance of species (Turrini & Knop, 2016).

Green infrastructure in urban areas is usually composed by distributed, small green patches as a result of urbanization (Turrini & Knop, 2016). The distribution of green patches due to urbanization is referred to as fragmentation (Konga, et al., 2010). Fragmentation is identified as one of the major reasons for habitat destruction and loss of biodiversity worldwide (Turrini & Knop, 2016) as the small size of the patches makes the generation of sustainable ecosystem services difficult (Andersson, et al., 2016). It is determined by Turrini & Knop (2016) that species diversity are dependent on patch size and connectivity. Connectivity implies that ecosystem services are dependent on the habitats to be connected (Andersson, et al., 2016). A wide perspective is therefore required to plan a city that sustain ecosystem services through connectivity.

Connectivity is defined as spatially continuous (Konga, et al., 2010), considering the movements of biotic organisms and abiotic compounds (Crooks & Sanjayan, 2006), and their interaction with each other and the environment (Luque, et al., 2012). Creating connectivity implies requirements on scale, both in time and space, and on species, processes and functions (Crooks & Sanjayan, 2006). A corridor can be used to create connectivity. But the corridor creates connectivity only if the species, to which it is designed for, use the corridor to be connected. To create connectivity the corridor must provide a suitable path for dispersal, resource availability and possibilities of shelter for the habitats (Cook, 2002). Designing a corridor also requires consideration of width, length and continuity (Parker, et al., 2008).

An issue that may arise while planning the urban development in adjunction to the green infrastructure is the isolation of the green patches due to the attractiveness they imply (Andersson, et al., 2016). Living close to green areas enhances human health and well-being (Beatley, 2011). This attraction generates increased urban development around the green patches which may lead to isolation of the area (Andersson, et al., 2016). Thereby some of the biodiversity and related ecosystem services are lost which were the reason why the area were attractive in the first place.

In order to enhance an urban ecosystem with good connectivity, and hence rich biodiversity Andersson, et al (2016) suggests that ecological and social interactions should be acknowledged in the planning and governance of a city. They have identified some existing governance strategies such as different property rights and diffuse borders between social and ecological governing which make planning difficult. A participatory management approach is suggested to deal with this diversity. This approach suggests that all stakeholders involved in a process should have influence and participation in order to support the innovative process (Bergvall-Kåreborn, et al., 2015). One type of participatory management approach suggested by Andersson, et al (2016) is to use the city as a living lab where new management strategies and structures can be tested and evaluated.

3.2.4.4 Biophilic Urbanism

The need for humanity to connect with Nature is due to the social and economic benefits that Nature provides in terms of health and well-being (Beatley, 2011). That Nature provide benefits for humans is associated with the anthropocentric concept of ecosystem services (Bolund & Hunhammar, 1999) but also with the concept of biophilic urbanism (Beatley, 2011).

To achieve sustainable and resilient design biophilic urbanism suggests that Nature is incorporated at either building, city or regional scale (Beatley & Newman, 2013). Therefore biophilic urbanism aims at achieving sustainable and resilient cities, this by considering the term *Biophilia* during the development of a city. Wilson (1984) defines biofilia as;

"The innately emotional affiliation of human beings to other living organisms. Innate means hereditary and hence part of ultimate human Nature"

Wilson (1984) claims that humans have evolved with Nature as a part of the global ecosystem and that we therefore are dependent on a connection with Nature to be healthy (Beatley & Newman, 2013). Incorporation of Nature in the built environment aims to provide benefits for humans (Kellert, 2008), and hence Nature provide an instrumental value for humans (Hedenus, et al., 2015).

The modern urban design paradigm is shaped by extensive transformation of the landscape and degradation of Nature (Kellert, 2008). Described by Mador (2008) the 20th century engineering practices have been focused on shrinking Nature and its value. Beatley (2008) highlight the advertisement done in Washington Post about a new development area in the city with the quote;

"The nice thing about the city is that it eventually ends"

Engineering practice focus little on involvement of Nature which has generated a barrier between the city and the Nature (Kellert, 2008). From this realisation a paradigm has evolved, the restorative environmental design paradigm. Here two strategies are developed, the low-environmental-impact strategy and the positive environmental impact strategy. The low-environmental-impact strategy is directed towards minimising and mitigating the adverse impacts humans have on the natural environment. The positive environmental impact strategy focuses on lowering the impacts caused by humans but also to create positive environmental impact. This strategy follows the concept of biophilic urbanism, to create and assimilate benefits by introducing nature into the built environment.

The natural elements that can be included in the building environment are wind, sun, water, green, sounds, smells, weather, animals and landscape (Kellert, 2008). The implementation possibilities are applied at different scales; building, neighbourhood and city (Sustainable Built Environment National Research Centre , 2012). However, Beately and Newman (2013) elaborate on six scales; building, block, street, neighbourhood, community and region.

Two basic dimensions exist in connection to biophilic design (Kellert, 2008). In one Nature is reflected in the built environment as shapes and forms. The other dimension is when the built environment is shaped after the natural landscape. In this way a building or infrastructure is connected to the culture and ecology of the geographical area. From the two dimensions, six biophilic design elements exist; environmental features (natural characteristics in the built environment), natural shapes and forms, natural patterns and processes, light and space, place-based relationship (connection to the culture and ecology of the landscape), and evolved human-nature relationship. The elements provide a basis for the development of innovative attributes of biophilic design. The connections between biophilic dimensions, elements and attributes are demonstrated in Figure 3-4.

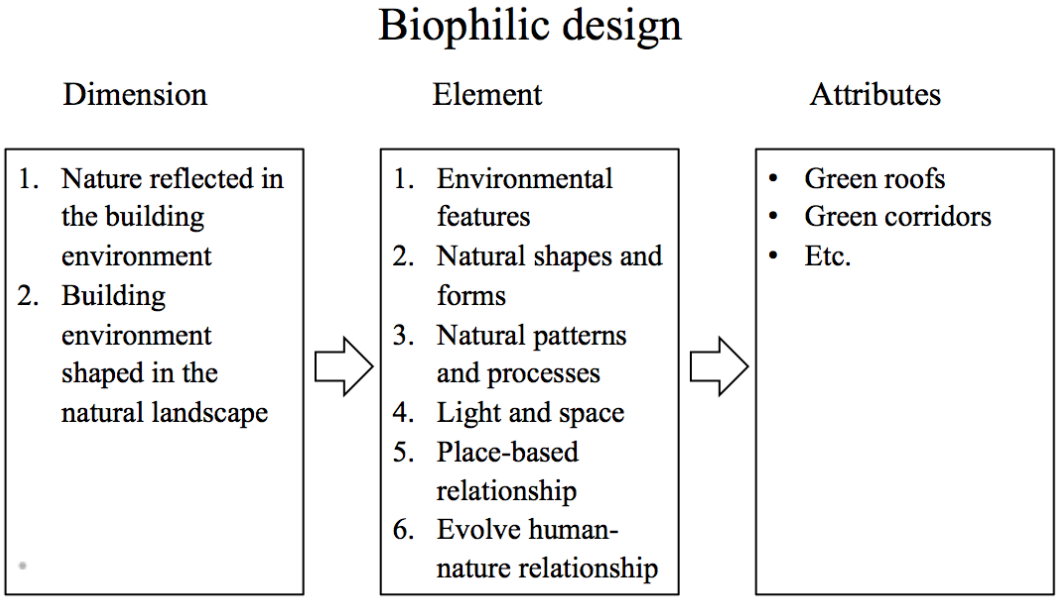

Figure 3-4. Biophilic design dimensions, elements and attributes.

Implementation of Nature in the built environment generates benefits for industry, government and community (Sustainable Built Environment National Research Centre , 2012). To support the choice of building with Nature, economic and social benefits need to be combined. The financial benefits are favourable in terms of real estate values but also due to the ecosystem services provided. Even if it is hard to measure the economic value of ecosystem services evidence are available. In Portland, USA, installations of green infrastructure reduced the infrastructural costs. The Millennium Park in Chicago has raised the real estate value and the tourism revenue. To compare the tourism revenue and raised real estate value with the investment, the tourism revenue is around 5.3 times higher than the investment and the real estate value around 2.9 times higher.

Claimed by Salingaros & Masden (2008) and Beatley (2008) the abstraction of Nature in the built environment is popular. However, to build with biophilic urbanism requires complex ecosystem thinking (Salingaros & Masden II, 2008). By studying the ecosystem as a community the benefits provided by Nature are revealed (Benyus, 2008). As described in chapter 3.2.1 Urban Ecology, an ecosystem is a complex system always adapting to the surrounding environment (Mitsch, 2012). Buildings which are claimed to follow biophilic design might instead give a poor abstraction of Nature (Salingaros & Masden II, 2008). According to Beatley (2008) the view of including Nature in the built environment need to be changed to consider Nature as a complex ecosystem (Salingaros & Masden II, 2008).

Beatley & Newman (2013) suggests pathways from biophilic urban design to urban resilience which are either direct or indirect. The direct biophilic pathways directly provide resilience by for example building a wetland that reduces flooding in case of large rain events. These direct pathways relate to the direct benefits received from ecosystem services (Bolund & Hunhammar, 1999). Although, the indirect Biophilic pathways represent another point of view compared with the indirect ecosystem services. Where the indirect ecosystem services refers to services not generated locally the indirect Biophilic pathways explores the view of the second hand benefit of humans (Beatley & Newman, 2013). For example by constructing green infrastructure physical activity is enhanced (Beatley, 2011) which in turn serve to foster healthy and resilient individuals and their ability to deal with future stress.

4 Case Study – Review of Greater Curtin Master Plan

The review of the Greater Curtin Master Plan includes a description on the background and vision of the plan. Related to the focus areas in the literature review, and to provide a foundation for the analysis, the involvement of Nature in the built environment within Greater Curtin Master Plan are described. Furthermore, other ambitions for sustainability innovations are identified and described. These ambitions are living laboratory, sustainable energy and sustainable transportation.

4.1 Background to the Greater Curtin Master plan

Greater Curtin is a precinct located South-East of Perth in Western Australia (Curtin City Project Group, 2014 b). The area is approximately 114 hectare and contains the Curtin University campus area. The precinct is facing an expansion described by the Greater Curtin Master Plan. The general goal with the master plan is to act as a guiding principle for the development within the next 20 years (Curtin City Project Group, 2014 a). The development of the area is aligned with the Western Australian Planning Commission's Direction for 2031 and the State Planning Policy 4.2 (Curtin City Project Group, 2014 b).

The Greater Curtin Master Plan contains four documents developed by the Curtin City Project Group (Curtin City Project Group, 2014 a). The four documents are; Greater Curtin Vision, Greater Curtin Drivers for Change, Greater Curtin Master Plan, and Greater Curtin Delivering the Vision. The first document, Greater Curtin Vision, describes the goal and the vision for Greater Curtin. Why Curtin University should transform into a city is described in the second document, Greater Curtin Drivers for Change. The third document, Greater Curtin Master Plan, elaborates on what the key elements will be in the future city, the framework of the precinct, and the key strategies to reach the vision. In the last document, Greater Curtin Delivering the Vision, it is described how Greater Curtin will be developed. Here an instruction manual is developed and designing principles are defined.

The Curtin City Project Group is a group of seven companies; AECOM, Arup, Block Branding, CBRE, Donaldson and Warn, Pracsys, and Syrinx Environmental PL. Curtin Properties is the unit of Curtin University that is responsible for the management and planning of the environment and properties at the campus (Curtin University , 2016).

The vision for Greater Curtin is to become a node of activity and create a hub of innovation and research where creative knowledge is promoted (Curtin City Project Group, 2014 a). The innovative hub is through a synergy between researchers, business, entrepreneurial enterprises and the government. The different stakeholders work in collaboration to develop innovative processes, services and products (Curtin City Project Group, 2014 b). Greater Curtin is described as;

"Greater Curtin will provide a boundless and adaptable urban context that supports constant exchange between industries, businesses, governments and researchers, forging partnerships in a place where new thoughts can be conceived and where knowledge and innovation extend beyond buildings."

The expansion area of Greater Curtin is defined by three distinct neighbourhoods; North, Central and South as displayed in Figure 4-1 (Curtin City Project Group, 2014 c). The three neighbourhoods have different character which will be displayed in the physical environment of each area.

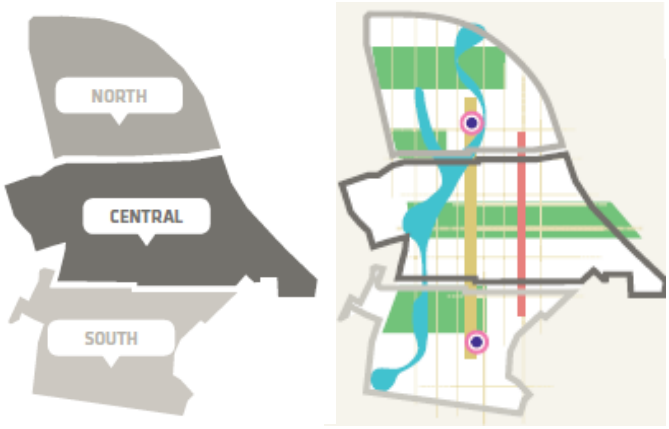

Figure 4-1. Greater Curtin expansion area and the three distinct neighbourhoods (Curtin City Project Group, 2014 c).

In Greater Curtin North a large green area should support recreation and sport together with diverse residential possibilities and a multi-modal transport interchange (Curtin City Project Group, 2014 b). In this area new health buildings will be constructed, and Perth Hockey Stadium and Curtin Stadium will be upgraded. The character of the neighbourhood is classified as a day-to-day working and business area with diverse business and retail activities (Curtin City Project Group, 2014 c).

Greater Curtin Central offer places for art, culture and ceremonial activities (Curtin City Project Group, 2014 b) and is therefore characterised as the ceremonial and civic heart of the city (Curtin City Project Group, 2014 c). The area features a central park, a business street, student accommodation, and a hotel and conference centre (Curtin City Project Group, 2014 b). The restoration of Edinburgh Oval South and Jack Finney Lake provide further possibilities for sport and recreation.

Greater Curtin South is defined by a similar day-to-day character as Greater Curtin North (Curtin City Project Group, 2014 c). Here a transport interchange provide access to an urban plaza and an area thriving of business activity and research with a focus on resources and industries (Curtin City Project Group, 2014 b). A large green area is a part of a green network which provide recreation and sport possibilities but also enhances biodiversity and human interaction with nature.

4.2 The implementation of Nature

Traditionally consideration to existing ecology has been excluded in development projects in Greater Curtin (Curtin City Project Group, 2014 b). Such practice has

resulted in loss of wetlands and natural vegetation. According to the master plan, Nature will attain a greater value in the development processes. Two examples on this are that services generated from nature will be recognised and valued higher, and ecology, hydrogeology, geology and topography will be assessed and taken into consideration. Biodiversity is an important driver for the revaluation of Nature. Historically a decline in biodiversity has been noticed in the area, mainly though loss of native plants.

Several blue and green features will be a part of Greater Curtin precinct and are described further in this chapter. The features shape green and blue systems within the precinct, displayed in Figure 4-2 (Curtin City Project Group, 2014 b). These systems are formed by the natural landscape of the area with the goal to protect and enhance the hydrological and ecological systems. The network aims to improve the biodiversity by its connectivity and continuity, which in turn will provide easier access to these natural attributes for the people in the area. Several initiatives are introduced to enhance these systems which are categorised as blue or green attributes.

Figure 4-2. Green and blue systems of Greater Curtin (Curtin City Project Group, 2014 b).

4.2.1 Blue and green attributes

The blue attributes in Greater Curtin are demonstrated and explained in the Integrated Urban Water Management strategy, which is a technical document to the master plan (Curtin City Project Group, 2014 b). Two blue attributes described in detail are the Living Stream and Jack Finney Lake.

Integrated Urban Water Management strategy

The Integrated Urban Water Management (IUWM) strategy is developed to highlight the importance of water as a resource and a spatial connector (Curtin City Project Group, 2014 b). The aim of the strategy is;

"…minimise the overall water demand, minimise the pressure on groundwater, scheme water supply, harvest rainwater and maximise opportunities for water recycling."

The strategy is divided into six strategies; demand management strategy, rainwater reuse and recycling strategy, wastewater reuse and recycling strategy, storm water management strategy, irrigation strategy, and roof garden strategy (Curtin City Project Group, 2014 b).

The rainwater reuse and recycling strategy is based on collection and treatment of rainwater collected from paved roofs (Curtin City Project Group, 2014 b). The rainwater will be reused for potable use, a term described in Appendix I. The water will be collected in underground storage tanks where the water will be treated before it can be supplied to the drinking water system. Overflow is led to the Living Stream.

