URBAN LIVING LABS: ROLE AS A PLATFORM FOR SMART AND SUSTAINABLE MOBILITY TRANSITIONS

MASTER'S THESIS IN THE HUMAN GEOGRAPHY:
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Summary

Cities are the major contributors to environmental degradation because of the increasing urban migration and thus resulting in high traffic congestion and CO2 emissions. Mobility in cities has been a problem that has been intertwined in Large scale systemic planning thus, making the geo-embeddedness/area-specific issues a secondary concern. However, in the thesis by choosing to study ULLs major focus has been laid on the ways in which the transportation planning can be unfolded from the clutches of systemic difficulties and move towards understating transitions from a pocket area scale i.e. dealing with niche level problems through pilots and upscaling it to regime level to implement them over large area.

The contribution of ULL to sustainability transition has been thus studied from mapping 3 ULLs while understanding their structures, goals, pilots implemented, participants involved, the evaluation criteria, upselling and its constraints etc. in the finings chapter to see the transitions unfolding in these ULLs. The three case studies are Strijp-S Living Lab, Helmond city: Driven Living Lab and SUMMALab.

This thesis recognized the role played by different participants in enabling and also destabilizing the transition process in the labs. The nature and the key characteristics of the lab has a crucial part to play in conducting and evaluation of the ULL. Additionally, the vision and goals of the labs are important to customize the knowledge created to address geo-specific issues. It has been found that impediments are many in this vague real-life experimental set up to become efficient and produce the expected results. Above all this study focuses on how ULLs transition and fits in the transition management model. Municipalities play a key role as in all three labs studied it's the funder thus, limiting also the transitions for reasons like commercialization. The technologies weighs in heavily in mobility-based living labs to provide better and smart living.

Preface

A year ago, I started my master's in human Geography while stumbling on many potential topics to research on in the Urban sustainability transitions. Right then I had this recent phenomenon which many cities across the world are using to deal with area-specific problems caught my attention. I took a short course about Urban Living Labs and their contribution to sustainability transitions in online platform called Coursera with Lund University. My commitment to recognizing the key role played by Economic Geography in sustainability transitions led me to choose Economic Geography while also following the course Urban and Cultural Geography. The courses in my masters helped in studying placemaking, the sense of place, economies of scale, Urban planning from new perspective. Simultaneously, I chose to study Urban sustainable mobility and the impact planned mobility in cities have on making transitions possible.

Finally, I settled on writing my thesis on Urban Living Labs (ULL) which are mushrooming almost in all Dutch cities. That's where the journey began, in the beginning I planned to research on green mobility like introducing alternative modes of transport. However, I found with research that smart mobility is one of the key factors in the chosen ULLs to embrace transitions. Thus, studying the combination of smart and sustainable mobility has become inevitable. However, delineating my thesis and choosing key variables to study as wells as operationalization of the theoretical framework in unprecedented times bought by COVID-19 pandemic in a foreign country were the hardest parts. Although the scope of my thesis has been shrunk, I managed to finish my research and come up with legible findings.

I would like to thank my Thesis Supervisor Arnoud Lagendijk for bearing with indecisiveness and question while helping me to finish this thesis. I would also like to thank my peer group members who helped in address the flaws since beginning and provided me guidance. Additionally, I would like to thank Martin van der Velde and Shoichiro Arai my classmate for their additional guidance and help to finish this thesis. I would also like to thank the interviews with Wouter Beelen and Yashar Araghi two experts from Strijp-S Living Lab and SUMMALab.

Finally, I hope after this intense season I could contribute to the literature on ULLs and mobility transitions with my findings. I hope that the vision to equip cities with their own customized Living Labs will help in taking right steps to deal with the CO2 emissions and providing safe and hustle free transport through better technologies and alternative modes of transport. Thus, contributing to better lifestyle for the respective citizens and globally.

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Chapter 1: Introduction

"*Imagine that space is becoming flexible, it's defined in real time by digital technology, and so everyone has the impression they live in a 100-square-meter space. We should be dreaming up living buildings, convivial structures and porous properties. We mustn't forget that architecture isn't just about what a building looks like, it's about living inside it too.*"

- Eric Cassar, architect.

This thesis is about studying the usage of Urban Living Lab (ULL) as a tool to promote urban innovation and capture the potential in urban areas to become sustainable. The main focus will be on sustainable mobility and the role played by ULLs. ULLs are popping like Mushrooms in all parts of the world especially in Europe (The European Network of Living Labs). As this consists of co-creation, Multi method approach, user-involvement along with multi stake holder participating in a real-life setting aids in understanding the location-specific problems related to unsustainable lifestyle can realized and solved (U4iot Handbook). As 50% of the world is already living in urban areas and the trend is only going to increase in the future. Establishing or using living labs to handle sustainable transitions can be a possibility. As these changes are linked to the urban resident's lifestyle and the diffusion of knowledge intrigued me as they are integral part of both Economic and Urban geography. The quote reflects the necessity of an alternative way of living in cities for making your surrounding sustainable and lively. With increasing technology used in smart cities cannot be the only way to sustainability however, using them in a specific zone can help in addressing the short falls efficiently.The key concepts involved in the thesis topic are sustainable mobility transitions, understanding individual behaviour and habits, elements like infrastructure and certain impediments towards transition, the scale in effect factor which means studying the already existing influence, transition taking place at a certain level from community context/ neighbourhood involving multiple actors/stake holders like non-profit organisations, municipality, residents etc. The literature review on the existing research on role of ULLs in Sustainable transitions. The above-mentioned concepts talk about the necessary physical, social and institutional elements, factors crucial in studying the transition process. I plan on to use urban living labs setting to make the experience of using sustainable modes of transport (green transport) more satisfying to the

residents in a monitored setting. This I believe can yield in better understanding and management of transitions in itself and coming up with ideal and innovative ways to adopt green transport. In order to be successful in this I plan on to use **overlapping domains framework** to structure my thesis including transition management.

A living Lab is defined by Anna Ståhlbröst of Botnia Living Lab, "A Living Lab is an orchestrator of open innovation processes focusing on co-creation of innovations in real-world contexts by involving multiple stakeholders with the objective to generate sustainable value for all stakeholders focusing in particular on the end-users" Quadruple helix involvement is identified in the labs these days as it includes the representatives from public sector, universities, companies, and citizens in the innovation process. It aids in dealing with local challenges in collaborative process of innovation, testing and evaluating further possibilities (u4iot, 2019).

1.a. Issue: The whole thesis is about dealing with urban sustainable mobility and the following transitions using the urban living labs as a tool. The reason behind studying sustainable transition is the urgent necessity to make the transportation sustainable for all. But, especially in big cities this phenomenon cannot be brought easily. There is a need for renewal of the system and this change/renewal is known as sustainability. Yet, with a complex world we also have complex relations and dynamics. This intertwined complexity can be handled when there is creation and diffusion of knowledge through innovation. One such innovative setting is using urban living labs to study and monitor the progress to introduce the technologies and policies elsewhere. Simply put, the issue is to handle the unsustainable transportations system of the contemporary cities and in order to do this I encourage the usage of alternative mode of transport. But as I also take into account the impediments to adopting green and smart transport as a lifestyle is inconvenient, I recommend doing this in a living lab setting where there is more space and ease to adopt innovative technologies and alternative modes of transport. My thesis will be based on understanding how we can reflect on sustainable transitions, efficiency of Urban living labs, and the constraints to upscaling.

1. Societal relevance:

Urban areas with never ending exodus of people moving are congest with high density of population that evidently puts pressure on the transportation systems. This can include varying issues like inadequate use of public transport and over usage of cars. This situation thus seeks for a change and this change can be studied as sustainable transitions. Now, even if

Sustainable transitions is an umbrella term for many environment friendly transitions this thesis will deal with the urban sustainable mobility transitions. As explained earlier this can be done using urban living labs setting. The relevance of urban living labs is that they are one of the best possible tools to study the urban resident's lifestyle changes like adaptation and resistance to new routine. This is most certainly related to my thesis as I plan to observe the behavior patterns of people. The study by Governance of Urban Sustainability Transitions (GUST) describes urban living labs as Geographically embedded and not predominant virtual platforms. All these testing of innovations in technologies, policies are highly visible and ULLs have to be owned by clear leader or owners with a delicate balance between controlling and steering. The time to time evaluation of actions and the impact helps in generation of formal knowledge. ULLs have to be flexible to accommodate all stakeholders. There are different types of ULLs like Strategic, civic and Grassroot. Additionally, Living Labs help in involving residents evidently as a result co-producing the whole project. Research in this field has specified that IOT systems requires the involvement and data collection regularly from residents which is also reflected in the smart-city studies. Another major component of using ULLs methodology is co-production coping with policy changes at local level (Nesti,2018). Co-production encourages the user participation which is lacking both in new public management approach and in practice by bureaucrats and professionals. Thus, it helps in 'customization' of services and performance in a living lab (Joshi & Moore, 2004). This requires understanding user's needs by policy makers and public managers to make the policy inclusive and open for all to critique. Co-production as a tool can be used for co-designing, co- evaluation and can involve different types of users.

Using co-production is also seen as democratic way of conducting a research as it also provides insights into the evolutions and success of a transition and transformation. Figuring out the possibility to introduce varied modes of transport already have been successful in Netherlands however, the usage of cars has remained or come down only with less success. Thus, we need to develop a multi-disciplinary discourse to solve multi-faceted problems in a local community. I suggest this multi-disciplinary discourse by taking into account the lack of work being done to bring different disciplines thus methodologies, techniques together and build a platform to enhance the ability of urban living labs. To add, the citizen science part of a living lab has to be given greater importance and attention along with the innovation and usage of technology. Innovation should be the basis for an urban living lab methodology as it deals with sustainable change(transformation).

2. Scientific relevance:

It all starts with the movement in a city, it is well known that mobility in city is its lifeline. It is important for the economy and daily activity in cities but due to the increase in urban dwellers like never before transportation became a burden to our urban environment. This unsustainable phenomenon has many negative impacts on environment, public health of residents and the economy altogether disrupting the society (Banister, 2005). However, there are many models under progress to introduce sustainable transitions to the sustainable mobility. Thus, this thesis will use the Transitions theory to study the change and models that can be built to bring in the alternative modes or carriers like e-bikes or bi-cycle (Köhler, Whitmarsh, Nykvist, Schilperoord, Bergman, Haxeltine ,2009). This I believe can help in understanding the resident's desired changes that can be introduced. For this one can use actor-network modelling.

With raising discussions and need for de-carbonizing the society is seen as better condition to introduce bicycle or e-bikes as an important mode of transport. As there is a requirement for fundamental changes in the technology, design, operation and financing of transport systems (Greene and Wegener, 1997). Initiatives to change the lifestyles can be benefitable not only to the people but also for the welfare of the society in whole. And I believe these innovations need testing beds as they are complex to randomly bought into practice. These testing beds or areas are scientifically called Urban Living Labs (ULLs). All across the world they have become a fashionable phenomenon that tackles challenges, fostering the development, implementation of innovation experimentation, knowledge in urban, real-life settings while focusing and embracing on key characteristics like co-creation demanding participation from all stakeholders (Steen & van Bueren,2017).

In the words of Prahalad and Ramaswamy, 'The essence of a living lab is that the solution is sought together *with* the user, rather than just applying a fixed solution and involving the user only for testing. To qualify as co-creation, the targeted users need to be involved in the various development phases of the living lab process: not only should they be asked for their opinions, they should have decision-making power throughout the phases' (Prahalad & Ramaswamy, 2004).