Wastewater from the buildings in Greater Curtin will be recycled and reused for irrigation and non-potable use (Curtin City Project Group, 2014 b). The wastewater will be treated through an advanced membrane bioreactor located in the precinct.

Management of storm water is performed with the blue and green network (Curtin City Project Group, 2014 b). This network is formed through the Living Stream and swales. Storm water can be stored, treated and transported to the Living Stream through the swales. Rain classified as storm water is the rain falling on green roofs.

The Living Stream and Jack Finney Lake

The Living Stream defines the blue system displayed in Figure 4-2 (Curtin City Project Group, 2014 b). The Living Stream is a blue corridor considered as a biophilic design attribute. It has the possibility to enhance both the hydrological and ecological systems by supporting the creation of healthy and productive habitats. The central location aims at connecting people with Nature. As described above the Living Stream is an important feature in the storm water management.

A key resource for recreation and ceremonial activities is the Central Park (Curtin City Project Group, 2014 c). It provides a space for people to meet, play and relax but also to access Jack Finney Lake. Jack Finney Lake is an open expression of the Living Stream (Curtin City Project Group, 2014 b) and plays an important role in the reflection of the natural landscape of the area (Curtin City Project Group, 2014 c).

Green biodiversity corridors

The green system is created by biodiversity corridors which is extended to the regional green network (Curtin City Project Group, 2014 b). The connectivity creates continuous green spaces that aims to facilitate the creation of healthy habitats, improve the biodiversity and support the management of the heat island effect.

Green canopies

The planting of trees along streets and walkways in the Greater Curtin area is referred to as the green canopies (Curtin City Project Group, 2014 b). The canopies are important for the character of the street. A mix of native and non-native plants is suggested for the canopies.

The greens
Large green areas are dedicated for sport and the Central Park (Curtin City Project Group, 2014 b). These areas are called the greens and represent the open space for recreation in Greater Curtin. The recreation is both active and passive where the active part is related to sport.

Green roofs and green walls
Green roofs are a natural design attribute articulated in the master plan. Green roofs are integrated in the Integrated Urban Water Management strategy and important for the connectivity of the biodiversity corridors (Curtin City Project Group, 2014 b). As a guideline, 25% of the rooftops should be classified as green roofs. Mainly native plans are suggested for the roofs.

Green walls are not directly mentioned in the master plan but visualised in the storm water management strategy (Curtin City Project Group, 2014 b). Here green walls are combined with green roofs, an example is shown in Figure 4-3.

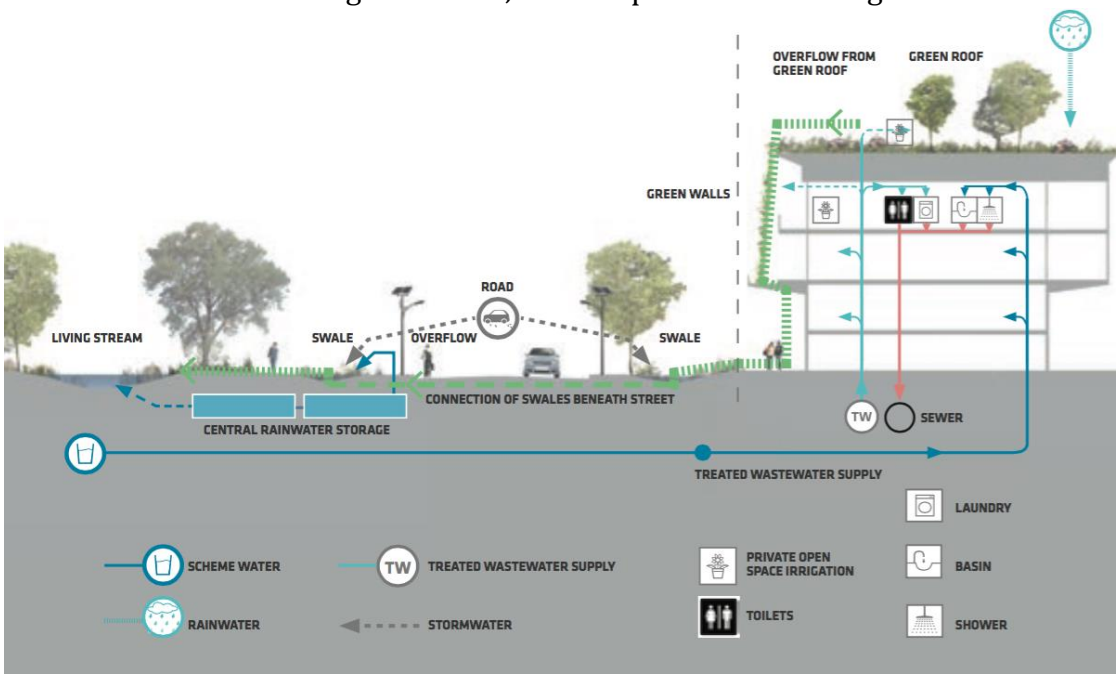

Figure 4-3. Visualisation of a green wall in the storm water management strategy (Curtin City Project Group, 2014 b).

4.3 The implementation of the living lab concept

In Greater Curtin Master Plan - Drivers for change (Part A) (2014 a) it is described that;

"The most successful innovation is occurring where the problems and needs of users and the potential of technologies are linked together in a creative and collaborative process."

To deliver the vision for Greater Curtin, six planning and design principles have been defined as Greater systems, Living Laboratory, Collection of cultures, Platforms for partnerships, Networked communities, and Distinctly Curtin (Curtin City Project Group, 2014 b). Here the living lab is described as platforms for

collaboration, innovation and exchange of knowledge. This to provide education and learning through academic and research opportunities.

The 20 years of development in the expansion area is divided into four stages, each with a time span of five years (Curtin City Project Group, 2014 b). Stage one is the first five years and here the public transport will be developed together with academic activities and commercial offices. Furthermore, a student housing will be established in this stage.

4.3.1 Curtin Living Lab: The Solar Studio

A living lab, currently referred to as Curtin Living Lab: The Solar Studio, is proposed as an annex to the student housing planned for stage one[8]. The student housing in stage one is planned to host 500 student apartments where the living lab annex will compose 50-100 apartments. The living lab is currently defined according to definition (3) in chapter 3.1 The Living Lab – A Real-life Testing Environment.

4.4 Sustainable energy

A renewable energy strategy is established in the Greater Curtin Master Plan to promote sustainable energy sources (Curtin City Project Group, 2014 b). Here energy is valued as a key resource with the objectives to maximise energy efficiency and minimise consumption, aim for self-sufficiency, and promote and integrate energy education. These objectives explains the aim to reduce the energy demand and create possibilities to promote renewable energy sources by a diverse and centralised energy system.

4.5 Sustainable transportation

One out of four networks defined for Greater Curtin is the Urbanisation Network (Curtin City Project Group, 2014 b). Economic activity will be based on public transport, densification in living, and a high rate of visitors and workers. The public transportation network in connection to Greater Curtin need to be extended and developed, this to make the area attractive. One expansion is suggested to be a Light Rail between Perth Central Business District and Greater Curtin.

[8] Unpublished Springer book on Living Labs, Curtin Living Labs: The Solar Studio, nd, G. Morrison

5 Results of Interview Analysis

The results are divided into five parts; (1) Presentation of defined themes for identification of attributional data, (2) Analysis of ambitions for sustainability innovations within the Greater Curtin Master Plan, (3) Analysis of the living lab concept, (4) Analysis of the concept of biophilic urbanism, and (5) Analysis of natural design attributes in the built environment. The sorting of the qualitative data for each focus area are presented in Appendix II, Appendix III and Appendix IV respectively.

5.1 Themes for Identification of Attributional Data

The methodology for thematic analysis described in chapter 2.3 Analysis was used to arrange the qualitative data from the interviews. As described in chapter 2.3.3 Application of Analysis Methodology the search for themes was carried out for three out of four focus areas discussed in the interviews. The areas are; Ambitions for sustainability innovations within the Greater Curtin Master Plan, The living lab concept, and The concept of biophilic urbanism.

The discourse and understanding of the focus areas are based on defined themes. These themes are developed from the literature review on the living lab concept and the concept of biophilic urbanism, and the review of Greater Curtin Master Plan. The reviews therefore represent the theoretical framework for the themes. In chapter 5.1.1 Themes related to Ambitions for Sustainability Innovations within the Greater Curtin Master Plan, 5.1.2 Themes related to the Living Lab Concept, and 5.1.3 Themes related to the Concept of Biophilic Urbanism defined themes are presented and described.

5.1.1 Themes related to Ambitions for Sustainability Innovations within the Greater Curtin Master Plan

In Figure 5-1 the defined themes of ambitions for sustainability innovations within the Greater Curtin Master Plan are presented. The themes are based on the review of the master plan, presented in chapter 4 Case Study – Review of Greater Curtin Master Plan. Two questions were asked on the focus area, presented in Table 2-1.

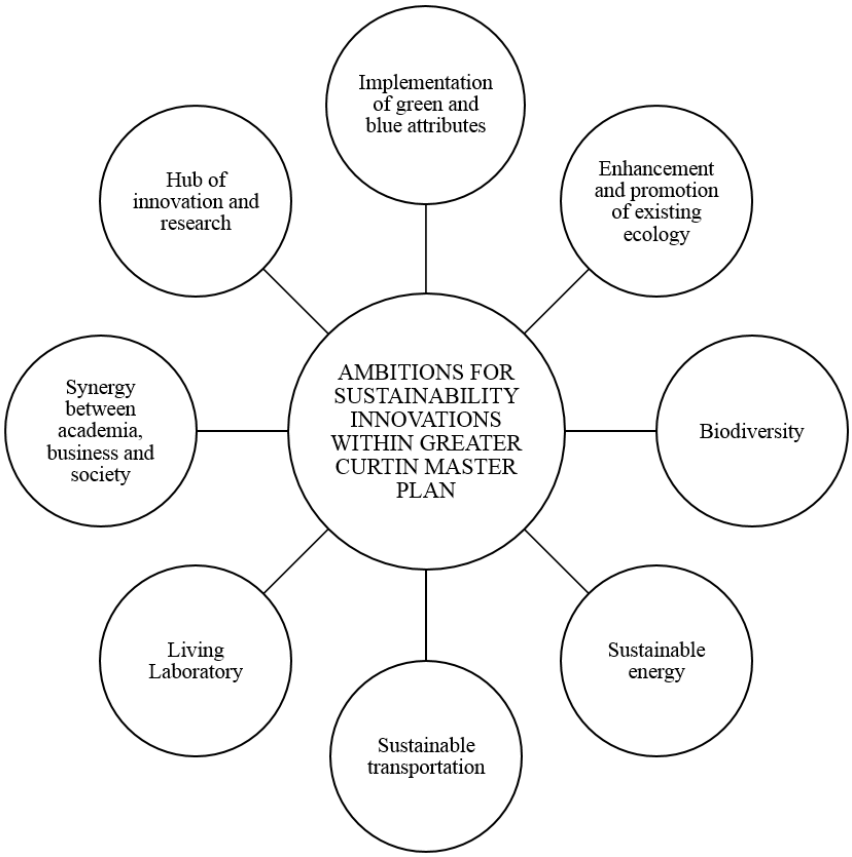

Figure 5-1. Attributional themes related to ambitions for sustainability innovations within the Greater Curtin Master Plan.

The two themes Hub of innovation and research and Synergy between academia, business and society are based on the vision for Greater Curtin. The Living laboratory is one out of six planning and design principles that should support the delivery of the vision. Sustainable transportation and Sustainable energy are two concepts clearly described in the master plan related to sustainability innovations. The three remaining themes, Implementation of green and blue attributes, Enhancement and promotion of existing ecology and Biodiversity are extracted from the importance of natural design attributes described in the master plan.

5.1.2 Themes related to the Living Lab Concept

In Figure 5-2 the defined themes of the living lab concept are demonstrated. The themes are based on the literature review on the living lab concept, presented in chapter 3.1 The Living Lab – A Real-life Testing Environment. Two questions were asked on the focus area, presented in Table 2-1.

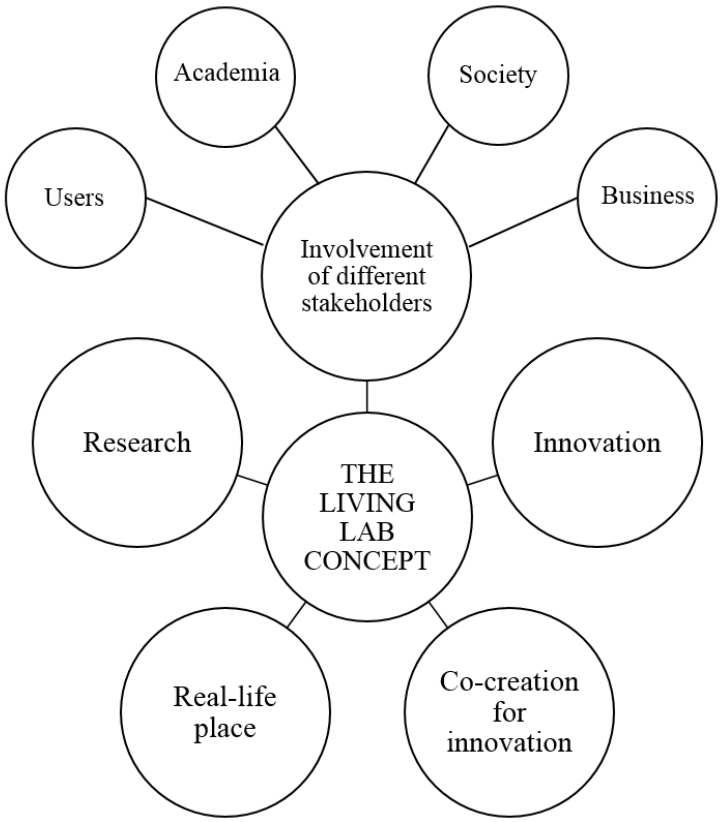

Figure 5-2. Attributional themes related to the living lab concept.

In the theoretical framework of the living lab, the concept is defined with four principles represented through; Involvement of different stakeholders, Innovation, Co-creation for innovation, and Real-life place. A separation is made between the products, services and concepts tested in the living lab, e.g. the innovations, and the process behind the innovations, e.g. the co-creation for innovation. The co-creation for innovations is built on sharing of knowledge and equality between stakeholders to create innovation. Research as a theme is derived from the common attributes revealed from a study where several living lab definitions were compared. The stakeholders involved in the living lab are identified as; Users, Academia, Society, and Business. The awareness of user involvement is highlighted by the user-centric and participatory approach. However, these approaches are not defined as themes, rather a further analysis of the understanding related to user involvement.

5.1.3 Themes related to the Concept of Biophilic Urbanism

In Figure 5-3 the defined themes for the concept of biophilic urbanism are demonstrated. The themes are based on the literature review on the concept of biophilic urbanism together with urban ecology, biodiversity, resilience and ecosystem services, presented in chapter 3.2 Biophilic Urbanism – Including Nature in the Built Environment. Three questions were asked on the focus area, presented in Table 2-1.

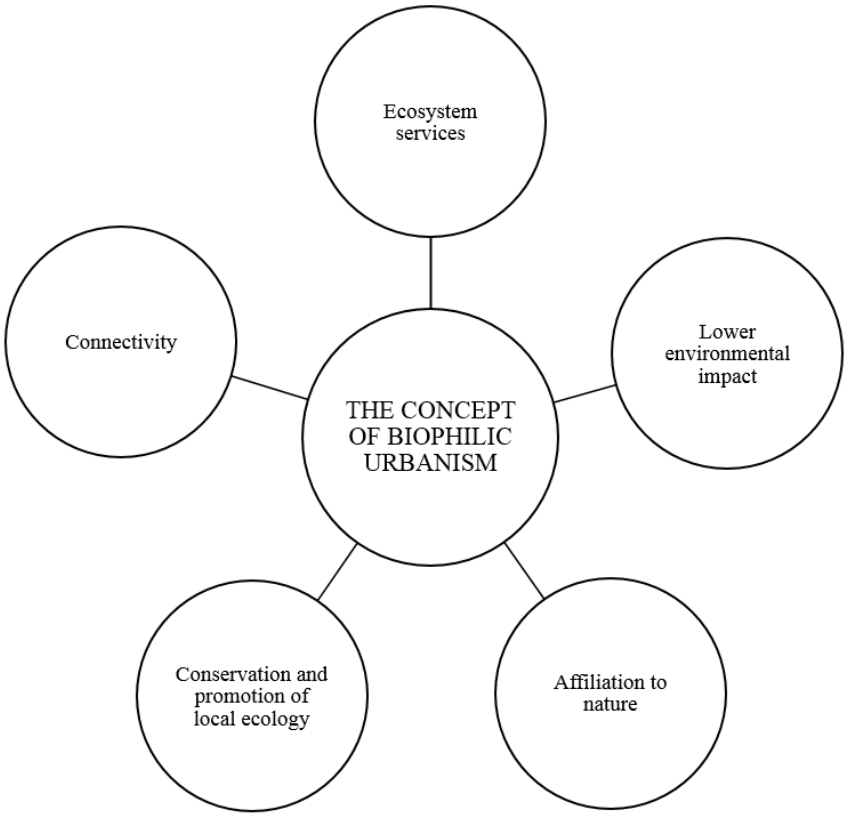

Figure 5-3. Attributional themes related to the concept of biophilic urbanism.

The concept of biophilic urbanism can be divided into five themes connected to the concept. Affiliation to Nature is the theme based on the human need of being close to Nature and the reason why Nature should be brought back to the urban areas. The focus on benefits derived from ecosystems, e.g. Nature, is derived from the theme Ecosystem services. Conservation and promotion of local ecology is required to enhance biodiversity and therefore resilience. One biophilic design dimension suggest to shape the built environment from the existing ecosystems and landscapes. This is described by the theme. The implementation of Nature in the urban area, creates an engineering practice which is described by the theme Lower environmental impact. Improved biodiversity and therefore also resilience is grounded in connectivity of green and blue areas, summarised with the theme Connectivity.

5.2 Analysis of Ambitions for Sustainability Innovations within the Greater Curtin Master Plan

The analysis on ambitions for sustainability innovations within the Greater Curtin Master Plan is based on two questions; what do you identify as the ambitions for sustainability innovations related to the master plan?, and why do you think ambitions for sustainability innovations are included in the master plan? The two questions are separated in chapters 5.2.1 Identified Ambitions for Sustainability Innovations, and 5.2.2 The Reason for Including Ambitions for Sustainability Innovations.

5.2.1 Identified Ambitions for Sustainability Innovations

Derived from the articulated level of data are six categories, demonstrated in Figure 5-4 and further described in articulated data.

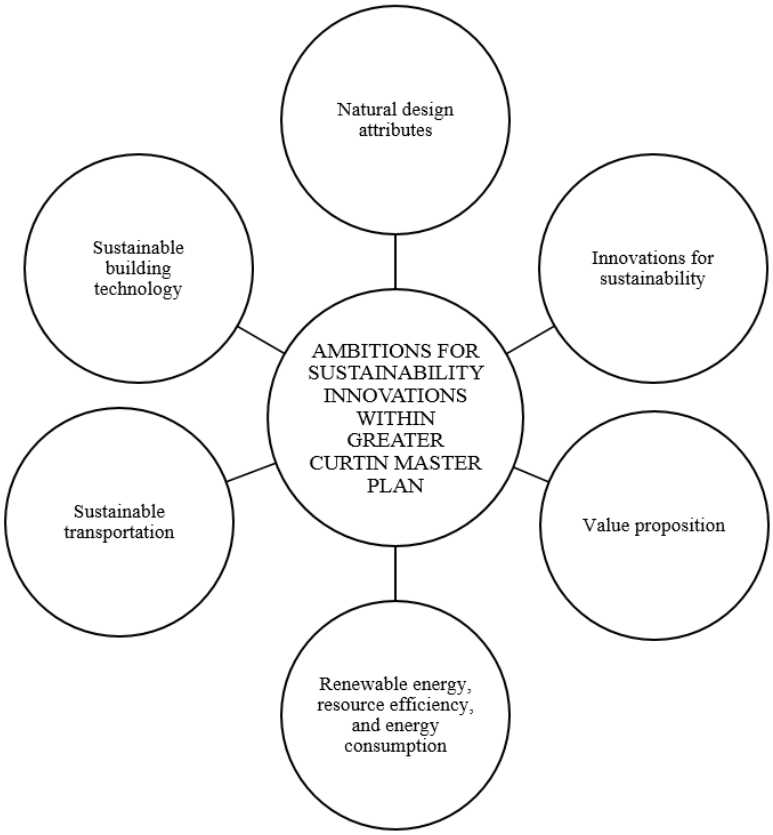

Figure 5-4. Categorisation of articulated data related to identified ambitions for sustainability innovations within the Greater Curtin Master Plan.

Articulated data

The implementation of Nature is described as an ambition for sustainability innovations. Implementation and promotion of greenery can be done through the application of a biophilic design approach. A water management strategy and green infrastructure will help the management of water from large rain events.
The category Innovations for sustainability is described by the vision for Greater Curtin, to be the city of innovation. The city should be a hub of innovation, develop collaborations and promote a sustainable community by supporting research and innovation.

Another discussion considers the Value proposition of ambitions for sustainability innovations. With these ambitions a high design value can be obtained on buildings and infrastructure. This also implies that a high quality of life can be achieved. High quality of life connects to the goal for Greater Curtin, which is to lead the way to a better future.

The discourse behind the category Renewable energy, resource efficiency and energy consumption is also emphasised. This category is described by promotion of renewable energy sources such as solar energy, and being carbon neutral and

self-sufficient. Sustainability innovations is defined as reducing the environmental footprint whilst improving the liveability. This can be achieved by the use of smart control systems to reduce energy consumption, and to develop innovations on renewable energy.

The interviewees also discuss Sustainable transportation. In the expansion area Sustainable transportation will be achieved by extension of the public transportation network with light rail.

The discourse of Sustainable building technology is suggested to be a part of the ambitions for sustainability innovations. Here sustainable buildings are suggested to be achieved by smart design and technology, and by building according to science e.g. the sustainability targets. Building with modular construction is a way of building according to science. The goal of being a sustainable building precinct can be achieved by aiming for a green star sustainable building community.

Emergent data

Presented in Figure 5-5 are emerging categories from the articulated category Innovations for sustainability.

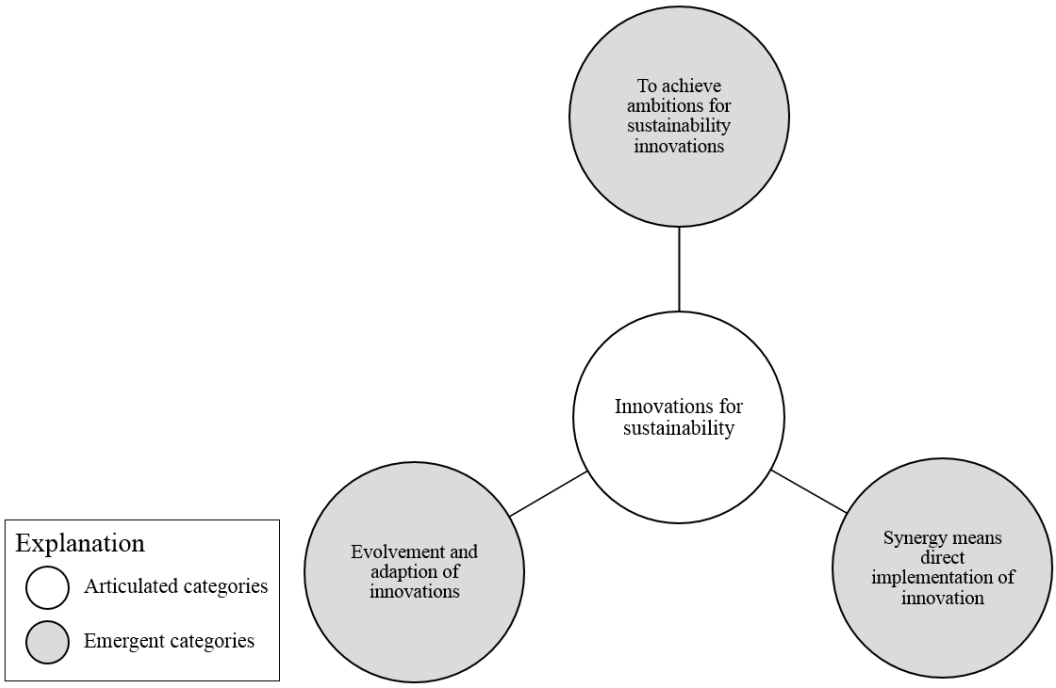

Figure 5-5. Emergent data from the articulated category Innovations for sustainability.

How ambitions for sustainability innovations can be achieved is an emergent category identified from the discussion. One way is through development of design guidelines, for example the amount of greenery that should be applied on or around a building. Another way is to develop policies to attain required effects. It was also discussed that the design and technology of the innovations are the easy parts of the achievement. The challenging parts are human interaction with the innovations, and the business case to enable the innovation.

A goal for the Greater Curtin area is to promote collaboration between business, society and academia. The synergy provides opportunities to create innovations and to directly implement innovations in the real world. Curtin University has a strategy to provide innovations and leadership which means being the leader and the first to develop innovations.

The last emergent topic is described by evolvement and adaption of innovations. This implies that the innovations and the environment where they are developed need to be adaptable to allow evolvement of the innovation.

The group discuss the importance of Sustainable building technology as an ambition for sustainability innovations. Presented in Figure 5-6 are the emerging categories from the articulated category. The circles with white background represent categorisations for the articulated data and circles with grey background for emergent data.

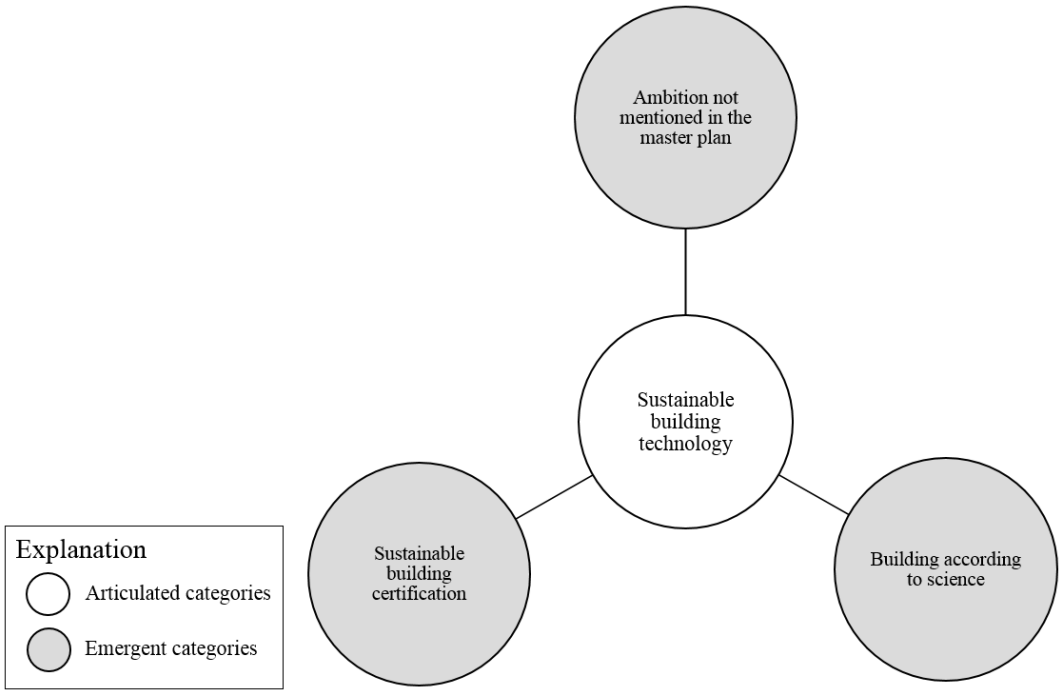

Figure 5-6. Emergent data from the category of sustainable building technology.

It is discussed that Sustainable building technology is an ambition for sustainability innovation. However, such ambition is not mentioned in the Greater Curtin Master Plan. Building according to science, with the sustainable development goals in mind is a way to "make tomorrow better", a goal set for the Greater Curtin precinct. Another way of achieving ambitions for sustainable buildings is to apply a sustainable building certification.

One emergent category is identified from articulated categories Sustainable transportation, and Renewable energy, resource efficiency and energy consumption. The discussion considers the importance of providing the right kind of infrastructure for the city of Greater Curtin to achieve their goal to become carbon neutral. Both transportation, and energy production and distribution require the right type of infrastructure to fulfil the goal.

There is an emergent response related to the category natural design attributes. The discussion considers the importance of raising the awareness of financial benefits of implementing natural design attributes in the built environment. The translation into financial benefits is a way to mainstream biophilic design.

Attributional data

Presented in Table 5-1 is the level of understanding related to the attributional themes for identified ambitions of sustainability innovations within the Greater Curtin Master Plan. Definitions for the level of understanding are described in chapter 2.3.3 Application of Analysis Methodology. The group provide a collective understanding to the themes; Implementation of green and blue attributes, Sustainable energy, and Hub of innovation and research. An occasional understanding is provided to the themes; Sustainable transportation, Living laboratory, and Synergy between business society and academia. None of the interviewees considered the themes; Enhancement and promotion of local ecology, or Biodiversity.

Table 5-1. The level of understanding related to the identified ambitions for sustainability innovations within the Greater Curtin Master Plan.

Attributional themes	*Level of understanding*		
	Collective	Occasional	Not considered
Implementation of green and blue attributes	X		
Enhancement and promotion of local ecology			X
Biodiversity			X
Sustainable energy	X		
Sustainable transportation		X	
Living laboratory		X	
Synergy between business, society and academia		X	
Hub of innovation and research	X		

The discourse to the theme Implementation of green and blue attributes suggests implementation of greenery suitable for the local climate, this by incorporation of biophilic design principles in the plan. Design guidelines for greenery and the water management strategy are important tools to achieve the ambition of implementing Nature in a sustainable way.

The group discuss the theme Sustainable energy by promotion of sustainable energy sources, resource efficiency and self-sufficiency as the ambitions articulated in the master plan. Other discussions related to the theme are guidelines to reduce the energy consumption, smart control systems and support for innovations to enhance renewable energy sources.

In terms of Sustainable transportation the extension of the public transport network through a light rail is discussed. Here a concern is raised regarding the possibility to implement the new network because it does not connect to the other public transportation networks in the area.

The living laboratory concept is discussed to be broadly mentioned in the master plan. The broad description implies an open interpretation of the concept. This means that the concept can be implemented in different ways to enhance sustainability innovations.

The Synergy between business, society and academia is discussed as a way to provide sustainability innovations.

The content to the discourse for Hub of innovation and research is explained by the goal for Greater Curtin to become a flagship for the city of Perth and a centre for sustainability innovations. A sustainable community is achievable by promoting research and innovation.

5.2.2 The Reason for Including Ambitions for Sustainability Innovations

Derived from the articulated level of data are two categories, demonstrated in Figure 5-7 and further described in; Articulated data. The emergent category evolves from both of the articulated categories. The circles with white background represent categorisations for the articulated data and circles with grey background for emergent data.

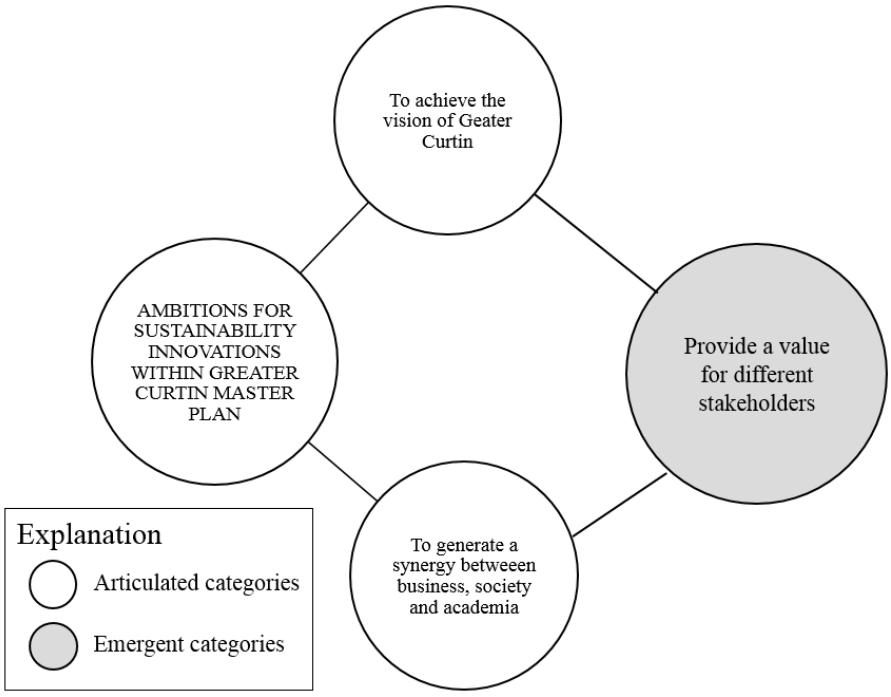

Figure 5-7. Categorisation of articulated and emergent data related to the reason for including ambitions for sustainability innovations within the Greater Curtin Master Plan.