Thus, stakeholder's participation including users become integral part of the development of urban living labs. There are all kinds of actors ranging from public to private like users, governments, businesses, firms and knowledge institutes that influence the outcome in a living lab setting. These are some of the characteristics of Urban living labs (Steen & Van Bueren,

2017). `Another major component of Living Lab methodology is the Co-production. Co-production as a tool can be used for co-designing, co- evaluation and can involve different types of users. Nabatchi et al., defined co-production 'as an umbrella concept that captures a wide variety of activities that can occur in any phase of the public service cycle and in which state actors and lay actors work together to produce benefits.'

Eco-design meaning the economic and socio-cultural innovation needs communication between the user and the companies in society to serve as bridge between intelligent need satisfaction and the technical solutions. Thus, the need for a modern design and innovation-oriented economy has been noted by EU report. While dealing with sustainability ecological design is essential to sustainable society. Thus, integrating the ecological design into the lifestyle of users and by integrating into the value chain is crucial factor to embrace Urban Living Labs (Christa Liedtke, et.al, 2012).

Urban living Labs like other form of experimentation involves a more interventionist, 'learning by doing' governing approach in which urban sustainability is emergent rather than pre-given (Bulkeley, et al., 2017). There is a need for more empirical work to explore the extent to which these diverse responses achieve their intended impacts and the unintended consequences these might produce in shaping urban sustainability transitions. This thesis will be about studying this innovation in living labs and recognize the short falls and ground realities when it comes to co-producing it. Thus, can contribute to the debate of the role of living labs in sustainable transitions.

3. Research objective and questions:

The research objective of this thesis is to understand the how urban living lab works. Along with it How to study and use the methodology of living labs to figure out the area/region specific problems and introduce innovative tools to tackle them especially in respect to Urban sustainable mobility. Additionally, observing the structures and institutions that comprise the living lab is crucial part of the thesis. Finally, studying the co-creation of the living labs involving the stakeholders, studying the upscaling that is important specifically to see transitioning in mobility sector. (i.e., citizens, businesses, organisations, municipality etc.)

Main Question:

How does living labs aid or (contribute) in sustainable transition particularly in the field of smart & sustainable mobility?

Sub-questions:

The first 3 questions cover the theoretical research part while the fourth and fifth sub questions are used in empirical research questions answered in combination in chapter 2 and 4.

1. How does specific characteristics of urban living labs aid sustainable mobility transitions?

2. How urban living labs will make a dent into the regime? Where are the chosen living labs as case study stand in this transition level?

3. What are the main impediments faced by the ULLs while upscaling?

4. What is the type of living lab (Technology, Transition and citizen driven Urban Living Lab)?

5. Where are the chosen living labs as case study stand in the (niche to regime) transition level?

4. Scope:

The scope of the investigation is limited to ULLs in general Living Labs that are working on smart and sustainable mobility contributing towards transitions. ULLs have their own objective and embrace characteristics that make up the nature of the lab. While understanding the role of characteristics, and the constraints to upscaling are also necessary. Thus, the geographic scope of this thesis is the Netherlands and the cities are Eindhoven and Helmond in terms of physical location whereas one of the case studies is a conglomerate of labs across four other cities. One of the key criteria is to study the labs that are setup in urban areas as the problem statement is about seeing the ULL setting in management of sustainable transportation in urban areas.

Chapter 2: Theory and Conceptual Framework:

In this section, the framework and the theories will be arranged to deal with central issues and main concepts in the thesis. The central issue is a concern about the commute life in Urban areas around the world. This led to the focus of the topic Sustainability. And how introducing green transportation in Living Lab setting using Transition theory and Institutional theory will aid in figuring out the solutions. Additionally, using the key characteristics of urban living labs to observe different living lab settings (case studies). Thus, by studying the key concepts and giving them the fundamental theoretical background. The first section will deal with Sustainability and Transitions and then the second sections will discuss Urban Living Labs and its key characteristics. The third section will be about Transitions using living labs and the hypothesis (for introducing green transportation).

2.1. Sustainability and Transitions:

It all starts with the movement in a city, it is well known that mobility in city is its lifeline. It is important for the economy and daily activity in cities but due to the increase in urban dwellers like never before transportation became a burden to our urban environment. This unsustainable phenomenon has many negative impacts on environment, public health of residents and the economy altogether disrupting the society (Banister, 2005). The need for sustainable transportation is particularly acute in urban areas. Though this phenomenon is well known, the prescription for how to move towards sustainable transportation is complex as it involves different interest groups and the complexity of urban spaces and fragmented decision-making bodies. For this there are 4 pillars to be established: effective governance of land use and transportation; fair, efficient, stable funding; strategic infrastructure investments; and attention to neighbourhood design (Kennedy, et. al, 2006). In this thesis, the fourth pillar i.e. Attention to neighborhood design will be emphasized as Living Lab is about building a neighborhood that is about catering to area specific problems. Although Significant investments in transit infrastructure are required to reduce the dependence on gasoline-fuelled automobiles, especially in parts of urban areas with high population growth and where transit is not competed with automobiles (Kennedy, et. al, 2006). McGill university defined Sustainability as meeting our own needs without compromising the ability of future generations to meet their own needs. Thus, using contemporary resources and technology available by not exploiting them is necessary.

2.1.1. Sustainable transport:

It has been observed that the very definition of 'Sustainable Transport' is not specifically made and the usage of term sustainable is always under question. Additionally, transportation sector deals with depletable resources which is the major cause for unsustainability and many important aspects the scale and impact of the policies made can impact the economic wealth and development in a region adversely. In order to develop and operationalize the notion of sustainable transport, the projects are divided into 2 major categories one is that envision it as a pathway and the other that envision it as an end state. The pathway depends on the process of attainment of sustainability without any indicators and end result (it's about progress). The end state is about meeting the criteria already set and is none to limit itself to environmental component of sustainability. There is an urgent need for a very clear idea of what a transportation system might look like that achieves its goals, or how it interacts with the larger economic and accessibility systems in which transport is embedded (Goldman, T & Gorham, R, 2006). As transportation system is more porous and is intertwined with many other systems. Many authors argue that in order to achieve sustainable transportation successfully, transport policy should take into consideration the larger systems in which transportation activity is embedded (Goldman, T & Gorham, R, 2006). The authors identify four emerging areas of innovation in the transportation practise: New Mobility, City Logistics, Intelligent System Management, and Liveability. These four will be bring systemic view either by acknowledging the relationship between transportation and other social and economic systems, or by adopting a more comprehensive view of the transportation system itself. Thus, a need to develop a transportation system in alignment with daily needs of commuters and larger neighbourhood itself should be taken into account. For this I suggest using the transition theory and urban living labs in understanding the complexity in bringing systemic change in transportation.

2.1.2. Smart Mobility:

Smart mobility is a new and revolutionary way to make the transportation especially in the urban areas to get around safer, cleaner, and efficient. The need for smart mobility arises from the increasing traffic congestion in the cities and the related side effects like pollution, fatalities and wasted time (GEOTAB). The smart mobility opportunities in Netherlands is high as it already boasts a culture of open networks and intensive cooperation with many prestigious knowledge clusters in the automotive, technology and high-tech industry. It also has a densely populated transport hub with an infrastructure and an innovation climate. According to TNO,

The Netherlands is seen as place where Living Lab can be fostered along with developing and testing many innovations (TNO, 2019).

2.2 Sustainability Transitions:

Sustainability transitions is defined as Long-term, multi-dimensional & fundamental transformation of large socio-technical systems towards more sustainable modes of production & consumption (Markard et al., 2012) particular to time, scale, scope, direction, systemic, technology. Thus, Transition theory helps in connecting the key concepts.

As it is observed that Sustainable transportation needs a large-scale disruptive changes in societal systems that emerge over a long period of decades i.e. transitions to sustainability (Loorbach, D., Frantzeskaki, N., & Avelino, F., 2017). Thus, using sustainability transitions to study and innovate to better transport systems though out of reach is necessary. It can be said that mobility transition just like energy transitions is not a mere technological transformation but a power struggle and a socio-cultural change that has an extensive and deep influence on the incumbent institutions, routines and beliefs. It can result in disruption and chaos but has to be changed. Loorbach et.al considers all of the research that relates to understanding the dynamics and governance of large-scale nonlinear complex systems change related to grand societal challenges to deal with grand societal challenge. The initial focus of transition research was on analysing transitions in socio-technical systems like mobility, energy. However, it started taking into account the socio-economic and geographically delineated parts like cities and thus extending the scale and scope of its research. It sees sustainable development as a bottom-up approach through grassroot initiative (innovations), experimentation (ULLs) and social innovation. This represents a shift in the object and dimensions of sustainability transitions: from a focus on sociotechnical systems to a recognition of socio-ecological, socio-economic, and socio-political systems as equally relevant objects of transition. Thus, a necessity to understand the niche to landscape development of any innovation surfaces.

The Dutch national government introduced transition policy in 2001 in the fourth National Environmental Policy Plan. Four transitions were identified one among them is the Mobility Transitions. This clearly signifies that mobility transitions is the one of the crucial parts of sustainability transitions. In order to understand

2.2.1. Transition theory:

Transition theory literature highlights the interdependency of institutions and infrastructures constituting societal systems and subsystems, which has created various types of lock-in that stifle innovation (Smith et al., 2005). Regime optimization can be another factor that might stifle innovation because of the habits, existing competencies, past investment, regulation, prevailing norms, worldviews and so on act to lock in patterns of behavior and result in path dependencies for technological and social development (Smith et al., 2005; Geels 2005). A transition occurs either when a regime is transformed or through regime change. This happens when the niche recognizes the pitfalls in the regime which will be unsustainable and ultimately break down and form a new regime according to the conditions (Köhler, Whitmarsh, Nykvist, Schilperoord, Bergman, Haxeltine ,2009).

To accelerate transformative change, sustainability transition approaches emphasize the importance of purposive experimentation, often in the context of socio-technical niches (Kemp, Schot, & Hoogma, 1998; Raven, 2005). Here, experimentation brings all stake holders like actors from governments and civil societies, entrepreneurs, firms, universities to negotiate and navigate the uncertainties in new socio-technical innovations through real world experiments in an learning by doing and doing by learning iterative processes (Ansell & Bartenberger, 2016). In order to bring this into reality, there is a need for shift in certain power dynamics and ideologies influencing the deep structures of the institutions hence producing sustainable transitions (Hodson, Geels, & McMeekin, 2017). As above mentioned, to bring in change there is a need for system or methodology where multi-stakeholders can work together and start learning by doing in real world situations like living labs. ULLs help in identifying the problem

and building it according to needs of the neighborhood. Thus, ULLs become a source for observing transitions. Thus, this thesis will use the Transitions theory to study the change and models that can be built to bring in the alternative modes of transport, smart technologies or carriers like e-bikes or bi-cycle (Köhler, Whitmarsh, Nykvist, Schilperoord, Bergman, Haxeltine ,2009). This I believe can help in understanding the resident's desired changes that can be introduced. For this one can use actor-network modelling.

Figure 1: Urban Living Labs structure. Source: AMS website.

With raising discussions and need for de-carbonising the society is seen as better condition to introduce bicycle, electronic cars or e-bikes as an important mode of transport. As there is a

requirement for fundamental changes in the technology, design, operation and financing of transport systems (Greene and Wegener, 1997).