Articulated data

The discourse of the category To achieve the vision of Greater Curtin is about the value-proposition for Curtin University. The vision for the Greater Curtin precinct is to be the city of innovation and develop innovative knowledge through research.

It is also suggested that ambitions for sustainability innovations exist To create a synergy between business, society and academia, which is the second articulated category.

Emergent data
The collaboration between business, society and academia, generates values. The value-proposition for the University is to achieve their goal of "making tomorrow better" and their vision for Greater Curtin. Researchers are able to see the direct application of their research which is beneficial both for motivation and the research itself. The industry is supported in business development. Lastly, the value for society is innovations that leads to sustainability, a better future.

Attributional data
Presented in Table 5-2 is the level of understanding related to the attributional themes for the reason of including ambitions for sustainability innovations in the Greater Curtin Master Plan. Definitions for the level of understanding are described in chapter 2.3.3 Application of Analysis Methodology. The group provide an occasional understanding to the themes; Living laboratory, Synergy between business, society and academia, and Hub of innovation and research.

Table 5-2. The level of understanding related to the reason for including ambitions for sustainability innovations in the Greater Curtin Master Plan.

		Level of understanding		
		Collective	Occasional	Not considered
Attributional themes	Living laboratory		X	
	Synergy between business, society and academia		X	
	Hub of innovation and research		X	

Provided to the living laboratory discourse is a discussion on the living laboratory as an innovative building where a nexus between business, society and academia can be achieved. This implies that the living laboratory is important to achieve the ambitions. This because synergy is an ambition related to sustainability innovations. The creation of synergy is also discussed as a reason for having ambitions for sustainability innovations. Values are created through this nexus for the stakeholders involved.

The interviewees also provide content to the theme Hub of innovation and research. It is described that innovative knowledge is developed from research, possibly creating a hub of innovation.

5.3 Analysis of the Living Lab Concept

The analysis of the living lab concept is based on two questions; what does a living lab imply for you?, and which main stakeholders should be involved in order to successfully implement the living lab concept? The two questions are separated in chapters 5.3.1 Interpretation of the Living Lab Concept, and 5.3.2 Stakeholders Involved in the Living Lab Concept.

5.3.1 Interpretation of the Living Lab Concept

Derived from the articulated level of data are three categories, demonstrated in Figure 5-8 and further described in articulated data. The emergent categories evolve from one of the articulated categories. The circles with white background represent categorisations for the articulated data and circles with grey background for emergent data.

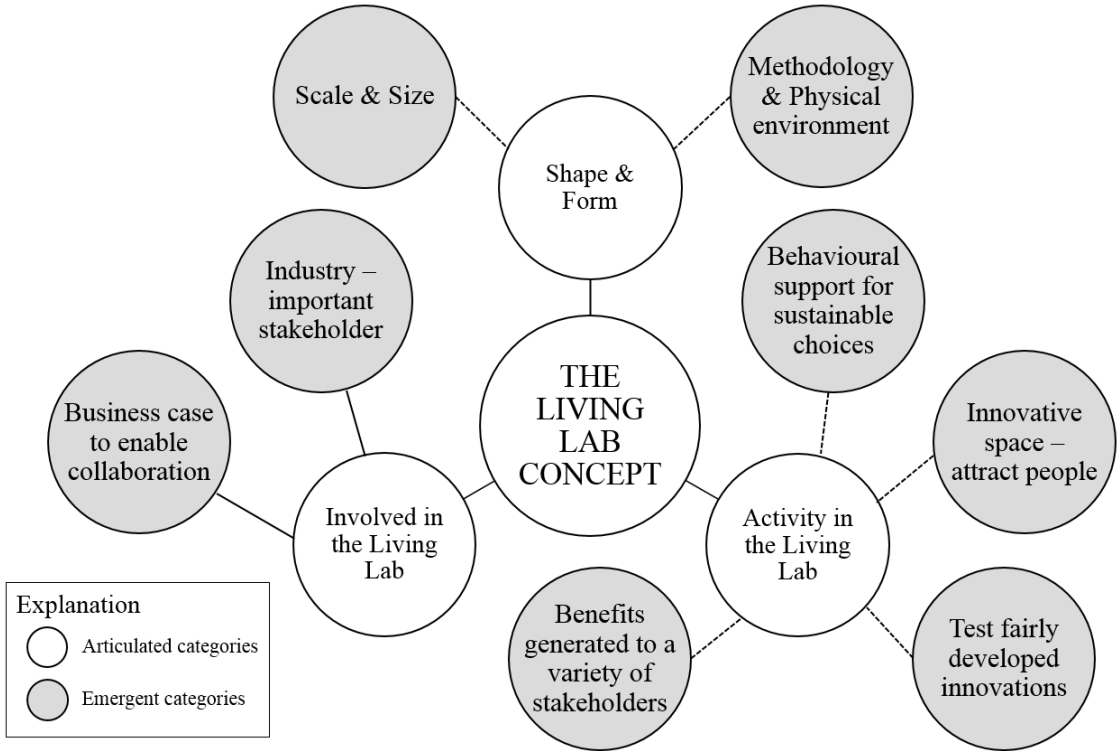

Figure 5-8. Categorisation of articulated and emergent data related to the interpretation of the living lab concept.

Articulated data

The first discourse concerns the shape and form of the living lab. The majority of the group evaluate the living lab as a place, building or physical environment and the rest as a culture or a methodology. The physical environment is sometimes considered a real-life and changeable environment.

The second discourse concerns the activity in the living lab. The main activity associated with the living lab is testing and evaluation of innovations. Other activities are research, study of human behaviour and to provide teaching and learning. The interviewees relate one of the four activities to the living lab.

The last discourse concerns the ones involved in the living lab. The discussion is about identification of stakeholders and the required collaboration process. The identified stakeholders are academia, business, society, and real-life people. The living lab is considered as a platform for collaboration.

Emergent data

Connected to the articulated category Shape and form are two emergent topics. It is discussed that the size of the living lab affects the feedback and control of the

occupants. A larger area implies less control and therefore less feedbacks from the occupants, and the opposite for a smaller area. Additionally, it is discussed that the living lab concept should be applied on a larger scale, to infrastructure projects.

Considering the living lab as a physical building and a methodology puts the shape and form of the living lab in a new context. The living lab is described as a place where research on human behaviour is performed in a real-life environment. The research in itself requires a methodology and the real-life environment a physical building.

Connected to the articulated categorisation activity in the living lab are four emergent topics; three connected to the outcome of the living lab and one to the innovations tested in the lab. The innovations tested in the lab need to be developed due to the real-life context of a living lab.

One of the outcomes from a living lab is that it can provide behavioural support for people to make sustainable choices. The second emerged topic is that benefits will be generated to different stakeholders defined as university, industry, public and policy makers. This may indicate a thinking about the value-propositions for the different stakeholders involved in the living lab. However, the generated benefits are not elaborated on. The last emerged topic linked to the outcome is the living lab as an innovative space, which will attract people to the Greater Curtin area.

From the articulated category Partners involved in the living lab, two emergent topics are identified. The first is the importance of involving industry. Industry is supposed to build, own and operate the living lab. The second emergent topic is the business case around the living lab. The collaboration process will not happen by itself. The stakeholders need to understand what their and the groups' gains and risks are by collaboration in the living lab.

Attributional data

Presented in Table 5-3 is the level of understanding related to the attributional themes for the interpretation of the living lab concept. Definitions for the level of understanding are described in chapter 2.3.3 Application of Analysis Methodology. The group provide a collective understanding to the themes; Innovation, Research, Real-life place, and Involvement of different stakeholders. An occasional understanding is provided to the theme; Co-creation for innovation.

Table 5-3. The level of understanding related to the interpretation of the living lab concept.

		Level of understanding		
		Collective	Occasional	Not considered
Attributional themes	Innovation	X		
	Research	X		
	Co-creation for innovation		X	
	Real-life place	X		
	Involvement of different stakeholders	X		

The discussion around the theme innovation is about why innovations are tested and the type of tested innovations. The innovations are tested to deliver low carbon living and sustainability, and study the human interaction with innovations. The tested innovations are those not mainstreamed at the market or experimental/advanced innovations.

The theme research is discussed on the basis of tested innovations. The aim with the research is to evaluate the performance of the innovations and the human interaction with the innovations.

Related to the theme co-creation for innovation is a discussion about the collaboration process between stakeholders to test innovations or provide teaching and learning. The group of stakeholders mentioned together with the collaboration process are researchers and business. The larger group of stakeholders, including society and real-life people, is not considered in the collaboration process.

Even though there is a discourse behind the shape and form of a living lab, if it is a physical environment, culture or methodology, the majority of the group consider it as a physical environment in a real-life context. Due to the fact that a culture and methodology can be applied in a physical environment, it is evaluated to be a collective understanding of the theme.

The involved stakeholders in the living lab are academia, business, society, and real-life people. Additionally, the collaboration process between stakeholders is mentioned in relation to the theme involvement of different stakeholders.

5.3.2 Stakeholders Involved in the Living Lab Concept

Derived from the articulated level of data are six categories demonstrated in Figure 5-9 and are further described in articulated data. The emergent categories evolve from one of the articulated categories. The circles with white background represent categorisations for the articulated data and circles with grey background for emergent data.

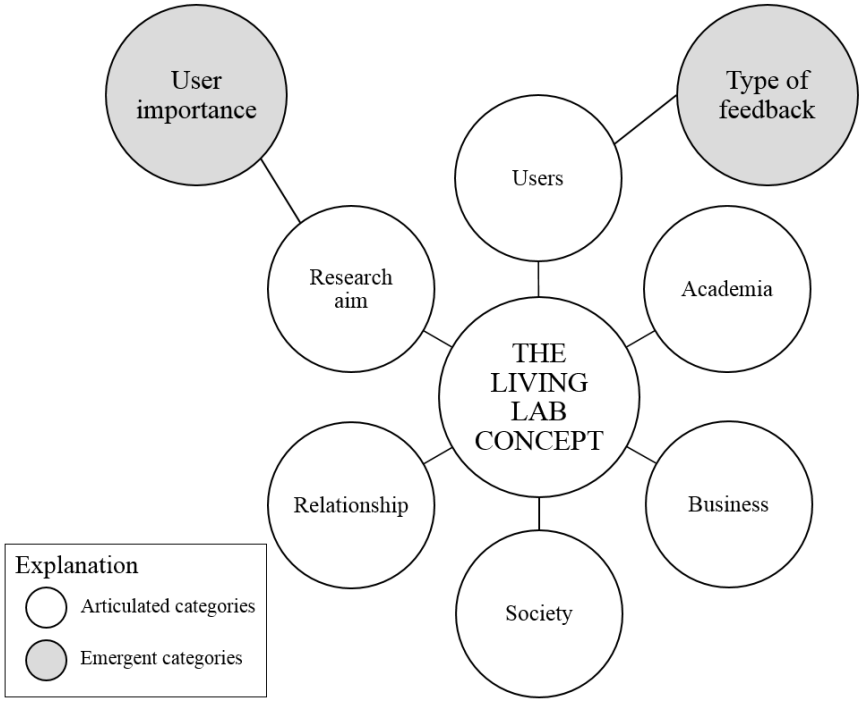

Figure 5-9. Categorisation of articulated and emergent data related to stakeholders involved in the implementation of the Living Lab concept.

Articulated data

The first discourse concerns users. The discussion is about whether real-life people are important for a successful living lab. Two sides emerge from the discussion, one considering real-life people important and one who does not. If real-life people are considered important they are perceived as participants, consciously or unconsciously involved in the research.

The entire group consider academia as an important stakeholder. Academia is separated in two groups; academic and professional staff. Academic are the teachers and researchers, and professional staff are the managers and property managers.

As for academia, business is considered as an important stakeholder to involve by the group. Three groups are identified within business; industry, consultancy, and property developers. An important branch of industry is the building sector working with sustainability innovations. Designers, architects and landscape architects are articulated consultancies.

The fourth discourse concerns society. The society is divided into two groups; government and public. The government is mainly associated as the local council and the agencies developing regulation, and the public as the community.

Sustainable relationship is the category evolved from the discussion on equality between stakeholders. The fundamental practice to successfully deal with stakeholders is to treat them as equal.

The last discourse relates to the category Research aim. The discussion is about the difficulty to pre-define a certain group of stakeholders for a successful living lab without knowing the aim or the scale of the research.

Emergent data

The emergent topic Type of feedback relates to the articulated category Users. The type of feedback is dependent on the people living in the lab. How keen they are on becoming a part of the experiment and their initial knowledge will affect the feedback. A social diversity in the group could represent the society. Also, different types of feedbacks are attained when the occupants are consciously or unconsciously involved in the research. Unconscious involvement may reflect the real human behaviour, whereas the conscious may not.

User importance is related to the articulated category Research aim. Involvement of users is dependent on the aim and scale of the research. If no consultancy with occupants is required for the research, they are not considered an important stakeholder.

Attributional data

Presented in Table 5-4 is the level of understanding related to the attributional themes for the stakeholders involved in the living lab. Definitions for the level of understanding are described in chapter 2.3.3 Application of Analysis Methodology. The group provide a collective understanding to the themes; Academia, Society, and Business. An occasional understanding is provided to the theme; Users.

Table 5-4. The level of understanding related to the stakeholders involved in the living lab.

Attributional themes	*Level of understanding*		
	Collective	Occasional	Not considered
Users		X	
Academia	X		
Business	X		
Society	X		

As presented in the articulated data, two sides exist in the group about the importance of users. If users are considered important the discussion indicates on user involvement according to the participatory principle. The principle implies that users, e.g. the occupants, are equally important as any other stakeholder in the design and innovation process.

Also presented in the articulated data is how academia is considered as two sides, the academic (teachers and researchers) and professional staff (manager and property manager). Professional staff is exemplified as Curtin Properties. It is highlighted that it is important to involve researchers in the design, building and monitoring of the living lab.

Business is separated in three groups; industry providing sustainability innovations, design and architectural consultancies, and property developers. Discussed is also the living lab as an opportunity for the industry. The opportunity lies in testing products and services in a real-life environment.

Society as a theme is considered as the government and public. Articulated is that the public is important to involve for support about the living lab concept and because they are the ones to benefit from the research in the living lab.

5.4 Analysis of the Concept of Biophilic Urbanism

The analysis on the concept of biophilic urbanism is based on three questions; why to include Nature in the built environment and what benefits are provided?, how can Nature be implemented in a sustainable way?, and if Nature is applied in/on/around a building, could it provide benefits for a larger area? The three questions are separated in chapters 5.4.1 The Reason to include Nature in the Built Environment, 5.4.2 Sustainable Implementation of Nature, and 5.4.3 Generated Benefits beyond Building Scale.

5.4.1 The Reason to include Nature in the Built Environment

Derived from the articulated level of data are four categories, demonstrated in Figure 5-10 and are further described in articulated data. The emergent categories evolve from one of the articulated categories or from the concept itself. The circles with white background represent categorisations for the articulated data and circles with grey background for emergent data.