Multi-level perspective:

Geels (2011) introduced MLP as a middle-range theory that conceptualizes overall dynamic patterns in socio-technical transitions. The basic concept of MLP is that there is no single driver of transitions. Instead, MLP views transitions as non-linear processes that result from the alignments of developments at three analytical levels:

1) Socio-technical landscape, which forms an exogenous context;

2) Socio-technical regime level, which refers to the rules that enable and constrain various incumbent actors, who reproduce existing systems;

3) Niche-level, where radical innovations emerge.

We are going to deal with niche level, where living labs operate and its ascent to the other two levels and the role it plays in these two. Niche level is where new innovations are introduced, develop in the old frameworks and are in the process of development through higher resource support. However, most niche developments suffer to get momentum to another level, but some become successful (Raven&Verbong, 2019). It is conceptualized as a 'protected space', where the selection pressures of the regime can be escaped and deviating from the dominant path becomes possible (Smith and Raven, 2012). The research on Strategic Niche Management (SNM) came up with a main idea that experiments help to foster processes of co-evolution (Loorbach and van Raak, 2006). Here, the prominence of living labs as beds for experimentation can play a key role as specified The role of experiments for sustainability transition has since gained significant traction with many scholars focusing on the notion of experimental governance of transitions, e.g. through urban living labs (Sengers et al., 2016; Turnheim et al., 2018).

Socio-technical landscape is the environment in which a regime is embedded, and it includes the physical environment and material infrastructures, societal values and concerns, macroeconomic trends, and long-term geopolitical dynamics (Geels et al., 2011). It is conceptualized as a 'protected space', where the selection pressures of the regime can be escaped and deviating from the dominant path becomes possible (Smith and Raven, 2012).

Depending on the nature of the landscape forces (reinforcing vs. disruptive) and the adaptive capacity of the regime, different transition pathways are expected to unfold (Geels and Schot, 2007; Smith et al., 2005). Thus, transitions are a result of the dynamics between stability and change and innovation.

As institutional theory has long history of conceptualizing social structures and analyze how they evolve and change and what makes them durable (Fuenfschilling, L. 2019). In order to conceptualise thinking in transition early scholars like Geels used institutional theory. It is now also dealing with structural change and process of agency (Fuenfschilling and Truffer, 2016).

Although institutional change is observed historically in case of extreme events like war, financial crisis or catastrophes or other exogenous developments like climate change, innovations like internet shacked up dominant mindsets and reconfigure dominant institutional settings (Sine and David, 2003). However, not all changes are a result of big event but on the meaning given to such events. The effect of an event on institutional change is thus to a big part socially constructed or at least heavily circumstantial and not a function of the event itself (Munir, 2005). Thus, using Institutional plurality to understand the multilevel developments in transitions using living labs can be helpful to recognise the institutional logics that represent relationalities that govern the behaviour of residents i.e. "organizing principles that govern the selection of technologies, define what kinds of actors are authorized to make claims, shape and constrain the behavioural possibilities of actors, and specify criteria of effectiveness and efficiency" (Lounsbury, 2002, p. 255). This institutional logic plays a crucial role at field level involving many organisational fields. Organizational fields are often governed by more than one of those institutional logics, which ultimately means that actors are subjected to different, sometimes conflicting institutional rationalities (Fuenfschilling, L. 2019). This leads to institutional complexities, where it provides a scope for agency as multiple actors(stakeholders) are involved. However, daunting this all may seem the research shows that organizations can manage different forms of complexity by taking particular measures like prioritizing, reinterpreting particular logics or decoupling from certain demands and dealing with them in a ceremonial manner. By compartmentalizing the departments on the basis of issues dealt can help in focusing on induvial problems and eliminating them. This is why individuals play an important role.

Additionally, by focusing on the "relative swing between agency and embeddedness" (Clemens and Cook, 1999, p. 222) and putting the interactions of an actor with its environment to the forefront, a more dynamic understanding of institutional change is created (Fuenfschilling, L. 2019).

There is a complexity of regimes and they stem from various sources. Particularly in transitions studies regimes are formed in certain sectors like transport and water.

As the regimes are influenced by different fields and, as a consequence, need to be conceptualized as semi-coherent rules of the game. So, analysing the type of complexity within

a regime and its effect on actors and innovation can produce insights in the transition dynamics of a sector. Additionally, relationship between the actors' actions and agency is very crucial for transitions. Institutional work in terms of understanding, studying, extensive theorizing about new knowledge and technologies, training and education, demonizing and valorizing of new practices using images and storytelling, a diverse range of lobbying and political work, engaging in social movements, creating professional standards or banning certain practices and technologies. All this at the niche level produces certain innovation and thus make up regimes. Scholars can pay attention to how actors build up and establish new systems and how new technologies and other innovations get legitimated (Binz et al., 2016; Musiolik et al., 2012) in the case of knowledge generated in living labs. However, this socio-technical change doesn't happen without the cooperation of actors in relation to the existing regimes.

Now we can clearly observe the relation between how living labs at niche level and the ascent to regime and landscape level under the sustainable transitions framework is only possible with the effect on individuals behaviour as it can trigger ideas or emotions towards specific problems and issues thus, contributing to innovation and change.

2.2.2. Institutional approach: The way to handle transitions using institutional approach.

As Sustainable Transitions are long-term, multi-dimensional and deep-structural changes of existing sectors and industries towards more sustainable modes of consumption and production (Grin et al., 2010). Transitions thereby advocates a systemic perspective on innovation and change by taking into account the historical evolution of institutions and technology through stable socio-technical systems and conceptualizes resulting in the path dependencies for innovation and change. Thus, recognition of basic institutions or key elements that constitute the dominant markets, actors, policies, regulations, business models, technologies, user practices and cultural expectations in sectors like water, energy, food or transport. To study such systemic change, we have to understand at a deeper level the functioning of existing socio-technical systems. In this process, transitions are about understanding persistence as much as they are about understanding innovation and change.

Sustainable transitions are about deinstitutionalization and destabilization of existing socio-technical configurations and the creation and diffusion, hence institutionalization, of new, potentially more sustainable ones (Fuenfschilling, L. 2019). Additionally, institutional theory gives insights into the durability such new set-ups and sources of innovation and change. In

this case the urban living labs are such new set-ups which are in need of transformations in the institutionalization.

As the socio-technical transitions like sustainable transitions are seen as long-term process this leaves space to see transformation of institution in long run as well. Sustainability transitions require changes in a range of elements and dimensions to alter the underlying deep structures that renders them unsustainable. At the regime level, is where the transition process occurs and is the heart of transition. Regime is made networks of actors and social groups, formal and informal rule and key elements (Kemp,2010).

2.3. Urban Living Labs:

Understanding **Difference between living labs and urban living labs** is the explicit focus on finding solutions meant to increase urban sustainability. The intricate number of variables and relationships influencing the process of creation of an urban living lab is the learning environment stakeholders look for and thus, it can provide real world solutions to real world problems while emphasizing on the need for this solutions to work (Steen, K. and Bueren, E. 2017).

Living labs can be used to introduce innovation directly or with less hustle to the users with the help of all stake holders actively involved. They are collaborations between companies, knowledge institutes, governments and users that develop new products, services and business models in a realistic context. The knowledge institutes can use their research skill to make innovations that can help or affect the immediate user. These benefits can only be achieved if the various parties are attuned to one another and are prepared to engage in a process on an equal footing.

2.3.1. Key Characteristics:

There are varied key characteristics that determine the uses of living labs. They explain the important attributes and their multi-functionality. The characteristics of ULLs are identified based on the respective goal, activities, participants and context of the lab. Goals are understood through innovation by developing new products or technologies to solve existing or new problems, knowledge creation and increasing urban sustainability though locally supported solutions. Under activities, development of innovations, co-creation, iteration between activities through feedback to further develop the product. The key participants are users, private actors, public actors, knowledge institutes that are provided with decision power. The activities happen in a real-life use context (AMS Institute, 2017).

‘The essence of a living lab is that the solution is sought together *with* the user, rather than just applying a fixed solution and involving the user only for testing. To qualify as ***co-creation***, the targeted users need to be involved in the various development phases of the living lab process: not only should they be asked for their opinions, they should have decision-making power throughout the phases’ (Prahalad & Ramaswamy, 2004).

There are all kinds of actors ranging from public to private like users, governments, businesses, firms and knowledge institutes that influence the outcome in a living lab setting.

Following are some of the characteristics of Urban living labs (Steen & Van Bueren, 2017). These characteristics are generally used to identify the nature of any form of living labs. A key characteristic of Living Lab methodology is the ***Co-production***.

Co-production: as a tool can be used for co-designing, co- evaluation and can involve different types of users. Nabatchi et al., defined co-production ‘as an umbrella concept that captures a wide variety of activities that can occur in any phase of the public service cycle and in which state actors and lay actors work together to produce benefits.’ The above-mentioned characteristics help us in identifying the important players to be brought together and make it less complex for decision making which is definitely hard in urban areas. Living Labs also focus on co-creation in which the role of the users is essential for the end result. They can be used to solve several problems ranging from safety and security of the residents to the introducing new innovations in technology and landscape usage. They can be breeding grounds for rising entrepreneurs and can be used by governments to solve the basic problems. Thus, also by engaging the residents more experiential knowledge about issues can be brought to the table. As one of the 4 pillars in the introduction paragraph the attention given to neighborhood building asks for more emphasis on area specific problems. However, there is a gap in literature on the impacts of neighbourhood form on urban travel behaviour. The Lifestyles of residents in that particular neighborhood has to studied. This also talks about the characteristic called ***Geo-embeddedness*** of Living labs which also mean they are predominately not virtual platforms.

Experimentation and introduction of ***Innovation*** to cities is one major characteristic on Living labs. According to GUST (Governance of Urban Sustainability Transitions) ULLs test new innovations, technologies, solutions and policies in a highly visible way. Additionally, living labs provide a platform to multiple players instead of traditional one or two players. Thus, they let small businesses or entrepreneurs to thrive along with knowledge institutes. All of them combined create knowledge and diffuse it to others which is also a necessary component of

sustainable transitions. The role of users is essential for end results. These characteristics help in understanding the structure and functions of the living labs better.

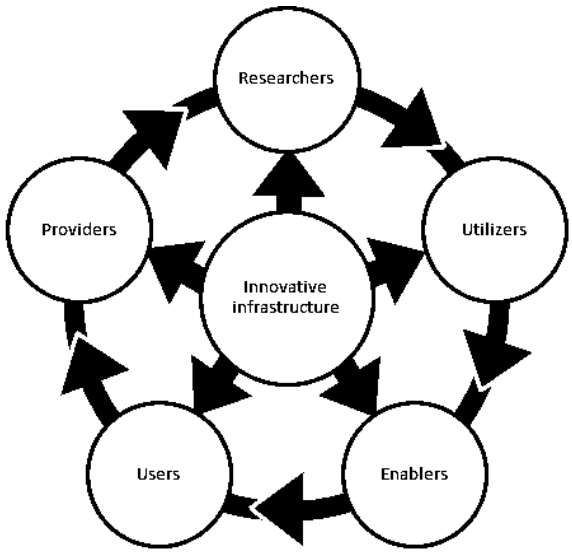
The literature points out that over emphasizing on experimentation in ULLs at the niche level confines the contextual binding of experiments in ULLs and while filling with both niche-regime constellations through creation or clustering of niche experiments can be a solution to bring societal change while challenging the power in regime (van den Bosch & Rotmans, 2008, p. 34). In order to overcome this paradox, we have to offset the contextual binding and develop promising pathways. By identifying the structural models out of an experimentation that remain central and flexible enough to contextualize and adapt to new localities appears to be a promising pathway (van Worth, et al, 2019). Additionally, the characteristics of new labs are seen as not new at all as the living lab studies are still in its infancy (Bulkeley et al., 2016) that has to be taken into consideration before clearly establishing key elements or characteristics at any living lab. This in a way remains a challenging task for scholars and planners to make its ascent into next levels. To add, the challenges of how to institutionalize the living labs beyond the short-term projects is another key challenge. Tim and his team argue that the importance of using ULLs in governing urban sustainable transitions should take into account the changing urban planning methods and techniques and move past the goals and attitudes towards consensus and experimentation by giving space to adaptability, responsive and participatory place making (i.e. politics) beyond just experiments (van Worth, et al, 2019). As forth mentioned, they also point out the re-contextualisation according to the needs and while keeping them modular and flexible to adopt to different geography (place), issues (organisations), at multi levels (policy). The need for research on the long-term effect of Urban living labs on Sustainable transitions and their potential for place making and urban regeneration in cities is required (van Worth, et al, 2019).