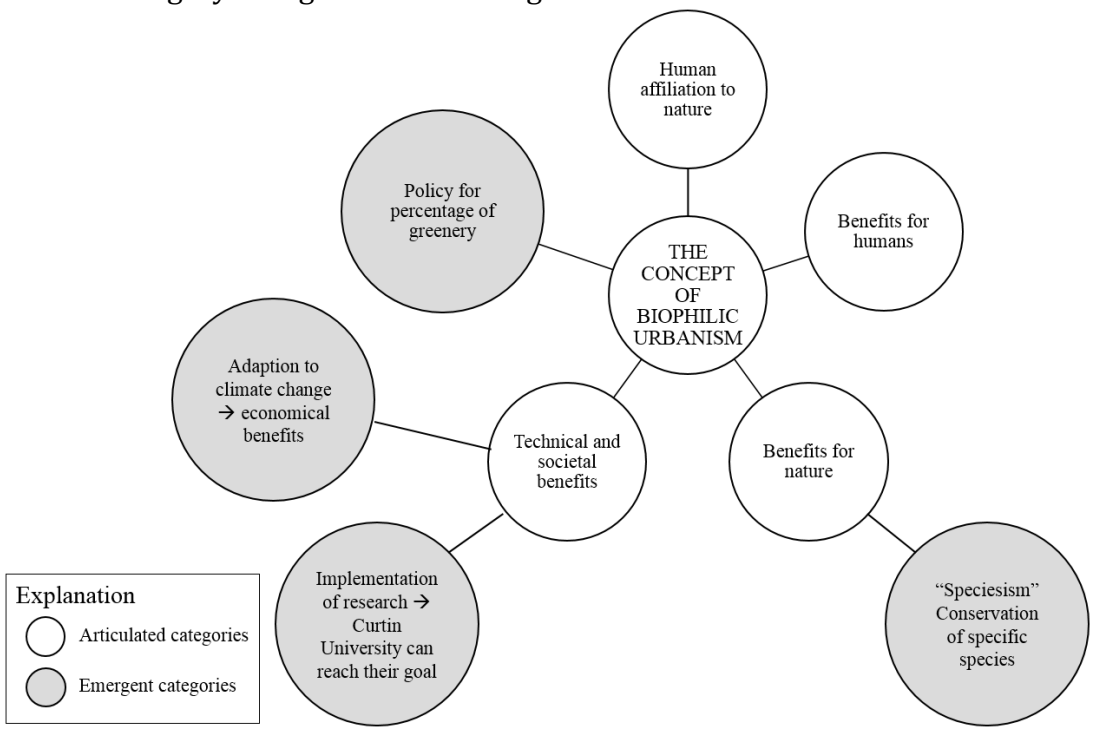

Figure 5-10. Categorisation of articulated and emergent data related to the reason for including Nature in the built environment and the benefits provided.

Articulated data

Human affiliation and humans innate attraction to Nature is discussed. The group also refers to the subject by discussing the ease for humans to connect with Nature and that humans need the interaction with Nature.

Apart from human affinity to Nature, a range of benefits of including Nature in the built environment are revealed. These benefits are sorted into three categories,

presented in Figure 5-11. However, there is no meaning in the positioning or size of the slices as they are only used as a visual representation. The categories are identified according to different perspectives of the benefits that Nature can provide. To the left in Figure 5-11 are the benefits provided directly for humans. The benefits provided for Nature are those who directly affect natural systems or ecosystems, that humans are indirectly dependent on. These are presented in the middle in Figure 5-11. The interviewees also refer to benefits which are not generated directly to an individual human but rather a larger population of humans. This by generating improvements of technical performances or providing benefits that gains the society in general. These benefits are categorised as technical and societal benefits and are presented to the right in Figure 5-11.

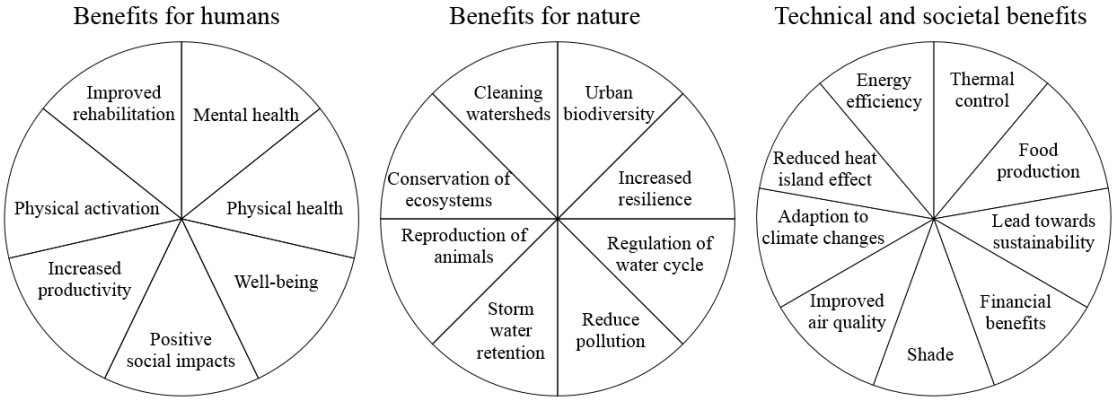

Figure 5-11. Articulated categories related to the reason for including Nature in the built environment and the benefits provided. The content is described as the benefits provided by including Nature in the built environment.

Emergent data

Emerging from the concept of biophilic urbanism is a discussion on the importance of implementing a policy to regulate the acquired amount of greenery in/on/around a building.

Emerging from Benefits for Nature is a discussion about "speciesism". The term indicates a focus on protecting certain species in an urban area rather than enhancing the general biodiversity. This since the urban environment may not be suitable for this specie e.g. because the habitats are too small to enhance it. Instead a focus on species suitable for the urban environment is suggested to improve and enhance the general biodiversity in the area.

Two emergent topics are developed from the Technical and societal benefits category. Here a discussion is raised on the economic gains that can be generated for the society if the urban environment is resilient to future climate changes, this by the implementing Nature. Furthermore, by implementing research on Nature in the agenda for a university, is a way of demonstrating leadership and innovation which is the second emerged idea.

Attributional data

Presented in Table 5-5 is the level of understanding related to the attributional themes for the reason of including Nature in the built environment and the benefits provided. Definitions for the level of understanding are described in

chapter 2.3.3 Application of Analysis Methodology. The group provide a collective understanding to the themes; Human affiliation to Nature, and Ecosystem services. An occasional understanding is provided to the themes; Lower environmental impact, and Conservation and promotion of local ecology. None of the interviewees considered the theme; Connectivity.

Table 5-5. The level of understanding related to the reason for including Nature in the built environment and the benefits provided.

		Level of understanding		
		Collective	Occasional	Not considered
Attributional themes	Lower environmental impact		X	
	Human affiliation to Nature	X		
	Conservation and promotion of local ecology		X	
	Ecosystem services	X		
	Connectivity			X

One topic represents the discourse of Lower environmental impact. This describe the importance of including Nature in the built environment to decrease the amount of hard and solid surfaces.

One topic is also provided to the discourse of Conservation and promotion of local ecology. The discussion focus on the implementation of Nature in the built environment to conserve local ecosystems and therefore improve the biodiversity.

The discourse behind the theme Human affiliation to Nature is represented either by directly referring to humans innate attraction to Nature, as described by E.O. Wilson (1984), or by referring to the humans need to be in contact with, and surrounded by Nature to be healthy.

The benefits that are revealed reflect a discourse related to Ecosystem services. As already mentioned the ecosystem services discussed by the interviewees, mostly represent those directly beneficial for humans. This can be seen as an anthropocentric point of view, which is closely related to the theory behind ecosystem services. Nevertheless, some of the answers also reveal environmental benefits and benefits connected to Nature. According to the ecosystem services point of view, these will also be beneficial for humans.

5.4.2 Sustainable Implementation of Nature

Derived from the articulated level of data are three categories, demonstrated in Figure 5-12 and are further described in articulated data.

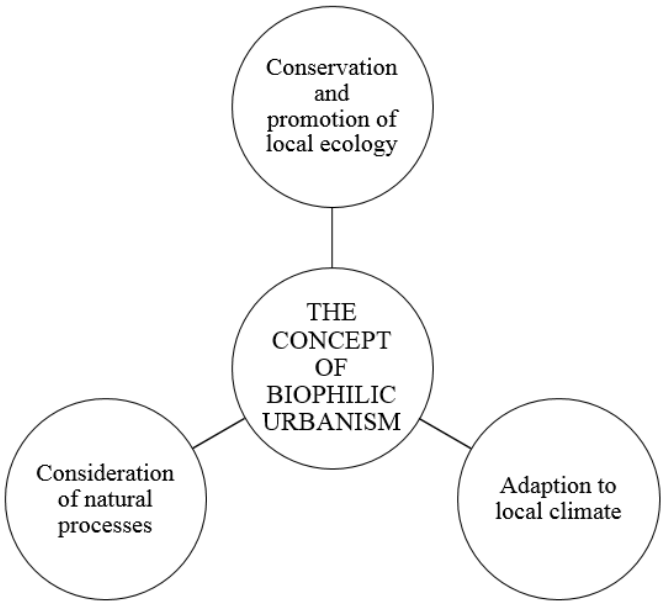

Figure 5-12. Categorisation of articulated data related to the implementation of Nature in a sustainable way.

Articulated data
The interviewees discuss the importance of choosing native plants, or plants suitable for the climate in the place of consideration. In Perth, plants and greenery should be chosen carefully to manage water shortage and hot temperatures.

To implement greenery in a sustainable way requires consideration to natural processes. This discourse considers the importance of acknowledging the natural processes to provide required benefits. This is suggested to be done by considering all types of Nature, applying a long-term thinking, and by careful management of water.

The interviewees also suggest conservation and promotion of local ecology. An appraisal of the local ecology reveal important elements to conserve and promote. This could be done by involving experts. Promotion of local ecology is suggested to be encouraged by incorporation of regulations on greenery in design principles.

Emergent data
The category Adaption to the local climate emerge into different aspects. Different configurations of native plants or plants suitable for the local environment in Perth should be tested to assess their performance. These tests can be done in a living lab. The importance to adapt to the hot and dry climate in Perth further emerge to a consideration for future climate changes. This discussion indicates that a systematic approach is required while choosing plants and greenery to implement in an urban environment.

Natural attributes provide benefits, also referred to as ecosystem services. It is important to consider the natural processes related to a natural attribute to gain the benefits required. One example explains that a green roof provide thermal regulating benefits to a building. By the acknowledgement of this benefit, less insulation is required to achieve the same performance. Another discussion

considers careful management of water to provide several benefits. By the use of recycled water or desalinated water produced with renewable energy, water can be implemented as a natural attribute in the urban environment but also in a sustainable way. In this way the water does not only provide the benefit of being drinking water but also the benefits by its presence in the urban environment.

Conservation and promotion of local ecology need to be considered to implement natural attributes in a sustainable way. An appraisal of the local ecology is proposed to be performed by a person with knowledge about the local environment, which include both ecology and climate. For the purpose of Greater Curtin, such expertise is available at the university. Another issue that arise is that an appraisal of the local ecology is expensive and is therefore often not performed since it is not required by legislation. This can be overcome by classifying land as natural heritage to protect important species.

Attributional data
Presented in Table 5-6 is the level of understanding related to the attributional themes for the implementation of Nature in a sustainable way. Definitions for the level of understanding are described in chapter 2.3.3 Application of Analysis Methodology. The group provide an occasional understanding to the theme; Conservation and promotion of local ecology. None of the interviewees considered the theme; Connectivity.

Table 5-6. The level of understanding related to the implementation of Nature in a sustainable way.

		Level of understanding		
Attributional themes		Collective	Occasional	Not considered
	Conservation and promotion of local ecology		X	
	Connectivity			X

An assessment of the local environment is suggested to describe the landscape, flora and fauna. This is related to the discourse behind the theme Conservation and promotion of local ecology. By including the landscaping of a development in the total budget of the project, promotion of local ecology is enhanced. Conservation of local ecology is suggested to be done by legislation that protect the natural environment. All type of Nature is needed to create biodiversity, which mean that local ecology is important for biodiversity and therefore need to be conserved.

5.4.3 Generated Benefits beyond Building Scale

Derived from the articulated level of data are two categories, demonstrated in Figure 5-13 and are further described in articulated data. The emergent categories evolve from one of the articulated categories or from the concept itself. The circles with white background represent categorisations for the articulated data and circles with grey background for emergent data.

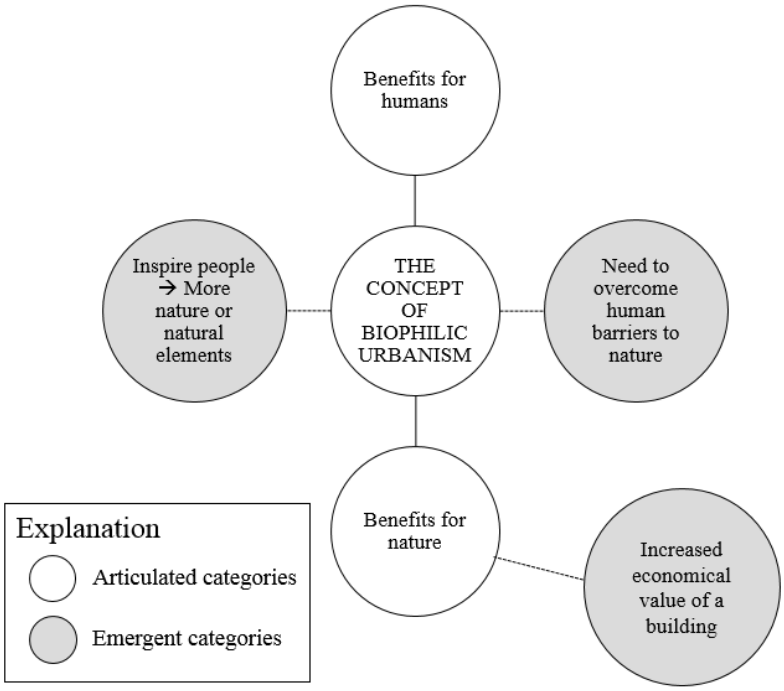

Figure 5-13. Articulated categories and emergent data related to the benefits provided if Nature is implemented in/on/around a building.

Articulated data

The articulated data is categorised in similarity to the categorisation in Figure 5-11; Benefits for humans and Benefits for Nature. The benefit of making an area more attractive by improved aesthetics is discussed, which also improves the accessibility to Nature for people in the area. Regarding Benefits provided for Nature, the interviewees agree on one benefit. Implementing Nature in the built environment increase the biodiversity in the area. The biodiversity is suggested to be increased due to the additional natural feature that create connectivity to other natural attributes.

Emergent data

Emerging from Benefits provided for humans is a discussion on the economic value that is added to a house if it is near greenery or if greenery is added to the house. In this way it is argued that Nature provides economical ecosystem services to humans.

The interviewees also discuss the possibility of implementing Nature on a building which inspire people in the area to do something similar. This would lead to increased amount of Nature in the area, and the benefits are increased. It is also suggested that installations and configurations of natural design attributes should be tested in a living lab. This, would also serve as an inspiration for people in the area.

Another discussion considers the human barriers to implement Nature in the built environment. Most natural things are not welcome in a civilised urban area, a state of mind that need to be overcome. This means that it is not only about presenting the benefits with Nature, it is rather about identifying and work with human barriers against Nature.

Attributional data
Presented in Table 5-7 is the level of understanding related to the attributional themes for the benefits provided if Nature is implemented in/on/around a building. Definitions for the level of understanding are described in chapter 2.3.3 Application of Analysis Methodology. The group provide a collective understanding to the theme; Ecosystem services. An occasional understanding is provided to the theme; Connectivity.

Table 5-7. The level of understanding related to the benefits provided if Nature is implemented in/on/around a building.

Attributional themes	*Level of understanding*		
	Collective	Occasional	Not considered
Connectivity		X	
Ecosystem services	X		

The discourse on Connectivity elaborates on the importance of green corridors to create connectivity to enhance biodiversity. This can be achieved by connecting patches of green. Nature implemented on a property can create connectivity.

To the discourse of the theme Ecosystem services, the group discuss benefits that can be provided for a larger area. These benefits prove on anthropocentric valuations which relate to the ecosystem services way of thinking. It is also discussed that the benefits provided from one building could be generated for people at different scales; the occupants of the building, the people in the direct surrounding of the building, and to people in the precinct and community where the building is situated.

5.5 Analysis of Natural Design Attributes in the Built Environment

The analysis of the natural design attributes possible to implement in the built environment is presented in chapter 5.5.1 Natural Design Attributes in the Built Environment, and is based on three questions; how can Nature be implemented in/on/around a building?, can you think of any innovative ways to incorporate Nature in the built environment?, and how can Nature be implemented in an urban area? Presented in chapter 5.5.2 Natural Design Attributes in a Living Lab is the analysis of natural design attributes interesting to incorporate in a living lab which is based on the question; which of the natural design attributes will be interesting to incorporate in a living lab?

5.5.1 Natural Design Attributes in the Built Environment

Summarised in Table 5-8, Table 5-9 and Table 5-10 are the natural design attributes possible to implement in the built environment. The attributes are categorised in three groups; building interior in Table 5-8, building exterior in Table 5-9, and surrounding of the building in Table 5-10. Each natural design attribute has a description to clarify the content behind the discourse together with articulated ecosystem service/s.

The categorisation Building interior is presented in Table 5-8. Presented are design attributes suitable for the interior of a building.