Participants:

Living Labs become platforms that bring relevant parties together by collaborating for innovation co-creation. Users, private and public actors, and knowledge institutes are key participants in a ULL. Actors from these four groups are active contributors to the developments taking place in a lab. The decision power is democratically distributed to all the actors at various stages of the innovation (AMS Institute, 2017). They play the role of Utilizer-it can be a public institution, enterprise or a company enabling the efficiency to develop and

commercialise the product in the ULL network. Enabler could be an educational institution, knowledge institute, consultants that provide knowledge, methods of research, evaluation. Provider as the name suggests is the financier to the development of knowledge in the lab and its dissemination. Users and producers are the residents who engage in the co-production of the Living Lab (Westerlund and Leminen, 2011). A Living Lab can be distinguished by the key role played by any one of the above-mentioned participants in the initial phase or later.

Figure 2: The anatomy of a Living Lab constellation



Source: Schuurman, 2015. p 195.

Establishing relationship between smart & sustainable cities and their role in upscaling to regime level transitions:

One of the important factors to consider in the form of participants is the Citipreneur. It is through this the role of local entrepreneurs in co-ordinating the transition at individual projects upscale to regime level becomes a catalyst in urban sustainability transitions. These local entrepreneurs are a part of the grass-roots movement which involves co-ordination between citizens and the market-based technological projects (Aylett, 2013). These communities generally consist of citizens who are motivated to use their knowledge, skills, expertise to apply them to make sustainable transitions possible in public affairs (De Jong et al., 2015). However, market based technological niches only include citizens in the last stages/phase of societal

diffusion in contrast to grassroots movement (Wittmayer et al., 2016). The role of entrepreneurs should be understood in relation to other actors that are involved in the transition and the government plays a key role in public value creation by dealing with tensions that exist between public and private actors by making institutional interventions (e.g. Lobbying, barrier removing etc.). Local entrepreneurs' competence and drive to make systemic change. Additionally, government should help in giving public value and incentivising the use of smart technologies for all citizens would aid in upscaling. Thus, considering entrepreneurs as one of the key agents driving the transitions and making partnerships with them is crucial to the overall smart & sustainable development and smart governance of the transitions (Tomor, 2019).

Quadriple helix involvement is identified in the labs these days as it includes the representatives from public sector, universities, companies, and citizens in the innovation process. It aids in dealing with local challenges in collaborative process of innovation, testing and evaluating further possibilities (u4iot, 2019). The chosen case studies also used the quadruple helix.

Theoretical segmentation of the ULL:

In order to conceptualize and classify the Urban Living Labs according to the type of approaches in bringing about the solutions to the issues recognised in the specific urban context. Following are the three types of Labs are recognised based on their character.

These are the technology-driven ULL, transitions-driven ULL, and Citizen-driven ULL.

However, these labels are observed to be overlapped, in that all ULL's are citizen centric in their very nature yet the main focus while building a project will not be the citizens. In the ULL that is driven by smart and sustainable development models they can use technology as the key player (Fiúza, 2017).

The technology-driven Urban Living Lab:

The real-life city here is particularly seen as the laboratory to invest more on the innovations and testing them with building more interaction with the citizens and exchange this data as knowledge towards establishing a smart city to serve the problems at hand and for welfare of that city by envisioning it as a laboratory (Baccarne, Schuurman, et al., , 2014). Clearly technologies are seen as the main focus of the pilots in this lab. In this ULLs citizens (the users) are seen as the observed subject and not an engaged citizen in the co-creation of ideas (Wallin, Horelli, et al., 2017). In the case studies chosen Helmond Driven Lab exhibit these characteristics where the users of the highway act a role of observed subjects in most of their pilots.

The transition-driven Urban Living Lab:

In order to roll out transitions need systemic changes in the urban system through which the services, and provisions are enabled by the new technologies in their very design and organisation while also bringing change in markets, policies and culture (Voytenko, McCormick, et. al., 2016). This in evidently asks for roll out of new institutions to accommodate and enable such systemic changes in the cities' planning and design departments. Thus, sustainable development becomes the main focus of this ULL while making pilots. The change not only through innovative technologies but in the consumption behavior and lifestyles culture (Voytenko, McCormick, et. al., 2016). This ULL will be a platform to develop and experiments technologies along with bringing the decision makers and planning departments to collaborate with partners in reaching self-organizing groups of the ULL to enable the sustainability transitions (Wallin, Horelli, et al., 2017). In conclusion, this ULL establishes the connection between the top-down policy and the bottom-up activities through systemic governance of stakeholders and their interactions (Baccarne, Schuurman, et al., 2014). One of the case studies chosen in the research is SUMMALab which is an assessment body to a group of ULL in four cities which deals with assessment based on the accessibility, livability, safety, healthy, equity, and upscaling criteria.

The citizen-driven living lab:

In this type of ULLs, citizens play different levels ranging from partners in the experimentation process to give feedback to the local governments about the effectiveness of products (Nesti, 2015). *"This type of Urban Living Lab works as a tool for reaching the users and transforming the real urban environment by encouraging the citizens to develop and produce urban artefacts"* (Wallin, Horelli, et al., 2017). Thus, the democratic participation of the users and producers in the lab is embraced as empowerment, co-creation, which allows them to do-it yourself attitude improving the living spaces. In this research, Strijp-S Living Lab encourages its residents as users and businesses as producers in the lab to build smart and sustainable neighbourhood.

The wider transformative change through ULLs:

The research reflects on using Embedding, Translation, and scaling as processes selected ULLs engage in diffusion.

- Embedding by building a strong sense of place in the immediate residents.
- Creation of collaboration in new network constellations a big part of Transformative placemaking. Impact emerges from interwoven practices serving strategies that complement each other. When taking a niche development perspective, ULL can be conceptualized as experimental spaces that 'provide learning platforms for new social networks to emerge' (Raven, Heiskanen, Lovio, Hodson, & Brohmann, 2008, p. 465). Hence, they become more of 'action and solution spaces for sustainable transitions.

The important stake holders for the extension of impact are the network of labs, and the need for local partnerships for amplifying sustainability transitions.

- Translation of the labs' operating model was found as a strategy in order to replicate the lab structures elsewhere. It deals with capacity building and set up of spin-offs from other special contexts ULLs. Research on how to translate necessary elements like central models, financial structures, operating rules etc of an experiment to a new context dependent lab is lagging back.

  -strong narrative helps in the diffusion of the living lab and its impact.

- This growth of a niche experiment entails the spatial scaling (i.e. the geographical extent of applying the circular approach is enlarged), actor scaling (i.e. the network of collaborating partners and customers is becoming bigger), while content scaling (e.g. by applying the circular models also to related but different materials) and resource scaling (e.g. by expanding the funding sources beyond the current single investor) are still in the planning phase. At the same time, the lab management reports a lack of agency and resources to further support these scaling efforts. Otherwise, the experiment runs the risk of diminishing in early stages of diffusion, as Heiskanen and colleagues (2017) reported. Though scaling is a long term and capital-intensive technique it also is not preferred by the lab owners as most often such experimental setting fail, and this can demote the popularity of living labs. This can help in learning by doing.

2.4. Transitions using Living Labs:

As explained in the previous section that this study is about transitions and living labs as potential contributor. The most important success indicator for Sustainable Living Lab(SLL) and ULL is what has been learned within a project. This contrasts them from conventional Living Labs targeting innovation service delivery. Providing space for innovative experimentation, that would not have taken place outside a SLL or ULL, is one of the key contributions to sustainable urban transitions (Schliwa, G., 2013).

Urban living Labs like other form of experimentation involves a more interventionist, 'learning by doing' governing approach in which urban sustainability is emergent rather than pre-given (Bulkeley, et al., 2017). There is a need for more empirical work to explore the extent to which these diverse responses achieve their intended impacts and the unintended consequences these might produce in shaping urban sustainability transitions.

As the major focus of the thesis is about sustainable mobility and transitions using living labs to see how this process unfolds, institutional approach and transition theory help in understanding this process. Institutional theory and Stake holder theory are connected in a way that, the later deals with the complexity at ground(field) level where stakeholders can influence the outcomes. They both together can help in understanding sustainability. As forth-mentioned, ULLs can be one such methodology to aid transitions. Thus, understanding transitions aids in viewing urban living labs as a potential tool to experiment and diffuse the knowledge learned and created. Living Labs aim at pooling knowledge from as many (willing) participants as possible for generating best possible solutions respectively innovations. The transformational potential of the ULLs can only be observed by applying lessons to places, organizations and policies.

Institutional theory helps in conceptualizing socio-technical regimes. Since sustainability transitions are interpreted as deep-structural changes, these insights are crucial to advance the understanding of how and why radical change unfolds. Thus, institutional theory aids in understanding the structures unfolding in the process of transitions. This can be linked to how ULL as an arena have its own governance problems between actors involved.

Living labs can be considered both as an arena (i.e. geographically or institutionally bounded spaces), and as an approach for intentional collaborative experimentation of researchers, citizens, companies and local governments (Schliwa, 2013). However, exploring ULLs usefulness and why local collaborations are trying to operationalize the ULL concept in real-life settings, and the potential impacts of ULLs and their ability to catalyze urban sustainability and low carbon cities is recommended (Voytenko, et. al., 2016). Additionally, the key question warranting further research in the way ULLs can become embedded in existing modes of governance instead of being individual projects (Voytenko, et. al., 2016). Paraphrased this demands a need for understanding the upscaling of the ULL small scale projects (niche level) to the broader level (regime) where the impact can result in an extensive and comprehensive transition.

Sustainable mobility in cites deal majorly with frights and CO2 emissions. Additionally, studying the development of green transport using the existing data and literature in Dutch

cities where organisations like TNO work will aid in observing if introducing these large-scale changes can be possible in living labs. However, there can be draw-backs to using ULL as they are not applicable to all types of urban innovation projects while embracing their co-creation requirement. There can be many challenges posed while developing projects that are dealing with highly technological innovation particularly in smart and sustainable cities through co-creative development rather providing solutions (Steen & van Bueren, 2017). More study has to be done on why and why not aspect of using Urban living labs to deal with these issues.
This thesis stems from the quality and impact of living labs in the academic field is still rather insignificant. Additionally, the practice-based side is much more developed than the theoretical side. There has also been more quantitative data and less empirical data in comparative studies that focus on the added value of living labs. The proposed framework will help in updating the data on the available literature about using ULLs as a potential model to study or capture the transition process in transportation sector. This thesis can help in studying the living labs from a non-European perspective as at this point most literature available is by European scholars (Schuurman, D., 2015). There are also recommendations to study the hybrid types of living labs such as technology-driven, transition-driven or citizen-driven, and their key differences (Mariana Costa Marques Fiúza, 2017). There is a need for understanding the upscaling of the ULL small scale projects (niche level) to the broader level (regime) where the impact can result in an extensive and comprehensive transition (Voytenko, et. al., 2016).