Table 5-8. Building interior categorisation of natural design attributes.

Natural design attribute	**Description**	**Ecosystem service**
Natural sunlight	Inlet of sun light through smart positions of windows.	Natural sun light.
Incorporate natural patterns	Natural shapes and forms in built environment.	Connection to Nature.
Indoor farm	Eatable indoor plants.	- Food production - Increased awareness of Nature. - Improved air quality. - Enhanced well-being.
Interior plants	Pots and plants.	- Clean the air. - Creates social comfort.
Grow tree inside a building	Innovative indoor greenery.	Connect artificial structures to natural environment.
Aqualibrium	An aquarium combined with herb garden. A way to mainstream Nature.	Aesthetical.
Water feature inside a building	Historical inspiration. Requires advanced engineering.	-
View of Nature	Facing windows towards Nature.	Nature awareness.

The categorisation of building exterior is presented in Table 5-9. Presented are design attributes suitable for the exterior of a building.

Table 5-9. Building exterior categorisation of natural design attributes.

Natural design attribute	**Description**	**Ecosystem service**
Green roof	- Test different combinations of plants, soils and irrigation systems. Suggested research ideas: - Water management through sensors to improve efficiency. - Innovative irrigation system. - Automated irrigation and maintenance. - Combine solar panels with green roof to provide shade on the roof.	- Attract wildlife and promote recreation. - Attract biodiversity at high raised level e.g. birds and insects. - Look cool, and provide health benefits and cooling effects. - Used as an open space for relaxation and patches of vegetation.
Green wall	- Test different combinations of plants, soils and irrigation systems. Suggested research ideas: - Water management through sensors to improve efficiency. - Automated irrigation and maintenance. - Innovative irrigation system.	- Attract wildlife and promote recreation. - Attract biodiversity at high raised level e.g. birds and insects. - Look cool, and provide health benefits and cooling effects.
Trellis	Bushes growing around the exterior of a building. A type of green wall.	-
Solar power	Provides energy and hot water.	Energy and hot water.
Geothermal cooling	Cooling through ground water.	Cooling.

The categorisation surrounding of the building is presented in Table 5-10. Presented are design attributes suitable for the land surrounding a building or a set of buildings in an urban area.

Table 5-10. Surrounding of the building categorisation of natural design attributes.

Natural design attribute	**Description**	**Ecosystem service**
Conservation of existing ecosystems	Consideration of existing ecosystem.	Conserve native plants.
Connectivity	Connectivity through green corridors allow movement of animals and resilient ecosystems.	Increase biodiversity and consistency of Nature. Benefits distributed to a larger area.
Urban farming	E.g. community orchards.	Food production, activation and commitment to Nature.
Swales	Green and blue natural feature.	Storm water management.
Trees and pergola	- Place on the north side of the building to provide shade. - Consider placement in relation to solar panels as they are most efficient on the north side of a building.	- Provide shade in summer but not in winter – possible with deciduous trees. - Select location to optimise wind flows. - To enclose a yard and reduce noise and pollution.
Implementation of greenery in open spaces	- Easiest space to implement Nature. - Create larger open spaces by grouping of houses.	- Activation of open spaces. - Health benefits.
Decrease amount of hard surface	- Build high-raised buildings. - Surround walkways and gardens with greenery. - Lawn instead of pavement. - Wood chips instead of pavement.	- Decrease the ambient temperature and increase cooling effects → decrease urban heat island effect (term described in Appendix I). - Attract wildlife and promote recreation.
Water features with recycled wastewater and storm water	- Natural: streams, lakes or wetlands. - Artificial: fountain grid.	- Social activation of the area. - Attract wildlife. - Cooling effects.
Mass planting of trees	Several different tree species are planted to assess the performance.	Provide breeding for endangered animals.
Aquaponics	Include greenery, water and wildlife. Eatable fish is grown in a pond and vegetation is grown upstream the pond. The fish faeces provide nutrients to the plants and the water is filtered through the plants.	- Food production

A summary of the natural design attributes presented in Table 5-8, Table 5-9 and Table 5-10 is visualised in Figure 5-14. Derived from the natural design attributes are evolving discussions which regard several or all of the categories. A discussion about the importance to adopt natural design attributes to the local climate is raised. Plants and greenery need to be suited for the local climate both at building exterior scale and surrounding of the building. Plants and greenery also need to

be adopted to future climate changes, with intense rain events and warmer summers. But it is also important to consider future development surrounding the plants or greenery. What today is a sunny place might in the future be surrounded with development that provide shade.

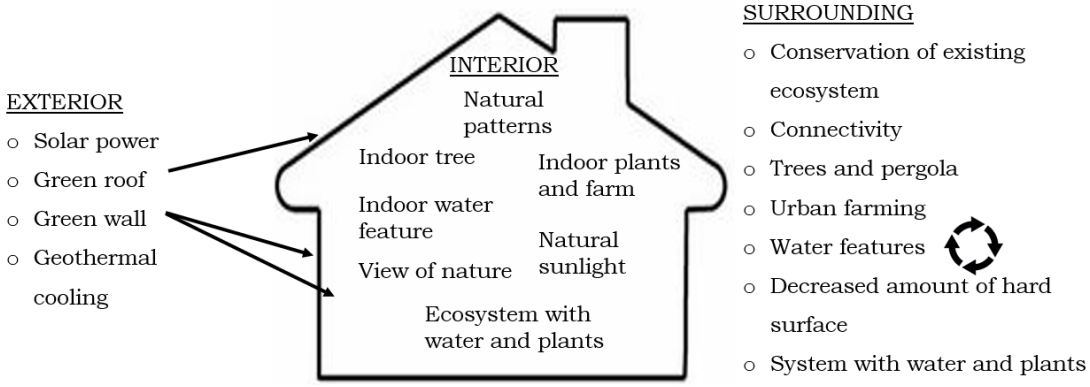

Figure 5-14 Visualisation of the natural design attributes in, on and surrounding a building.

Challenging the idea of adopting greenery to the local climate is to consider the benefits that Nature provide, the ecosystem services. Such benefit is for example cooling through evapotranspiration, a term described in Appendix I. To increase the cooling effects in a hot and dry climate requires plants with a high rate of evapotranspiration. This requires engineering solutions that enable constant irrigation.

It is also discussed that that Nature can be implemented in the urban environment without hindering urban activity. An example is given from Perth where an urban wetland and urban farm is constructed in the city centre, at the roof of a parking lot. The activities performed in the area before the installations are still possible to do, but now in a creative environment.

There is also a discussion about evaluating Nature before it is modified or removed due to human development. At Curtin University this is demonstrated with a "tree replacement plan" where trees are evaluated before modification. The value is formulated as a tree replacement ratio by replanting four new trees when one mature tree is cut down. For instance the tree is valued due to its interaction in the ecosystem and the captured carbon.

5.5.2 Natural Design Attributes in a Living Lab

Summarised in Table 5-11 are the articulated natural design attributes interesting to incorporate in a living lab. The natural design attributes are categorised in the three scales; building interior, building exterior, and surrounding of the building. Each natural design attribute has a description about possible research and weather user-involvement is relevant for the research.

Table 5-11. Summary of natural design attributes interesting to incorporate in a living lab.

Categorisation	Natural design attribute	Possible research	Relevance of user-involvement
Building interior	Green wall	Possibility for eatable plants.	Yes
	Movable plant boxes	Changeable configurations to create different spaces.	Yes
	View of Nature	Facing windows towards Nature. Study how users are affected by Nature awareness.	Yes
Building exterior	Green roof	- Find design for local climate. - Configurations to test: plants, growing media, irrigation system, water source, and structures. - Evaluate financial benefits.	No
	Green wall	Identical to green roof.	No
	Reuse of grey water	Research on water quality in relation to treatment methods and irrigation possibilities.	No
	Solar power	Possibility to combine solar power with green roof.	No
	Geothermal cooling	Possibility for groundwater in cooling systems.	No
Surrounding of the building	Trees	Possibility to use trees in solar passive design.	No
	Urban farms	Possibility to provide activation and community commitment.	Yes
	Wood chips	Evaluate the accessibility for all people.	Yes
	Green spaces	Evaluate how the green spaces are used.	Yes

Four evolving discussions are identified related to the topic. The first evolving discussion is about suitable research projects in the living lab environment and relates to the articulated category Research aim in Figure 5-9. One part of the group evaluates the living lab as a testing environment of natural design attributes without users. The testing should provide evidence on generated benefits with a special focus on financial gains, and the configuration suitable in the local climate. The other part of the group evaluates the living lab as a testing environment of natural design attributes with user-involvement. If the testing of natural design attributes requires user-involvement it fits the purpose of the living lab. Exemplified studies are human interaction with Nature and how the human health is affected by Nature.

The second evolving discussion is about the possibility for natural design attributes to deliver both social and technical benefits when the natural design attributes are accessible for humans. Discussed is the benefits provided by green roofs. The access to the green roof can generate social and cultural activity. At the same time the roof should provide thermal control and storm water regulation. How the technical performance is affected by human activity is a proposed research topic for the living lab.

The third discussion is about the short-term testing environment in the living lab and how this may limit the research on sustainable implementation of Nature.

The final discussion is about implementing green attributes in a living lab for branding. A living lab with a green character is attractive and beautiful. Additionally, it will provide benefits for the occupants in the building.

6 Discussion

Included in the discussion are; an elaboration on the limitations with the research, the discourses on ambitions for sustainability innovations within the Greater Curtin Master Plan, the living lab concept and the concept of biophilic urbanism, and an elaboration on the potential of biophilic urbanism in the living lab concept.

6.1 Limitations with the Research

The assessment of the potential for biophilic urbanism in the living lab concept is done through a case study on the Greater Curtin Master Plan. The potential is evaluated based on the environment and climate in Perth, Western Australia. Furthermore, Curtin Living Lab: The Solar Studio remains in a planning stage. Information on property location and spatial information is not available at the time of the thesis. The potential of biophilic urbanism in the living lab concept is therefore assessed considering the living lab as an undefined building.

The interviewees are involved in the Greater Curtin Master Plan. They are considered as a group of property developers, researchers, and academic experts, all representatives of Curtin University. Whether the potential of biophilic urbanism in the living lab concept is representative for the general society is discussable. The discourses and levels of understanding about the concepts, and revealed knowledge about natural design attributes are affected by the type persons interviewed. The results demonstrate a scenario where the interviewees are homogeneous in terms of common interest for the university, all with a high degree of education. The homogeneous group could imply in less variety in the discourses and reduced variety in suggested natural design attributes. However, that academic experts focused on Nature in the built environment were involved in the interviewed group has most likely reduced the risk for lack of suggestions. The high degree of education may provide a "best case scenario" in the level of understanding about the concepts. Many of the interviewees have worked with one or more of the interviewed focus areas which increase the probability for a collective understanding. Including stakeholders from business and society would increase the probability for occasional understanding.

The method chosen for the thematic analysis of qualitative data is a method developed for qualitative data obtained from focus group interviews. Differences in the type of data was identified through literature. An assumption was made that the analysis methodology developed for qualitative data gained from focus group interviews could also be used for the analysis of in-depth interviews. The assumption was confirmed through the work with the analysis. The method was proven to be structured and made the raw data from the transcripts understandable. Using the method implied a scientific background to the thematic analysis. Nevertheless, it is important to emphasise that the methodology in itself implies subjectivity.

6.2 The Discourse on Ambitions for Sustainability Innovations within Greater Curtin Master Plan

The discourse connected to the ambitions for sustainability innovations present a different content compared to identified themes from the master plan. The

difference is demonstrated through a collective understanding to a few of the identified themes. Most of the themes are either occasionally understood by the group or not considered. Two additional topics are considered important to include as ambition for sustainability innovations. The topics are Sustainable building technology and Value proposition for stakeholders involved in the innovation process.

Reveled through the analysis is that the living lab concept indirectly is identified in the ambitions for sustainability innovations and the concept of biophilic urbanism is identified directly. The living lab concept is indirectly identified by combining articulated ambitions of a Synergy between stakeholders and Hub of innovation. This because the living lab is an environment where innovations are tested and developed in a synergy between stakeholders. The concept of biophilic urbanism is identified directly through ambitions for implementation of Nature and natural elements. It is discussed that the implementation of Nature can be performed by applying biophilic design. That the two concepts can be found directly or indirectly within the ambitions for Greater Curtin expansion area increase the potential for biophilic urbanism in the Curtin Living Lab: The Solar Studio.

6.3 The Discourse on the Living Lab Concept

The discourse connected to the living lab concept is presented in three categories; Shape and form, Activities and Stakeholders involved. The Shape and form is a physical building in a changeable real-life context, but also a culture or methodology. The Activities are testing and evaluation of innovations, research, study on human behaviour, and teaching and learning. Stakeholders involved are academia, business, society and users. Through the attributional level of data it is revealed that some themes relies on an occasional understanding. These themes are Co-creation for innovation and the importance of Users.

Revealed from the analysis are two contradicting sides, one considers users important and one does not. An evolving analysis of how users are considered important indicates on the participatory principle. The principle implies that users are equally important as other stakeholders in the innovation process. The core in the co-creation process is equality and sharing of knowledge. Referred to the participatory principle gives an indication about understanding of co-creation for innovation. The understanding of user importance therefore relates to the understanding of co-creation for innovation.

The value of being involved in the living lab is articulated as benefits for stakeholders. Articulated benefits are development of an attractive area and the possibility for business to test products and services in a real-life environment. An attractive area is a motivator for the university and society because it can create economic activity through business development and visitors. The benefit of testing products and services in a real-life environment before launching at the market implies decreased risk of failure in business or product development. It is important to identify the value proposition for all stakeholders to generate an attractive living lab.

Highlighted through the discourse of Shape and form is the discussion about the living lab as a methodology and a physical building. The research on human behaviour requires a methodology and the implementation of such research requires a physical building. The distinction between the activity in the living lab and the shape and form of a living lab appears to be vague through the interviews. The reason may be the broad meaning of the living lab concept presented in the Greater Curtin Master Plan. In literature similar confusion is identified in the various definitions of a living lab. The implementation of the living lab concept requires both a methodology and a real-life place.

A possible outcome from a living lab is discussed to be behavioural support for sustainable choices. Behavioural support can be formulated as policies or regulations. This may be effective but can also force people to act in a sustainable way, with a risk for rebound effects. Another way of behavioural support is to design for enabling sustainability. In this way people can act in a sustainable way through smart designs. Here the living lab has a potential by combining behaviour and sustainability science with building design.

6.4 The Discourse on the Concept of Biophilic Urbanism

The discourse connected to biophilic urbanism is described by human affiliation, and benefits provided for human and Nature. The group understand that Nature provides benefits for human which indicates an anthropocentric ethical view and an understanding of ecosystem services. It is suggested that the ecosystem services are demonstrated, with a focus on financial gains and the lower environmental impact, to make biophilic urbanism a part of the urban development. Demonstration should also provide practical evidence on how Nature can be implemented in the built environment. The testing environment of a living lab has the potential to demonstrate the benefits and practical implementation of Nature in the built environment.

That Nature generates benefits for a larger area is discussed through improved biodiversity. Biodiversity requires connectivity with other natural features, both discussed by the interviewed group and identified through the literature review. Applied on the living lab concept, connectivity implies a discussion about scale and boundaries. Improved biodiversity can be achieved when the living lab is considered as a part of the urban environment, in a large context. Connecting the living lab to other natural features in the urban environment is essential to create an environment possible to enrich the biodiversity.

Added to the discourse are three measures for implementation of Nature in a sustainable way. These measures are Conservation and promotion of local ecology, Adaption to local climate, and Consideration of natural processes. Conservation and promotion of local ecology is suggested with an appraisal which include the climate and the environment of an area. In the appraisal a value can be assigned to the benefits Nature provides and the natural processes creating the benefits. Thereby the appraisal assigns value to the generated ecosystem services. The local ecology need to be conserved as it is important for biodiversity and increase the urban resilience. It is discussed that a focus on specific species, “speciesism”, may result in a loss of the general biodiversity.

With the knowledge from the appraisal, plants and greenery can be adapted to the local climate. In Perth the adaptation implies management of water shortage and hot temperatures, but also dealing with future climate changes which implies increased number of large rain events and higher temperatures. Adapting to the local climate is challenged by another perspective. Here the plants and greenery are chosen dependent on requested ecosystem services. An example is to select plants with high evapotranspiration rates to provide cooling. The perspective requires innovative engineering solutions where consideration is taken to the natural processes. However, it is important that the solutions remain sustainable. The different aspects, adaptation to local climate or how to obtain requested ecosystem services, need to be addressed dependent on the aim with the implementation of Nature.

6.5 The Potential of Biophilic Urbanism in the Living Lab Concept

Revealed from Table 5-8, Table 5-9 and Table 5-10 are natural design attributes in, on and surrounding a building. The design attributes in the building are greenery, natural shapes and patterns, natural sunlight, and water features. On the building, green roofs and green walls are suggested installations. Regarding the surrounding area of the building, implementation of green and blue features in open spaces are suggested to decrease the amount of hard surface. Connectivity and conservation of existing ecology are two natural design requirements related to the surrounding area. The natural design attributes are possible to implement in a built environment and therefore also in a living lab.

The analysis reveals the need of a testing environment for natural design attributes. Related to the natural design attributes are suggested research topics. Two sides exist connected to user involvement, one with user involvement and one without. According to the definition of a living lab identified through literature, user involvement is a part of the concept. Here technical and social innovations are tested and developed in a real-life context through user involvement. It is concluded from the living lab definition that research topics related to biophilic urbanism will be restricted to user involvement. Although, there is a potential of biophilic urbanism in the living lab concept.

Another discussion about suitable research topics on biophilic urbanism in the living lab concept is the short-term testing environment. The short timeframe implies limitations for research on urban ecology, biodiversity, resilience and sustainable implementation of Nature. A longer timeframe in the testing environment is required to increase the possibility for such research. One solution is the sharing of results in a living lab network. Within the network different settings are tested, but the timeframe in each living lab is longer. Another important factor is the scale and boundary of the living lab. The living lab in a larger context is an important aspect for research on biodiversity.

6.6 Suggestions for future research

In the aim of the thesis it is stated that the thesis will act as a starting point for future work with biophilic urbanism connected to the living lab concept and for further research within the concepts. The future work with the implementation of

biophilic urbanism in Curtin Living Lab: The Solar Studio implies requirements identified through the analysis. The implementation of the living lab concept in Greater Curtin Master Plan need to be defined and communicated to those involved in the master plan. It is also beneficial to distinguish whether the living lab is a physical building or a methodology, or if both are required. Furthermore to successfully implement the living lab concept in Curtin Living Lab: The Solar Studio requires an identification of the value proposition for the stakeholders involved in the lab and the importance of users for the innovation process.

The analysis provide suggestions on natural design attributes possible to implement in a living lab. Further research is required to determine which of the attributes that will be implemented in Curtin Living Lab: The Solar Studio. The implementation of natural design attributes in Curtin Living Lab: The Solar Studio will support future research within biophilic urbanism connected to the living lab concept.

The interviewees provide an occasional understanding to the themes; Lower environmental impact, Conservation and promotion of local ecology and connectivity. To successfully implement the concept of biophilic urbanism in a living lab requires a collective understanding of these themes.

It is stated that connectivity can be created between a living lab and other natural features. When the spatial data for Curtin Living Lab: The Solar Studio is available, further research on connectivity is recommended. It is suggested that a living lab network can be used to test natural design attributes with a longer timeframe. This suggestion requires a cooperation between multiple living labs preferably in the same type of climate zone. Further research is therefore required to define this collaboration and the other criteria needed for this type of research to be successful.

7 Conclusions

The analysis reveals a potential of biophilic urbanism in the living lab concept through the ambitions for sustainability innovations in Greater Curtin Master Plan that directly or indirectly are connected to the concepts. There is also an identified need for a testing environment of natural design attributes in Greater Curtin. Suggested attributes can be implemented in, on and surrounding a building, and are therefore consequently possible to implement in a living lab. Design attributes in the building are greenery, natural shapes, patterns and sunlight, and water features. On the building green roofs and green walls are suggested. Green and blue features are suggested to decrease the amount of hard surface around the building. Conservation of local ecology and connectivity are approaches important to consider in relation to biophilic urbanism in the living lab concept. How the approaches will be addressed in the Curtin Living Lab: The Solar Studio, requires further research. Which of the suggested natural design attributes that should be implemented and the technical design of them requires further investigation.

Related to suggested natural design attributes is a diversity of research topics. However, the living lab concept implies restrictions on the research possible to implement due to user involvement and the short timeframe of the testing environment. To define possible research in the Curtin Living Lab: The Solar Studio requires further investigation. Nevertheless, the potential of biophilic urbanism is not restricted by the living lab concept.

There is a collective understanding that nature provides benefits for human. Today the understanding does not give enough motivation to implement Nature in the urban development. It is therefore suggested that benefits provided by Nature are demonstrated. Together with the benefits, the demonstration gives practical evidence on how Nature can be implemented. Living labs have the potential to demonstrate the benefits and practical applications of Nature in the built environment due to its testing environment. In Perth, Curtin Living Lab: The Solar Studio remains in a planning stage. Curtin Living Lab: The Solar Studio has the potential to demonstrate benefits and practical application of Nature in a tropical to subtropical climate.

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APPENDIX I – GLOSSARY OF TERMS

Term	Description
Evapotranspiration	Evapotranspiration is evaporation from vegetation, and is the sum of evaporation and transpiration. Transpiration is the process where water enters the roots of a plant (Robitu, et al., 2004). This water is evaporated through the pores of the plant by transferring to vapour (Almusaed, 2011).
Latent data	Latent data are data inaccessible without specialised tools and techniques (Nelson, et al., 2006).
Potable water	Potable water are water treated to meet the standards of being drinking water (Enkivillage, u.d.).
Urban heat island effect	Urban heat island effect is described by the difference in maximum temperature between urban and rural areas due to heat created when solar radiation hits hard and paved surfaces (Hankai, 2008).

APPENDIX II – DATA AMBITIONS FOR SUSTAINABILITY INNOVATIONS

Articulated									
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	Innovations for sustainability	A flagship for the city of Perth, a hub for sustainable innovations.	On-going innovation which need to evolve and adapt evolvement from the original design.	**FQ6:** The LL connects to sustainable innovations.	Provide innovations to reach sustainability targets	Innovations developed in collaboration between industry, academia, and possibly the government.	To be the city of innovation and a sustainable community, by supporting research and innovation.		
					The city of innovation				
	Renewable energy, resource efficiency and consumption	Promotion of renewable energy e.g. Solar energy.		Carbon neutral			Resource efficiency	Reducing the environmental footprint whilst improving the liveability.	
							Self-sufficiency	Energy efficiency	Resource efficiency
								Smart control systems for reducing energy consumption	
								Innovations in renewable energy	
	Sustainable transportation	Public transportation network with tram line.		Sustainable transport					
	Natural design attributes	Inclusion of biophilic design principles.		Implementation of greenery			Enhance the implementation of greenery	Biophilic urbanism	Green infrastructure
							Implementation of water management strategies		
	Sustainable building technology			Sustainable buildings and housing	Building according to science		Green star sustainable building community	Modular construction	Smart design and technology
	Value proposition				Lead to a better future (being the leader)				High design value

Question		Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	Value proposition				Practice of their own (the university) research				High quality of life
					Having the whole budget dedicated to teaching and research.				
Why do you think ambitions for sustainability innovations are included in the master plan?	To achieve the vision of Greater Curtin	To fulfil the goal of the university to produce innovative knowledge, through research.		NA	The university perform research on sustainable development why ambitions for sustainability innovations are included.		To support the university to achieve their vision: The city of innovation.	NA	NA
	To generate a synergy between business, society and academia		Generate a nexus between academia, properties and industry.			It provides a value for researchers, the university and the industry.			
Attributional									
Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	*Implementation of green and blue attributes*	Incorporation of biophilic design principles - includes principles for natural attributes in the urban environment.	-	Greenery should be implemented in a sustainable way, suitable for the local climate - sustainable implementation of greenery.	-	-	Provides suggestions of guidelines directed to the implementation of greenery and the use of water management strategies to reach the vision - connected to ambitions are both green and blue attributes.	Suggests implementation of biophilic attributes to be a part of the ambitions for SI - refers to nature and natural elements in the urban environment.	Green infrastructure is an example of sustainability innovation.
	Enhance and promote existing ecology	-	-	-	-	-	-	-	-
	Biodiversity	-	-	-	-	-	-	-	-

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	*Sustainable energy sources*	Promotion of renewable energy sources e.g. Solar energy - promotion of sustainable energy.	-	-	-	-	Ambitions are described by resource efficiency and self-sufficiency - indicates on the use of sustainable energy sources.	GC has guidelines: reduce energy consumption by improved energy efficiency and smart control systems, and innovations on renewable energy - sustainable energy guidelines.	Discussing resource efficiency. And smart design and technology - indicates sustainable energy thinking.
	Sustainable transportation	Development of the public transportation network with a tram line - public transportation is considered sustainable transportation.	-	Sustainable transport by implementation of light rail. Discuss the possibility for this to work as it lack connection to the rest of the PT network.	-	-	-	-	Discussing high quality of life and smart design and technology - might imply sustainable transportation thinking.
	Living Laboratory	-	-	**FQ6: C**onnected to sustainable innovations and mentioned in a broad matter in the plan. Lead to an open interpretation of how it is implemented - the concept can be implemented in different ways.	-	-	-	-	-
	Synergy between academia, business and society	-	-	-	-	Innovations are developed in a collaboration between, industry, academia and the society.	-	-	-

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	*Hub of innovation and research*	A hub for sustainable innovations, a flagship for Perth - a centre for innovation.	-	-	The purpose for GC is to innovate, be the city of innovation, and demonstrate how the innovation should be done. Discuss how innovation should be reached, by including teaching and learning in development, practice of own research, and building according to science. Also discuss what legislation is required.	-	The vision for GC is to be the city of innovation to promote research and support innovation, to be a sustainable community - indicates hub of innovation and research.	-	The ambitions are to provide examples of what is possible in terms of sustainability innovations - indicates that GC promotes innovation and research.
Why do you think ambitions for sustainability innovations are included in the master plan?	*Living Laboratory*	-	LL is seen as an innovative building that provide a nexus between academia, properties and industry - The LL is important to achieve ambitions.	NA	-	-	-	NA	NA
	Synergy between academia, business and society	-	The ambitions can generate a nexus between academia, properties and industry - there exist a value in creating this nexus.	NA	-	Value for researchers, university and industry - To create value for stakeholders a synergy is required to achieve ambitions for sustainability innovations.	-	NA	NA

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
Why do you think ambitions for sustainability innovations are included in the master plan?	*Hub of innovation and research*	Innovative knowledge is generated from research and will create a hub of innovation -this is the goal for the university and Greater Curtin.	-	NA	-	-	To support the university to achieve their vision: The city of innovation - the development will help the university to achieve the vision, connected to creating a research and innovation hub.	NA	NA
Emergent									
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	Innovations for sustainability		On-going innovation is needed - means that innovations need to evolve and adapt to be sustainable. Applied in the building environment: Require a building design that can cope with adaptation and evolvement.		The university has a strategy to provide innovation and leadership - which mean to do something (innovations) first and leading the way.	Due to the collaboration between academia, industry and society, innovations can be implemented in the real world. Important that implementation happens directly for it not to be out-dated - the collaboration is important to create innovation and to implement of the innovation.	The ambitions for sustainability innovations can be achieved by developing design guidelines. E.g. On amount of greenery on and around a building - how to actually make it happen.	A way to achieve the ambitions for SI is to develop policies. The policies should be detailed to attain the required effect - how to actually make it happen.	The challenges connected to sustainability innovations are human behaviour and business case. The easy part is the design and technology behind sustainability innovations - the business case need to be innovative to provide evidence that the investment is paying off.
					Targets are need to be specified for sustainable innovations. To motivate decisions in the right direction and reach min acceptable performance - sustainability				

					targets are required.				
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	Sustainable transportation			Discussing the importance of providing the right infrastructure for the city to become carbon neutral - connects to sustainable energy sources and sustainable transportation?					
	Natural design attributes	Include biophilic principles, awareness of the financial benefits need to be acknowledged - benefits with biophilic design need to be translated into financial benefits to be mainstreamed.							
	Sustainable building technology			Discussing that sustainable buildings and housing is a goal for sustainable innovation - an ambition not articulated in the plan.	Sustainable innovations is about building according to science with the sustainability targets in mind (the sustainable development goals) - to make tomorrow better.		Another way to achieve the ambitions for SI is by using sustainable building certification - how to actually make it happen.	Modular construction is suggested to be an example of sustainability innovations to include - may refer to sustainable building.	

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
What do you identify as the ambitions for sustainability innovations related to the master plan?	Value proposition				By adopting a culture of teaching and research into the budget of the university and the development projects, makes the investment used efficiently in to reach the goal for the university.				
Why do you think ambitions for sustainability innovations are included in the master plan?		-	-	NA	-	It provides a value for stakeholders involved. Researchers: see direct application of the research, university: help to achieve goal to make tomorrow better, industry: helped in business development - value proposition for stakeholders in collaboration.	-	NA	NA

APPENDIX III – DATA THE LIVING LAB CONCEPT

Articulated										
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Sub categorisation
What does a living lab imply for you?	Shape and form of the LL	A building or a place	A place	Physical environment	A culture		The entire university can be considered as a LL.	One place	Operational environment.	Shape
			Physical building						Scale of a house or bigger.	
									A process	
			Real people	Real life context		Environment with real situations				Real-life situation - Form
						Real people				
						Constantly changing environment.		Changeable building.		Changing environment - Form
	Activity in the LL	Innovative ideas are incorporated and evaluated	Test products and services	Test new products and services	An innovative space.			To achieve sustainability innovations.	Testing of innovations delivering low-carbon living.	Innovation
			Innovations can be introduced					Innovative concept.		
					Research	People living and working in the lab are performing the research.			Research through action by doing.	Research
				Analyse behaviour and interaction		Study on peoples interactions with the environment and innovations.			Provides learning on building performance and human behaviour.	Study on human behaviour
					Teaching		Teaching and learning is built into the day-to-day development within GC.		Provides learning on building performance and human behaviour.	Provide teaching and learning

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Sub Categorisation
What does a living lab imply for you?	Involved in the LL	Data generates benefits to university, industry, the public, and policy makers.	-	Business and real life people come together	Engagement between academia, industry and outside bodies to create partnership.	-	Connects teaching and learning (Students), business/industry, and the university.	Industry and university are brought together.	Innovations tested in collaboration with business.	Involved stakeholders
				Researchers involved						
					A place for collaboration between different stakeholders.		Stakeholders work together to achieve a common goal.			Working environment
	Others	Complex design			A part of the vision for GCMP.			Operated by industry partners.		-
Which main stakeholders should be involved in order to successfully implement the living lab concept?	Academia	University represented by researchers-main stakeholders.	Academia	Researchers	Teacher and researchers	Researchers	NA		Researchers	Researchers and teachers
						People working in the lab.				
		Curtin Properties	Properties/Management		University professionals			Curtin Properties		Property people
	Business	Building industry working with sustainable innovation	Industry	Business	Industry		NA	The private sector	Industry	Industry
		Designers, interior designers.								
		Architects and landscape architects								Consultancy
						Property developers				Property developers

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Sub Categorisation
Which main stakeholders should be involved in order to successfully implement the living lab concept?	Society		-			Society/General public	NA	-	Community	Public
		Council representatives		Local council	Government				Agencies developing regulations	Government
									Local government	
	Users	-	-	Real-life people	-	People living in the lab - consciously or unconsciously participating.	NA	-	Participants	
	Relationship	-	-	-	Every stakeholder is considered equal.	-	NA	-	-	
	Purpose dependent	-	-	-	-	The main stakeholders are depend on the aim of the research.	-	-	The stakeholders involved depend on the scale and the goal of the project.	
Attributional										
Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
What does a living lab imply for you?	*Innovation*	Innovation are tested in the LL environment and evaluated - the innovations work or fail.	Two types of innovations can be tested; Innovations available on the market, or Experimental innovation - testing and developing innovations is an important part of the LL.	Test products and services new to the market - provide understanding of innovation and the testing of innovation.	-	Peoples reaction to innovations are studied - implies that innovations are present in a LL.	-	The aim with the LL is to develop sustainability innovations.	Innovations for low carbon living are tested - a goal with the living lab is to test innovations to provide learning.	
	Research	Research is performed by the testing of innovations. Data is collected and evaluated to test if the	Research is performed by the testing of innovations.	Products and services tested by researchers - research involved.	Opportunity for research and the culture implies research in development projects related to	The study of people's behaviour implies research and it is discussed that the ones living and working in	-	-	The LL concept is research through action by doing - a specific research methodology is described.	

		innovations work or fail.			GCMP. Research is a big part of the culture.	the lab are participants in the research.				
Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
What does a living lab imply for you?	*Co-creation for/of innovation*	-	-	(Emerged from 2b) Discuss co-creating for innovation by elaborating on the importance of the participants (real-life people) involvement to create innovation.	(Emerge from 2b) Academic and professional staff (Marketing, administration and properties) work with industry to provide teaching and research - Co-creation between stakeholders is needed. Transdisciplinary knowledge, stakeholders share the vision and are considered equal.	-	Discussing the importance of the stakeholders working together to achieve a common goal - co-creation. However, the common goal is not defined, but could possibly be to create innovation.	Industry and university are brought together to achieve sustainability innovations - co-creation facilitates innovation. Has a belief in the industry which may decrease the importance of the co-creation process for innovation.	Discussing the importance of collaboration between research and business to test innovations - the goal seem to be to evaluate innovations and the behaviour related to them, rather than create innovations.	
	Real-life place	-	A place/physical building with real people - real-life place	Physical environment in a real life context - real-life place	The culture can be applied on a real-life place (ex. Curtin LL)	Real-life people are studied in an environment with real situations.	-	-	Human behaviour is studied in an operational environment with the scale of a house, or bigger.	