Transitions: ULLs can be potential policy instruments to enable the sustainability transitions by providing space to create knowledge by experimentation. ULLs can be considered by planners to bring systemic and institutional change to escape the persistent and path-dependent unsustainable urban development processes. So far, ULLs have been isolated initiatives at local level, while assimilating them into wider systemic transition strategy will aid in scaling and institutionalisation of the lessons learned. Additionally, they can act as policy instruments for developing public support, and applicable evidences for expected sustainability transitions (Puerari, et.al, 2018).

Upscaling ULLs in sustainability transitions:

In Urban Living Labs and or Smart City Living Lab which are emerging approaches that are referred to projects to design test and learn from innovative social technical practices by diverting from conventional ways of doing things in real time especially in urban contexts which are complexly intertwined by various stakeholders. However, the successful

implementation of the LLs does not guarantee the large-scale adaptation that is planned for achieving resource efficiency particularly in mobility transitions. The transport innovations are about becoming smart and sometime can result in excluding certain social groups as not fit for 'smart citizen' profile (Cellina et al., 2018).

Literature on strategic niche management (SNM) and transition management (TM) used the notion of upscaling in the studies of transitions. More emphasis was laid on the niche internal dynamics and future visions and less on the constrains upscaling in this socio-institutional context. Contextual constraints have to be given explicit attention and anticipation while upscaling the pilot through retrospective system analysis and formulating joint learning goals. Certain constraints are city specific and have to be identified through a specific analysis based on local situations (Dijk et, al., 2018).

Impediments to upscaling ULLs:

In order to Upscale there are many constraints that are to be understood like following:

1. Financial feasibility: There is specific financial- economic constraint which is also a major interrelated constraint. Upscaling any technological innovation whether its electric buses by municipality or electric bike/car sharing, is twice expensive and requires more investments. Additionally, concession constraints from municipality while commercialising a product comes with the tight and inflexible performance requirements. There is uncertainty, longer duration and flexibility of the project and product itself that put more pressure on concessions (Dijk et al., 2018).

2. Exclusion of certain social groups: There is a higher possibility for exclusion certain people because of their financial-low income, Intellectual-understanding of the technologies applied because of low education level or age, Human resources- language proficiency of foreigners and new-comers to the area. This can be avoided by repeatedly offering possibilities for stakeholders to participate and actively approaching them for a long period of time by including all marginalised groups. Building a common vision with the participants and being transparent with stakeholder will avoid mismatching goals between citizens and the ULL. Instead of overlooking people outside the ULL context which can be result of the geographic context, ranging from a building block to a neighbourhood, a municipality or a whole urban area. Thus, excluding the potential participants living beyond the perceived boundaries. In order to upscale the pilot, the impact it will have has to be from regime scale (Cellina et al., 2018).

3. The power structures inside the ULL: In reality, Labs fail to achieve the real participation instead of various circumstances can lead to mere reproductions of the power structures already existing in real life. This can be result of improper distribution of power throughout all stakeholders and precautions to be taken to provide equal opportunities to all. However, to avoid, carrying stakeholder analysis to assess thus, yielding a communication strategy to reach all type of participants through tailor-made methods for each group. Only communications or Using ICT tools will aid but the organizers have to conduct events and activities to let the people adapt at their comfortable pace (Cellina et al., 2018).

4. Limited learning: All participants including civil servants, for city owned LLs, or voluntary citizens for civil society-based LLs have to benefit in terms of the knowledge conveyed and learned at the Lab. They often lack comprehensive view of the process thus lacking knowledge. Thus, having no overview of all options, mechanisms and impact of the LL mean there is no diffusion to future users thus making the upscaling improbable. *"That's why explicit learning strategies are needed that are capable of capturing and monitoring knowledge creation and transferring it to all actors."* Understanding the actors and catering people-to-people interaction can aid in tactic knowledge to emerge (Cellina et al., 2018).

5. Wait-and-see attitude: ULL project are not routine projects but have key attention to diffusion of knowledge and learning, throughout the pilot even if the upscaling efforts are not considered. It's always beneficial at the beginning to make an upscaling strategy of what can be reasonably upscaled. However, this strategy should be designed to efficiently communicate the measures and be flexible for evolution of the Lab. Thus, emphasising on the language, right channels and time are necessary while upscaling to depending on varied contexts (Cellina et al., 2018).

6. Low Institutional and stake holder receptiveness: Most times the results of the LLs can be promising as expected in the beginning however, certain participants like public and also political majority might not be interested in upscaling the innovation pursued in the project. Other times it might be because of the lack of motivation or open-mindedness in institution(decision-makers) and policy makers because of their unfamiliar with codesign approaches and sometimes simply prefer not to make the decision-making process complex by engaging stakeholders in it. To avoid this early inclusion of both stakeholders and institutions have to be sought to make the future process attractive through engaging through giving voice

and role to all citizens groups, civil society organisations and experts, policy makers and institutions (Cellina et al., 2018).

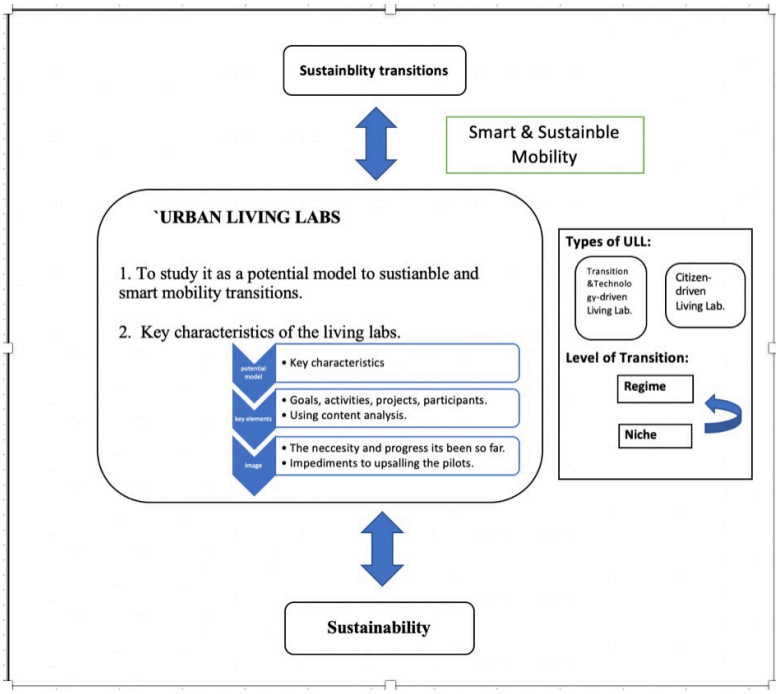
7. Sticky urban assemblage: Its one of the complex constraints as it deals with stubbornness of urban assemblages that can result from persisting infrastructure, legal lock-ins, long term contracts. To deal with the decisions have to be taken at higher political level instead of attaching to the outcome of the participatory process. In order to deal with such circumstances, the communication strategy and methodology have to be designed accordingly to avoid higher or wrong expectation among ULL participants. Behavioural analysis can yield good results in terms of structural change over time (i.e. transition) (Cellina et al., 2018).

8. Broader urban locality: Neglecting the locality outside the project area will result in unbaling of the upscaling process as the broader urban context is not taken into consideration. This will result in ignoring the effects on its boundaries and to be on safe side considering projects' indirect and cross-scale effects, and actively engaging stakeholders of the broader urban context is suggested (Cellina et al., 2018).

Additionally, User driven innovation for sustainability is another crucial factor as the ecological design in new development of technologies and products that are user-oriented can make the users participate in the design process as result customizing according to the need at hand. While, helping the producers to test the design and evaluate its environmental impact simultaneously in the Living Lab setting thus, contributing to market innovation. Secondly, contribute to innovation in practice by pioneering new forms of in-context, user-centered research, including long-term and cross-cultural research (Christa Liedtke, et.al, 2012).

Thus, figuring out the what type of (driven) living labs are following, additionally the type of living lab it is and studying the necessity of smart and sustainable transportation in this context in Dutch cities will aid in contributing to the above-mentioned recommendations.

Conceptual model:



The above illustrated conceptual framework is used to study the role of Urban living labs as a potential model to study and understand sustainability transitions. As can be observed, thesis is to establish the relationship between sustainability and sustainability transition. The fundamental research goal in this thesis is to understand the ULLs and the way the key characteristics aid in classifying them using key elements and the image that has been created so far in the available resources. Identifying the characteristics can further help in looking at how they are applied, the nature of the ULL in practice. Additionally, studying the context of sustainability transitions in ULLs with the type of ULL i.e. Technology, Transition and citizen-driven along with the level of transition i.e. Regime and Niche level. The essential role played by the users in determining the design and new innovations introduced in the ULLs. The impediments to upscaling in the labs. All of these are used to figure out the way in which the transition is ascending into the higher (regime) level in the chosen ULLs and the specific type the ULL adopts or if it's a hybrid ULL. For this analyzing the existing literature in any form is

Chapter 3: Methodology - part 1.

3.1.1. Introduction:

This chapter explains the research methodology used to answer the main question. This methodology is divided into two parts (research strategies) to study the secondary and primary data separately. The first part deals with secondary data collected through the search engines. This method is known as the Desk research strategy of academic Literature. The overview of the materials collected using key words are used to answer sub-questions 1&2. This strategy is chosen as the study is a newly uprising phenomenon in urban innovation and experimentation.

3.1.2. Research objective and research question:

The research aim of this chapter is to answer the sub-question 1&2 thus answering the main question subsequently. The research objective is to understand the ways in which Urban Living Labs work in sustainable transitions particularly smart and sustainable mobility. By recognizing the key characteristics and the hybrid types of the urban living labs, figuring out the type of (driven) Living Labs, participants and context are following and studying the necessity for smart and sustainable transportation in this context in Dutch cities. Additionally, recognising the upscaling and the impediments is crucial to this research.

Main Question:

How does living labs aid or (contribute) in sustainable transition particularly in the field of smart & sustainable mobility?

Theoretical Research sub-questions:

Under this chapter 2 of the 3 sub-questions are answered through literature review. These questions are mentioned below:

1. How does specific characteristics of urban living labs aid sustainable mobility transitions?

2. How urban living labs will make a dent into the regime? Where are the chosen living labs as case study stand in this transition level?

3. What are the main impediments faced by the ULLs while upscaling?

3.1.3. Research strategy:

Research approach- The Exploratory research design can be used to study the structures of living labs and transitions simultaneously as it's a quite less researched field. Along with this design can aid in answering the questions and bring in insights rather than conclusions as a result. The research strategy chosen is Desk Research using Systemic literature review.
According to Booth, Sutton, et al. (2016, p 11), the systematic literature review can be used "to identify, select, and appraise all the studies of a previously agreed level of quality (either to include all studies or only those that meet a minimum quality threshold) that are relevant to a particular question (Booth, et al.,2016). The results of the studies are then analyzed and summarized. Synthesizing evidence helps us to find out what we know and don't know about what works and what doesn't work." This is used to first identify the living labs phenomenon and its link to sustainable transitions. Additionally, understanding the unsustainable transportation and how they are dealt in living lab framework is the crux of the thesis. All the literature analysis is a conceptualization of this study to summarize and analyze it, which intern is exploratory research (Van Thiel, 2014). Van Thiel (2014) describes the Desk Research method as the use of existing data sources, namely primary and secondary material. In this research, the strategy drew upon existing secondary data, such as earlier research findings, to create a systematic review. Thus, the theory extracted from this research will be a result of how ULLs have been studied so far and their characteristics, and the approach's sustainable transitions use to make a dent to regime and landscape levels. To answer the sub questions this phenomenon has to be studied.
Desk Research is also suitable because of its cost-effectivity and efficiency (Van Thiel, 2014).

3.1.4. Data Collection Methods:

The data collection method used is **qualitative** data as it comprises mostly opinions and beliefs as this approach is preferred when the research deals with new phenomenon like ULLs. Both primary and secondary data will be collected and analyzed to get the hypothesized results. However, for the collections of secondary data the method is Academic literature review, and the approach used is to analyze the related research articles on living labs and sustainable transitions, along with the available literature on the sustainable and smart mobility.

Desk Research – Literature review:

1. Secondary Qualitative Data Collection: (search engine):

Academic literature review: It is about using the existing data that is collected, published by other researchers to identify the key variables and the processes. The author was also aware of the particular variables that are to be studied simultaneously which are important to current research. The main objective of this is to figure out the role played ULLs embracing smart and sustainable mobility in transitions. To address this phenomenon, finding relevant literature is crucial part.

Research using academic databases and search engines for articles with Urban living labs, sustainability mobility transitions, sustainable & smart transportation as key words were chosen. The following table contains the searches made in academic databases and the number of articles in books, journals showed up. However, all of them have not been used only the articles that best fit the current research were chosen.

Key words	**Academic data base/ Search engines**	**Website link**	**Search parameters**	**Results**
	RU quest	https://ru.on.worldcat.org/discovery?lang=en	Articles in journals and books	81 + (85) for sustainability transition &ULLs

Urban Living Labs. Sustainability transitions. Smart & Sustainable mobility.				14 for all three key words
	Research gate	Researchgate.net	Articles only	50+
	Google scholar	scholar.google.com	Articles	18.200

Table 1: Academic data base/ search engine articles. Source: Author (2020).

3.1.5. Data Analysis Methods:

The data analysis method used is the literature review obtained from the secondary qualitative data was used to better understand the context and variables involved in ULL phenomenon. Additionally, the concepts related and in parallel with the theory chosen to support the findings are studied. (The analysis done on the existing material was done manually and supported by the software Mendeley.) The literature studied was based on the following elements:

1) What are Living Labs? What are the different types of living lab?
2) How are ULLs classified using key characteristics?
3) The role played by ULLs in sustainability transitions?
4) ULL's role in the smart and sustainable mobility in Dutch cities?
5) Identifying the sustainability mobility transitions that are happening in the chosen living labs.
6) ULL transition level and its illustration (role in answering or providing possibility) of the mobility transitions making a dent into regime.
7) How does

Part-2:

3.2.1. Introduction:

This chapter of research design and methods deal with the second part. In this part we deal with primary data collection and analysis. In this chapter author dealt with empirical research and answer the 3rd sub-question. This chapter is focused on the data collection, analysis methods adopted to conduct a Case study research. Additionally, the theory will be tested with real life settings.

3.2.2. Research Question:

Empirical Questions

1. What is the type of living lab (Technology, Transition and citizen driven Urban Living Lab)?

2. Where are the chosen living labs as case study stand in the (niche to regime) transition level?

3. What are the main impediments faced by the ULLs while upscaling?

3.2.3. Research strategy:

Case study research

The research strategy used is Case study to answer the fourth mentioned questions. This strategy is chosen because it supports exploration of a topic in its 'normal' context and time frame is contemporary to the researcher. Additionally, it can aid in describing a phenomenon in its context and can use to test or use theory (Bassey, 1999: p.60-64, Yin, 2014 p.238). Case study is a flexible research methodology and as there is a constraint of resources for this research it's an apt methodology. Four Urban Living Labs are chosen to study the phenomenon.

3.2.4. Data collection Methods:

As mentioned in the previous chapter, secondary data collection is done as this research deals with new phenomenon.

1. Primary Qualitative Data Collection:

a) Content Analysis: This method comprises all the published material (written or printed sources) such as legal documents, website pages, reports, promotional material like brochures, newspaper articles, periodicals etc. This method fits the exploratory nature of the thesis well.

- Firstly, the search was done on the official website of the cases chosen to study. All the background information about the ULL like the history, vision, and projects are studied using the homepage, about us and project pages of the official website. The partners and other related projects of the organizations are also consulted.
- the social media pages like Facebook, twitter found on the official webpage of the ULL are used. This is to make sure the thesis is updated to the activities through photographs of the actors that participate in the ULL functions.
- Stakeholders information is collected to compare their opinion and view on the success of a pilot. Some regional newspaper articles and other websites have been used in the research to see the success of pilots and observe the community reflection as I have not interviewed the users.
- others website like knowledge institutes that work with ULLs to conduct the lab and gather data and other websites where the interviews were previously conducted. The major source of the content used was from the websites, promotional content like social media, broachers.

b) Interview: For the empirical data to be validated the interviews with experts using questionnaire with open ended, closed questions will be done. I have conducted expert interviews with two personals from Strijp-S Living Lab and the SUMMALab. These interviews aided in supporting the findings drawn from content analysis and observation made. The interviews are conducted via online video calling websites like Microsoft Teams and Skype. The questions are prepared before the interview is conducted using the operationalization of the concepts. Semi-structures interviews are used in this research.

c) Observation: Visits to the 2 ULLs are done to observe the establishments and the reality check of the operations of living lab and the setting of the labs to triangulate the data collected through literature and content analysis.

2. Secondary Qualitative Data Collection:

Academic literature review: All the relevant information about the chosen case studies and the academic knowledge available on the ULL phenomenon has been used to triangulate the information as primary and secondary data in combination. This allows in achieving the validity and reliability of the data collected and analyzed in this thesis.

3.2.5. Data Analysis Methods:

Apart from expert interviews, content analysis can be another method to collect and analyse data. This involves analysis of written or printed data such as reports, website pages, legal documents, newsletters, periodicals, promotional material etc which is used by Fiúza, M.C.M. (2017). She says this method will be efficient in the exploratory research. The secondary qualitative data collected through the literature review of the academic material available on ULLs aided the selection of variable and materials to study in the case studies chosen. In the findings chapter, the research has been structured according to chapter 2. Thus, operationalising the research. Semi structured interviews are conducted and recorded with authorization of the interviewees. This method is to in order to leave room for the experts to be free while answering the questions and contribute to the discussion. The interviews are transcribed, and the findings were interpreted, and the results are illustrated in the Findings chapter.

3.2.6. Methodological Limitation:

The data collection was constrained because of the already less availability of stakeholders and the scarce literature available on Urban Living Labs, sustainability transition that also deals with sustainable and smart mobility. Visits to all cities under SUMMALab spread across four cities was not possible because of distance and budget reasons. Additionally, the empirical data collection was not done as planned because of the lack of interaction between the experts, residents in those labs. COVID-19 pandemic has been a major restraint in taking

person-to-person interviews and the two interviews are only conducted through online video calling websites. The labs were studied from a single level, however, different levels could have yield greater knowledge. The sub-projects were not completely addressed because of the lack of time and willingness from the stakeholders.

3.6. Operationalization: Variables, Indicators

In this thesis, the variables I picked to study are mention in the Operationalization table below. Here, you can also find the explanation and the questions that are going to be not only used in interviews but also to guide the data collection while using primary and secondary data. The variables and questions are formulated on the basis of research questions (sub) and literature review done (so far). The table consists of variables, definitions and questions on them. (I am planning to add sub-variable and explain them so that it becomes easier to break down the research.)

The question dealt in the table is about - How does the sustainability (mobility) Transitions(A) can be achieved using efficient ULLs(B)? (What is the relationship between sustainable mobility and transitions and what can be done to accommodate ULLs to achieve this?)

Variables	Sub-variables	Definitions	Guiding Questions
Sustainable mobility	Smart & sustainable mobility	To address the transportation policy and networks that considers the bigger systems it is embedded in like the lifestyle, infrastructure, type of economy, environment and other major components.	Where does the problem arise and why use transitions to provide solutions? How does ULLs contribute to transportation issues? (Is ULL relevant) Why using ULLs help in dealing with major components of the bigger system? How come we draw the attention to adopt sustainable mobility? How come sustainable and smart mobility become a necessary component in the urban planning?

Sustainability Transitions		The long-term, multi-dimensional & fundamental transformation of socio-technical world towards a more sustainable modes of production and consumption. Under this studying the need for using ULLs to achieve transitions is one of the main goals.	How do they accommodate the ULLs? What are the loopholes or gaps in the literature to using ULLs to successfully achieve sustainability transitions? How can ULL with a smaller influence area can aid in a bigger scale at which transitions work? How can the transition to smart mobility take place?
Urban Living Labs	Goals Framing the lab.	The basic information on living labs. The different types of ULLs. The way ULLs are used to observe transitions in a particular region.	When, how and why did the ULLs began? Which organization or person is behind it? What are the different types of ULLs? What is the current main goal of the ULL? How does the ULL contribute to sustainability transitions? How does the activities of ULLs take place? How does the ULL start projects?
Characteristics of ULLs.	Technology-driven Transition Citizen-driven transition	The key characteristics used to categorize living labs and elucidate their functions. In this transition a research environment is created to collect data about the users on services which has been used to improve the urban environment and local services.	How to identify key characteristics from the chosen ULLs? How do you define characteristics of a particular Living lab? How can characteristics help in identifying the level at which transitions are?

Levels in Transitions	Regime level	The 3 levels in which Transitions take place that are defined by Multi-level Perspective. Landscape, regime and niche level. (one of the sub-questions is about this)	How can the ULLs make a dent into regime and landscape? Where does this particular ULL stand? What is the aspect to change in the regime for sustainable mobility transition? What can a ULL do for this change? If it's at regime level, how did the successful transition take place? What kind of policies will aid in the accession in levels for ULL's organizers?
	Niche level		
Participants	Scale	The no of users involved in living lab research activities such as the living lab panel.	Who are the participants in the Lab? How do they contribute? How the knowledge created is shared? Are the residents or users of ULL actively participating? Is the living lab user centric? Is the division of power equal or is there any few who are in charge? How do the participants (mainly residents) find the transitions taking place? Are they aware of the change? What is the scale at which the living lab works? How is the lab governed? Who is responsible for managing the evaluation of the lab? What is the role played by Municipality (public bodies) in sustainable development/transition of the living lab?
	Public and private actors, knowledge intuitions. (Technicians centered)	The stakeholders in the process of development of a living lab. Like expert organizers, planners (public and private actors), and knowledge institutes, residents.	
	Users (residents)		
	Decision makers	All type of users are included in the decision making at different stages of the setting up process of living labs.	

			Is the decision-making power equally divided between all the stakeholders and user?
Context (Fundamental information)	Geographical area covered	This is the area covered in terms of a specific zone in the city, district, neighborhood, a road or a building.	What institutions does the ULL collaborate with? Are they knowledge institutes or public organizations? How long is the ULL going to operate? How do you set the time-framework to reach the milestones? How can the ULL help in addressing the green transportation related issues in the neighborhood? Does it seek the user's role seriously? Why (not)? How? How does the technology play a role especially in sustainable transportation?
	Experimental setting (real life/educational institution)- Ecosystem.	ULLs are designed or cover different systems in a city. The ecosystem they are embedded in defines the system they are part of like transportation. ULL can be part of planning at co-governance or community development.	