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
What does a living lab imply for you?	*Involvement of different stakeholders*	-	-	Business, real-life people and researchers	Research, teaching and engagement with industry and bodies outside the university - LL provides opportunity to involve stakeholders for research and teaching.	Discuss about the ones working in the lab (probably researchers) and the ones living in the lab - two different stakeholders involved.	The connection between Students, Business, and the University suggests a multidisciplinary stakeholder involvement.	People from industry and university are brought together - two main stakeholders involved.	Collaboration between researchers and business. Involvement of people living in the lab is indicated by the aim to perform behavioural studies.	
Which main stakeholders should be involved in order to successfully implement the living lab concept?	*Users*	-	-	Real-life people consciously involved - participation and evaluation - participatory	-	(Emerged from 2a) People living in the lab - consciously or unconsciously participating. Discuss that people living in the lab can be participants in the research - participatory.	NA	-	The participants are the ones active in the research - cannot draw conclusion on degree of participation.	
	Academia	University is the main stakeholder and Curtin Properties is considered a stakeholder. The researchers at the university should be included in the design, building, and monitoring of LL.	Academia and property/management - difference between the research part of the university and the professional part.	Researchers - perform the innovation, not all stakeholders is a part of the innovation process - lack of insight in co-creation for innovation (Connected to 2a)	Academia means teachers, researchers and professional staff difference between the research part of the university and the professional part.	Researchers, and Curtin Properties as a part of the property developers - represents the university.	NA	Curtin Properties - a part of the University, they have the possibility to incorporate criteria for innovation.	Researchers represent academia.	

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
Which main stakeholders should be involved in order to successfully implement the living lab concept?	*Society*	Council representatives - a part of society	-	Local council - a part of the society	Government - a part of the society.	The society need to be involved to support the LL and the ideas behind it - reveals the importance of having support from the society.	NA	-	State agencies and local government developing regulations, and the community that benefit from the research.	
	Business	Group of industry partners: Designers, architects - create the building criteria. Companies involved in the building sector that can provide sustainability innovations.	From the technological point of view the industry is important as they provide input to solutions - the role of the industry.	Business	Industry - Business	The industry and the ones building the structure - can represent business.	NA	The private sector, where the innovations occur.	The industry that has the possibility to test products and services in the LL environment.	
Emergent										
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
What does a living lab imply for you?	Outcome of the LL space	Discussion about who benefits from the testing of innovations in a LL. Benefits are provided for a variety of stakeholders, e.g. university, industry, the public and policy makers.		-	This innovative space will attract people to the GC precinct.	-	-	-	The outcome of a LL can be behaviour support for people to make good choices. Also a basis for policy making. - Enabling design or "forced" design for sustainability.	

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
What does a living lab imply for you?	What innovations can be tested		Innovative products and services need to be fairly developed before tested in a LL due to the real-life place environment.							
	Elaboration about the teaching and learning in the LL	-	-	-	The Living Lab culture implies that teaching and research is built into development projects related to GCMP. The whole budget for the university is dedicated for teaching and research.	-	-	-	-	
	Elaboration about the shape of a LL	-	-	-	-	**FQ4:** The LL concept is considered both a methodology and a physical building. The behavioural research requires a methodology, and the innovations are tested in a physical structure.	-	-	-	

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
What does a living lab imply for you?	Elaboration on stakeholder involvement in the LL	-	-	A business model is needed to involve stakeholders and enable innovation - Further explanation how people can come together.	-	-	-	Essential that the industry is involved, as they deliver sustainability innovations. It is suggested that the industry should build, own and operate the LL to enable sustainability innovations.	-	
	Elaboration on the scale of the LL.	-	-	**FQ3:** The size of the physical environment affects the feedback and control of the occupants. Large area means less control and feedback, small area means more control and feedback.	-	-	-	**FQ5:** To apply the LL concept on a precinct is preferable because infrastructure systems are included - sustainability need to be considered at a larger scale, not only in a building. However, the Solar Studio will be a good example for the rest of GC to follow.	-	

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	
Which main stakeholders should be involved in order to successfully implement the living lab concept?	Purpose dependent	-	**FQ2:** Occupants are important if feedback is required for the experiment. The role of the occupants can be consciously or unconsciously studied, resulting in different type of representation of the real behaviour. Pre-choosing the ones living in the lab gives a lack of diversity of people.	-	-	The importance of people living in the lab depend on the aim of the research. The research may require consultancy with the people or not (as opposed to the case where the people's behaviour is only recorded) - This may imply that there is not a fixed set of stakeholders to define it a LL, rather that the aim of the research define the stakeholders involved.	NA	-	-	
	Type of feedback	**FQ1:** The importance of the occupants depend on how keen they are on becoming a part of the experiment, and their initial knowledge. A diverse social group gives more valuable data.	**FQ2:** The role of the occupants can be consciously or unconsciously studied, resulting in different type of representation of the real behaviour. Pre-choosing the ones living in the lab gives a lack of diversity of people.			The main stakeholders are depend on the aim of the research.			The stakeholders involved depend on the scale and the goal of the project.	

APPENDIX IV – DATA THE CONCEPT BIOPHILIC URBANISM

Articulated									
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
Why to include Nature in the built environment and what benefits are provided?	Human affiliation to Nature	People have always lived in close relationship with nature.					Easier to connect with soft natural elements, compared with hard concrete elements.	Human need the interaction with nature	Human affinity to nature
		Humans have an innate attraction to nature							
	Benefits for humans	Human health and well-being	Positive social impacts.	Health benefits for humans.	Health benefits.	Physical health, inspire physical activity.	Enhanced well-being.	Physical health benefits	Mental health
				Mental health benefits for humans.		Mental health, reduce stress.	Indoor: Increased productivity and attentiveness.	Mental health benefits	Physical health
							The outdoor area is activated by: Shade, shelter and seating.	Improved rehabilitation	Social health
								Improved working (office) environment	
	Benefits for nature	Enhanced urban biodiversity				Regulate water cycle	Reduce air pollution and emissions.	Environmental gains, e.g. Storm water retention	Cleaning the watersheds
		Increased resilience				Biodiversity	Negative environmental impacts with introducing hard/solid surfaces.	Increased biodiversity	
							Reproduction of animals.	Conservation/ implementation of ecosystems	

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
Why to include Nature in the built environment and what benefits are provided?	Technical/societal benefits	Food production	Technical performance e.g. Thermal comfort and energy efficiency.	Heating and cooling effects.	Improved air quality.	Thermal control	Reduce heat island effect.		Technical design benefits
				Provide benefits to adapt to future climate changes.		Shade	University takes the lead towards sustainability.		Monetary gain for the society due to human health effects
				Economic benefits.		Clean the air			Reduces the urban heat island effects
									Improves the thermal performance
How can Nature be implemented in a sustainable way?	Conservation and promotion of local ecology.	The degree of housing development affects how nature can be implemented in a sustainable way.			Involve expertise from the university.			Incorporate regulations on greenery in design principles.	Capturing the broader benefits of nature.
		If no development is present, an appraisal of the existing ecology is suggested.							
		If there is existing development, the appraisal is performed on surrounding ecology.							

Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
How can Nature be implemented in a sustainable way?	Adaption to local climate		Adopted and optimised for local climate.	Plants and greenery have to be suitable for the local environment, especially to the climate.	Adaptation for current/local climate	In development projects, considerations should be taken to the existing environment.		Test different configurations of green features.	Installations need to be adopted to the local environment and climate.
					Related to Perth; adaptation for water shortage	Chose native plants suitable for dry and hot climate in Perth.			
	Consideration of natural processes		The natural processes providing a benefit need to be considered when a natural attribute will be implemented.	All nature is needed to provide biodiversity.	Long-term-thinking.				Perform Life Cycle Analysis (LCA) of green solutions
				Management of water is important e.g. By recycling of water.					
If Nature is applied in/on/around a building, could it provide benefits for a larger area?	Benefits for Nature	Increase the biodiversity for the entire Greater Curtin precinct.	Provide biodiversity for the urban area.	Increased biodiversity in the area	NA	Improve biodiversity through connectivity.	NA	NA	
	Benefits for humans		Increased accessibility to nature.	Reduce heat island effect		Reduce heat island effect.			Benefits from nature affects the occupants, people in the surrounding, and induce a happier and healthier community
			Green facade look good from a distance.	Health benefits for people in the entire area.		Better air quality.			
						Improvement of soil.			

Attributional									
Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
Why to include Nature in the built environment and what benefits are provided?	*Lower environmental impact*	-	-	-	-	-	Reduce amount of hard surfaces. Discuss the consequence of removing green attribute and replace with hard/solid surface. This means loss of benefits due to re-movement and negative impacts due to replacement. E.g. Loss of interaction with nature and increased temperature - Include nature to decrease amount of hard/solid surfaces but also about conservation of nature.	-	-
	Affiliation	Humans have an innate attraction to Nature. Imply that the environment feels subconsciously friendly. Additionally humans have evolved in close relationship to nature.	-	By seeing and being in nature makes people more calm and relaxed, and reduces anxiety - human needs nature to be healthy.	-	-	Humans connect easier with soft (natural) elements, and nature Improves human well-being - human affiliation to nature.	Human need interaction with nature and humans have co-evolved with nature and are therefore physically and mentally enhanced by nature - affiliation	Human affinity to nature is connected to health and social benefits. Removing nature from the human environment cause negative consequences on human health - humans need nature, affiliation.

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
Why to include Nature in the built environment and what benefits are provided?	*Conservation and promotion of local ecology*	-	-	-	-	-	-	If nature and natural elements are implemented in the building environment existing ecosystems can be conserved or improved. Leads to improved biodiversity.	-
	Ecosystem services	Benefits provided from nature are for human health, e.g. By increased urban biodiversity, food production, and improved resilience. Benefits are provided for humans, not nature in itself.	There is a need for nature due to positive social effects and technical performances - nature provide benefits for humans.	Health, environmental, and economical benefits are provided by nature - ES.	Health, environmental, and economical (University) benefits - ES.	Health and environmental benefits, and biodiversity - ES.	Social benefits, environmental benefits, human health benefits, and economical benefits.	Benefits; environmental, social, human health and biodiversity - ES	Human health benefits, environmental benefits, social benefits - ES, benefits for human
How can Nature be implemented in a sustainable way?	*Conservation and promotion of local ecology*	Both where no development and where development exist it is suggested to conserve and promote local ecology. It is done by assessing existing environment, described by the landscape, flora and fauna.	-	All nature is needed to provide biodiversity. Nature also includes animals - indicates that the local ecology is important for biodiversity.	-	-	Conservation of existing environment can be done by including landscaping in the budget for new and existing development or by legislation that protect the natural environment.	-	-
	Connectivity	-	-	-	-	-	-	-	-

Question	Theme	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
If Nature is applied in/on/around a building, could it provide benefits for a larger area?	*Connectivity*	-	By implementing patches of grass between green areas enhance biodiversity - connect green areas.	-	NA	Improve biodiversity by green corridors that connect green areas - connectivity enhance biodiversity.	NA	NA	-
	Ecosystem services	A LL could become a good example of how to increase the biodiversity in GC - Benefits provided by increased biodiversity at property level are provided for a larger area.	Economic benefits by adding more value to a building - ES. Biodiversity for the urban area.	Health benefits by being around greenery, reduce heat island effect by reduced temperature, and increased biodiversity in the area - ES; environmental, human health and biodiversity	NA	Environmental benefits by cooling, improved air- and soil quality. The soil quality is improved by more trees, which produce more leaves that improve the soil when composted - ES.	NA	NA	Benefits provided to the human population in three scales; the occupants, the surrounding, and the broader community - ES
Emergent									
Question	Categorisation	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8
Why to include Nature in the built environment and what benefits are provided?	Benefits for Nature	Policies for a percentage of greenery on and around a building is suggested – Emerge directly from the focus area biophilic urbanism as it describe a measure on how to implement greenery.	-			-	-	Speciesism: focus on protecting and implementing local species in urban area. The urban environment may not be suitable as the habitat may be too small. Rather than working with specific species, improvement of the general biodiversity can be done by implementing species suitable for the local environment.	-

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Why to include Nature in the built environment and what benefits are provided?	Technical and societal benefits			To adapt to climate change through implementation of nature provides financial benefits. Suitable plants and greenery can help resist climate changes - not only financial benefits aesthetically but also through resilience, nature can be seen as a long term investment.	Implementation of the university research, regarding nature and natural attributes, is evidence of innovation and leadership and therefore provide benefits for the university - fulfils the goal of the university.				
How can Nature be implemented in a sustainable way?	Adaption to local climate		Solutions for green roofs and green walls need to be tested in the local climate in Perth to adapt optimise their performance - indicates system thinking.	Discussing the importance of choosing greenery suitable for the local environment and climate. Both present and future climate need to be considered (climate changes) -indicates system thinking.		There is no general way of implementing nature in a sustainable way. It is a matter of handling nature from case to case. The solutions for nature need to be adopted to local climate - indicates system thinking	Important to choose native plants suitable for dry and hot climate in Perth - indicate of system thinking	To test different biophilic configurations in a LL is a way to translate theory into practice, which will show good examples - practices/good examples are needed to mainstream the biophilic theory.	The installations of nature and natural elements need to be adopted to the local environment. The local environment in Perth requires: shade (trees), plants suitable in sandy soils, water recycling (water shortage, hot climates), water management (irrigation).

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How can Nature be implemented in a sustainable way?						In Perth; An adaptation is water shortage. Suggested are plants that require less water, less water intense irrigation system, and an innovative water source.			
	Conservation and promotion of existing ecology.	Conserving existing ecology is expensive and not required by legislation. Conservation of habitats are considered if it concerns protected species or areas. Therefore conservation of local ecology often is excluded.			Sustainable ideas can be generated from expert involvement. For GC experts are available at the university - sustainable process thinking.		Overcome engineering view to choose technical solutions, with cheap installation and maintenance. These often neglect conservation of existing nature. Can be overcome by classifying land as natural heritage to challenge the view.		The broader benefits with nature need to be communicated to the society. The broader benefits are described in 3a). The benefits provided to the human health can also generate economic benefits for the society.
	Natural processes		To get the benefits (ES) provided by nature, the natural processes providing the benefits need to be considered in the context where the attribute will be implemented. E.g. A green roof should provide thermal regulation, this mean that a thinner layer of insulation is required - indicates system thinking. Another	Management of water features in the urban is important. This due to water shortage in Perth, and fast evaporation of open water due to the warm climate. It is suggested that the water is either recycled, or desalinated using	To implement nature requires a long-term-thinking to make it sustainable - indicates system thinking.				LCA of green installations – system thinking

			example (from 3c) is to consider the length of the grass to provide biodiversity.	renewable energy sources.					
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If Nature is applied in/on/around a building, could it provide benefits for a larger area?	Benefits for Nature		Greenery can add more value to a building - economic ES.		NA		NA	NA	-
		Nature applied on the exterior of a building serve as inspiration for people in the area - inspires people to do something similar, which creates more nature in the area, and hence more benefits – emerge from biophilic urbanism.		Applied nature in/on/around a LL can inspire people in the precinct to do something similar - inspires people to do something similar, which creates more nature in the area, and hence more benefits - discussed that the trend applies in business and residential areas – emerge from biophilic urbanism.		Discussing how nature can be enhanced by overcoming existing barriers - enabling nature in the built environment is not mainly about presenting the benefits with nature, it is also about identifying and work with barriers against nature – emerge from biophilic urbanism.			