Source: Veeckman, Schuurman, Leminen, and Westerlund, 2013.

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Booth, A., Sutton, A., and Papaioannou, D. (2016). Systemic Approaches to A Successful Literature Review. (2nd Edition) SAGE publications. p:11. Retrieved from: https://us.sagepub.com/sites/default/files/upm-binaries/78595_Booth_Taking_a_Systematic_Approach_to_Your_Literature_Review.pdf

Chapter 4: Findings: Case Studies

In this chapter, the case 3 case studies chosen to understand Smart and sustainable mobility progress in the Urban Living Labs particularly the upscaling transitions. These case studies helped in recognizing the key characteristics mentioned in chapter 2 or 3. Additionally, understanding the motivations behind the functioning of ULL like citizen, transition and or technology centric lab it is. Finally, figuring out the transitional level of the ULL and the impediments to upscaling. Thus, answering all the three sub-questions. In this findings section greater emphasis is laid on the functioning, the goals and from the experts who manage the lab viewpoint. Thus, upscaling (i.e. Sustainability Transitions) can be understood from their viewpoint and justified through content analysis.

In order to understand the set-up of the case studies dealt under this chapter, it's important to understand the strategies like Triple Helix help in strengthening the sustainable innovation development in a region. This involves a successful collaboration between industry, knowledge institutes and government. For example, the Eindhoven's brain port region is known to be the s 'Smartest Region of the World'.

Along with sustainable transitions, the image of being smart is important to today's urban areas. This smart city emerges not just from the developed Information Technology and sharing this with citizens through providing digitally enabled services but enhanced by a well-orchestrated regional innovation ecosystem (Research report by TU/e, February 2016). In all the Eindhoven Living Lab development Philips played major role in funding and maintaining along with Brain port development which is a government agency collaborating on the development of a city divided in small areas with different living labs.

The European commission funded research on the Living labs in cities all across Europe identifying certain cities where the impact on investment in circular economy for sustainable development through systemic innovation dimensions is great. This research proved with the sample data used that Cities like to invest in circular economy in tern in the sustainable transitions associate it mostly with "Technological innovations" and "citizen's involvement". This result can emphasize on the necessity to deal with technology-based transition and citizen-based transition in ULLs (Santonen, Creazzo, et.al, July 2017).

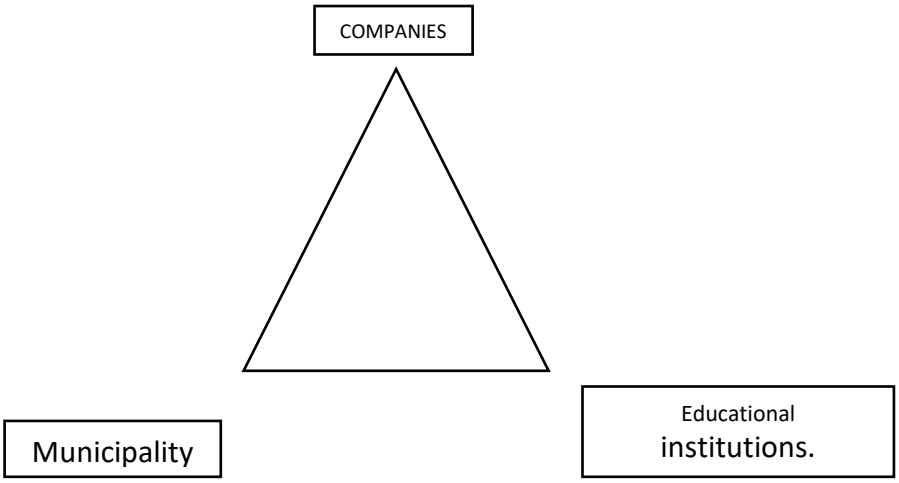


Figure 3: Triple Helix of the Urban Living Labs. Source: Author (2020)

The history of Eindhoven is an underlying reason is having suffered economic crisis in the early 90's made the city and the regional partners to work hard in collaboration to develop the economy of the city. However, situated in the center of the Brain port Eindhoven region is established to have strong commitment towards the enhancement of the resident's quality of life. To make this possible the city is opening up itself as a real-life testing ground for products and services with an added value that meets the needs of the respective end users. Using Triple helix model, they are now converting the city into 'The City as a Living Lab'. The innovative smart products and services are being developed and implemented in the Eindhoven city to make the city undergo sustainable Transition using both the technology and citizen-based transition (European Network of Living Labs website, n.d.).

Strijp-S:

The idea behind Strijp-s is to make it the best example for a historical industrial complex that should be turned into a dynamic post-industrial city district, in which culture and technology in other words embracing smartness play a key role (Kuiper Compagnos 2007, p.85). Simple put to create a multi-functional urban sub-center which accommodates a combination of living, working, cultural and recreational, facilities etc. This place is also known seek skilled labor and artists from across the world to Eindhoven city. In the observations made Strijp-S has been successful into bring the public and private organization together to make it a sustainable and smart neighborhood. The site was developed in 4 stages and is made to be flexible to serve the

multi-functionality factor of living labs. The history of Strijp-S began with Philip, *'Intimately interwoven with the growth of electronics giant Philips'* (Park Strijp Beheer, 2018).

The master plans are based on three fundamental themes which are culture, design, innovation, and technology. This resulted from the mixed metropolitan programme by landscape designer and urbanist Adrian Geuze and the municipal council (Park Strijp Beheer, 2018). There were considerations about an architectural conflict that happens when the historical building can be less adaptable and the decay (Curilli, 2007)[1]. The main reason why the neighborhood is chosen is because of its modern yet historical roots. The two main stakeholders in managing Strijp-S locality are the municipality of Eindhoven and the real-estate company Volker Wessels in a public-private partnership as Park Strijp Beheer ('Park Strijp Management) set up in 2002 (Kourtit, 2013).

As part of this thesis, I focus on the smart mobility facilities provided in the Strijp-S to encourage sustainability transitions in the region. So far, Strijp-S has done exceptionally well on providing its residents, users and visitors clean mobility services. It is also known as knowledge location in Eindhoven where the developed technologies and products are experimented and implemented. Additionally, having access to an advanced neighborhood aids in accelerating the transitions as they are already flexible[2]. It has been a place for citypreneurs especially creative entrepreneurs are based in cities. They play a key role in setting the smart and sustainability transitions in urban areas on motion. Along with these the new users to blocks 59,61 and 63 are occupied by new owners and renters and providing parking for them is another challenge. That's why Mobility-S builds an above-ground parking facility between the residential building and the train track. Thus, Strijp-S become a living lab in the key characteristics it is based on like the geo-embeddedness, Coproduction and innovation[3].

One of the key programme (also an independent sub-organization) in promoting smart and sustainable mobility in Strijp-S is Mobility-S. Mobility and accessibility in the lab is ensured under the Project-S to provide ample parking and car-free zone. More will be discussed in the project section. The combination of sustainability and 'smart mobility' is the fundamental principles embraced by Mobility-S. In order to deal with the raising traffic in the region and the pressure on parking because of the new houses being built and occupied. To ensure the soft

[1] Curulli, G. I. (2007). De-cay or re-vamp? : the irresistible wastelands. CHEPOS, (012), 36-39.
[2] Strijp-S website. From: https://strijp-s.nl
[3] Key characteristics as per the Theoretical and conceptual framework chapter.

flow of vehicles proper signage and routing is crucial too. By providing alternative modes of transport is a prerequisite to controlling number of cars in the area like Shared bicycles and cars (Strijp-S Koerier, 2016).

Goal and aim(vision):

"*We believe in cities that offer a more social, comfortable and sustainable way of life*[4]." Mobility-S aims at reducing the number of cars used at Strijp-S. In simple words it's to redevelop the entire Strijp-S district by the end of the whole project.

Projects:

Project-S: Strijp-S is developed in three stage the same way Mobility-S follows a three-level approach like the service, development and innovation. The levels are designed to contain the services in the form of providing basic facilities like parking for cars and bicycles, while supporting innovative services in the form of research and implementation like sharing indigenously developed electric car charging infrastructure for cars, bicycles and scooters, app-s which is a smart phone application to support mobility planning in real time, dynamic route reference system, shared bicycles. Many such innovations are to aid the visitors and users by integrating the mobility with public transport and collaboration with market providers (Mobility-S website, n.d.).

Figure 4: Strijp-S mobile application logo. Courtesy: Appstore.

Mobility-S was given full responsibility and exceptionally high amount of autonomy to manage mobility in the area. Ensuring smart mobility through smarter traffic management and a greater range of mobility choices/options and real-time monitoring to contribute to cleaner and greener transport in Eindhoven. Mobility-S thus encourages the citizens to choose alternative, sustainable forms of transport more and more (bee smart city, 2018).

[4] Mobility-S website. From: https://www.mobility-s.nl/living-lab-strijp-s

Sharing bicycles is one of the initiatives taken by Mobility-S to provide bikes for short rides in Strijp-S or the train station, high-tech campus or TU/e, etc. There plans to make them available across the city through Hopper point system with a smart lock as in figure (5) (Strijp-S Koerier, 2016).

Figure 5: Mobility-S bicycles for visitors to use. Courtesy: Author

Parking-S: Parking is basic and key facility in any mixed neighborhood, in combination with the goals of providing smart and sustainable mobility services in Strijp-S Mobility-S established project called Parking-S. This project aids in providing hastle-free and car-free roads through Strijp-S app or the option available on website called 'Where is place' where you can find the parking free zones, electric vehicle charging points on the map as in figure (6). This real time data upgradation will not only aid the users but also the managers of Strijp-S to establish smart mobility. It has hourly, monthly and daily subscription plans to support the implementation of such smart services in the neighborhood. As Strijp-S is located near the Philips Stadium on PSV laan, During the home games of PSV and the stadium concerts the

subscription holders can park in the parking facilities (P-Torenalle and P-Kastanjelaan) at Strijp-S (Mobility-S website, n.d.).

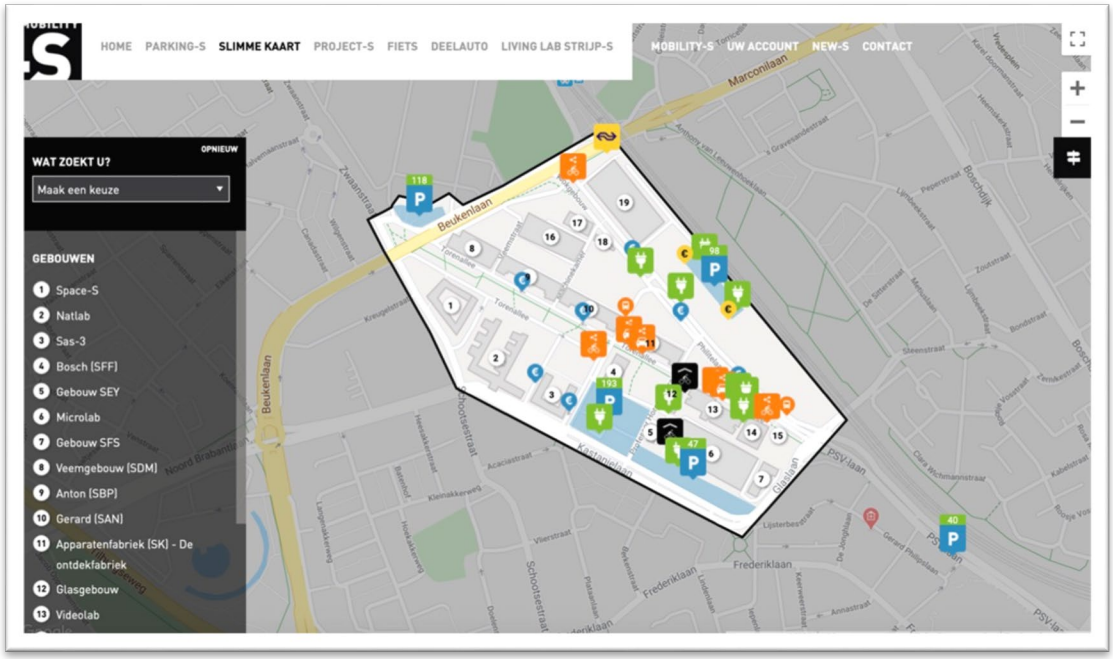


Figure 6: Real time Map showing the availability of parking and electric charging point in Strijp-S. Credits: Screenshot taken from https://www.mobility-s.nl/mobility-s

Shared cars in collaboration with BMW using their electric i3 car models. BMW-i Lab: BMW in collaboration with Strijp-S and Mobility-S has set up a living lab at Strip-S. Through this living lab they plan to gather more knowledge about green energy through testing their established services in North Brabant. The plan is to provide around 200,000 electric cars by 2020 and facilitating this plan by setting up special charging stations in the city and in Strijp-s that are integrated with BMW-I ChargeNow technology. It's also said that the BMW-I car drivers can user their charge cards at the station. This partnership has been established to make the Strijp-S the testing ground for sustainable and alternative mode of transports. This project is essentially made to upscale the transitions to the national level by analyzing its success at regional scale. Additionally, the partnership between BMW and Strijp-S was based on the shared goals and objectives in coherence with the National energy agreement and to make living environment in cities healthier (BMW i: project met 'Strijp-S' 21 oktober 2015 woensdag). However, the project failed in providing the expected solutions due to technical problems

according to Wouter Belen the interviewee. It helped in creating knowledge on how to handle such electric vehicle charging projects and aided in upscaling other charging points in the district by great numbers till 2020. There many electric charging points are being installed with increasing demand and stimulating change in the future too.

Figure 7: BMW-i poster in Strijp-S. Courtesy: Amber, from: https://twitter.com/Drive_Amber (2018)

Apart from these initiatives Strijp-S does cross-campus collaboration with various other campuses and organizations across Brainport region to share knowledge created through the data collection and analysis. They work on accessibility, including partial and electrical solutions in the field of bicycles and cars (Mobility-S website, n.d.).

Smart mobility is one of the key objectives of the *living the lab* model in Strijp-S. In order to achieve this the above-mentioned projects and collaborations are crucial and many more have to be introduced in the future. This is not all, but it is stepping in the right direction.

Participants:

According to Wouter Beelen, the lab is based on Quadruple helix which partners with Eindhoven Technical university, Automotive Campus, Strijp-S, Brain port Industries Campus as in the figure-4. In this co-operation, all key organizations play a designated role of creativity & design, learning, testing, technology application, production and deployment. It about

bringing all these stakeholders and businesses, to enable an ecosystem to stimulate the growth of startup companies and last but not least the residents and users (W. Beleen, personal communication, July 3rd ,2020).

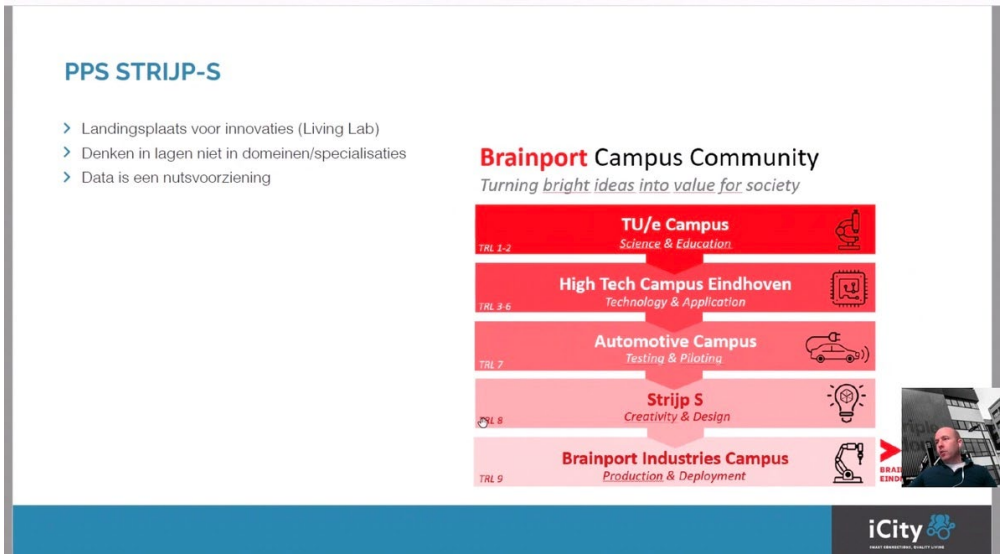


Figure 8: Quadruple helix with key partners. Courtesy: W. Beelen, personal communication, July 3rd 2020.

The key participants in Strijp-S living labs is its residents and entrepreneurs/start-ups. Additionally, the users and the visitors also contribute to the transition taking place in this area. The companies and the employees working in them are provided extra facilities during the day and the residents get extra parking during the night. Stakeholders and decision makers in this living lab are Eindhoven municipality and the real estate company Volker Wessels in public private partnership as Park Strijp Beheer (Willem van Winden, et.al, 2013). As mentioned, Park Strijp Beheer is the provider for the living lab. Mobility-S is responsible for maintaining smart and sustainable mobility at Strijp-S. Traditionally it was parking company which uses paid subscriptions to provide better and ample parking services now they became a Hospitality organization providing shared bi-cycles, cars, charging points for electric cars. Playing the role urban mobility operator (W. Beelen, personal communication, July 3rd, 2020).

Mobility-s also play a crucial role specifically in the Smart mobility functions of the living lab. They arrange and manage the lab introducing new technologies and solutions by testing them simply put they assemble the lab. Additionally, Mobility-S deals with the collection of funds

from user transections to get access to the parking and sharing vehicles at Strijp-S. The ULL collaborates as forth mentioned with many campuses and organizations like TU/e, High-tech campus etc. to exchange knowledge (Strijp-S Koerier, 2016). The knowledge created in the lab is consistently shared with other campuses to make the brain port region greener and smarter. The residents and users have a say in what we develop. Co-creation is embraced at the Strijp-S, this can be observed in the Mobility-S Facebook page[5] that is used to notify the users and residents about the availability of parking spots, new places, technologies and smart cards introduced. Simply put, updating the progress of the lab and the collaboration with automotive campus, Brain port Industries Campus through social media websites like Twitter. They give suggestions on this page to lead the new users to make the most of the facilities provided by Mobility-S like Free2Go sharing cars & bikes.

Figure 9: Parking facilities at Strijp-S. Courtesy: Mobility-S (https://twitter.com/MobilityS)

Thus, it can be called a Utilizer driven lab as Municipality and the Volker Vessels work together in enabling this labs' ecosystem.

Experimental setting:

Strijp-S is a real world setting which is also multifunctional setting oriented to support the creativity. In this living lab preserving the historical identity with Philips and its buildings is as important as being flexible in serving the innovative and smart facilities to the new residents. One of the key challenges in maintaining this living lab is to bring the change or transformation

[5] Mobility-S Facebook official webpage. Retrieved from: https://www.facebook.com/Mobility-S-326170214157407

of places which everybody needs however, the way to roll out this change in real world setting is the hardest part of it all. At Strijp-S they aim at this change in smart and sustainable projects and make it more interesting for everyone. Another challenge is to be scaling up the project "*Everything we discover at the level of Strijp-S, we want to be able to replicate quickly in other places in the world*." (Innovation Origins, 2017). The living lab is conducted in 3 stages.

1. The cloud layer: the cloud layer is where the data is collected, analyzed and communicated to establish the content and context to support the innovation, smart and sustainability of the city particularly Strijp-S.

2. The livable layer: In this layer, Strijp-S aims at providing its residents a tangible and sustainable living environment through certain applications and tools.

3. The infrastructure layer: This layer as the name suggests deal with the transitioning of the infrastructure in transporting and transmission of important resources like energy, water, waste, and data. Additionally, smart and sustainable mobility is fostered and encouraged in this Living Lab to support the flow of people and goods (Strijp-S, n.d).

Time frame: The time scale of the living lab so far has been long term as upscaling the knowledge created in the lab to other parts of the world globally. According to the interview: '*the long-term project that is the Redevelopment of Strijp-S planned until 2025 but due to corona virus pandemic it can extend till 2030. It was a project spanning 20 to 30 years for the development of the whole district. But, when it comes to technology, we do projects which have just been a time span of maybe four years. subsidis for example European subsidy projects. [00:21:06] but also for maybe a week or a month to experiment with solution so depends.' (*W. Beelen, personal communication, July 3rd, 2020).

This shows that the time span of the distinguished projects small and long-term projects varies on the basis of the technologies used and objectives. The long-term redevelopment of Strijp-S is a 20 to 30-year project began in early 2000's. One example of the small-scale project for testing new technologies is BMW collaboration. Whereas the projects dealt by Mobility-S might differ respectively like BMW collaboration is for 5 years to test the usage of i3 model cars. The projects thus have been set according to the time meticulously to bring out better results. The technology used in the lab in the form of software to collect and store data, other technical tools used to record the air quality Etc. are again designed to provide solution for the area specific issues thus geo-embeddedness is observed as a key characteristic. An

intermediate software layer is created to collect data from different sources as there should be a connection to communicate between vendors, manufactures.

Upscaling:

At Strijp-S, upscaling is observed in terms of prototyping and customizing the technologies and products to implement in other ULLs and areas. According to the interviewee, all the successful pilots and products are upscaled according to the new terrain which is being redeveloped like Strijp-S as the center of the Netherlands as well as in other parts of the country like in eastern part Zwolle. At Strijp-S Living Lab they focus on the design by adjusting the process specifically to that location and the issue at hand. The transitional level they work at focuses on prototyping and show solution which with some small adjustments are able to also provide them for other cities or for other districts. As forth mentioned, data collection is the key part of maintaining in this lab and a lot of data connection in the public domain and then it's about privacy regulation and other related issues. It's about a process to cooperate to be flexible with the master plans that takes a process approach, learning than individual experiment. They perceive ULL at Strijp-S as a process in happening, not an experimentation thing.

Context:

Strijp-S Living Lab clearly has many areas to contribute to improve the quality of life of users by offering solution that add value. Many types of sensors to measure air quality, cameras to track and analyses traffic movements and smart lighting. Thus, all these measures clearly imply that its geographically embedded where innovation through smart technologies are key characteristics of the Lab. As Strijp-S is an outdoor laboratory where the projects are simulated into real-life features which are users by visitors and residents at their own choice is however a Testing bed where there are rules and regulations though flexible implemented. The geographical site consists of shops, restaurants, cafes, food courts, offices, public square, recreational spaces, streets, covering a greater surface area. The projects that are conducted here include smart mobility, smart office, smart charging of electric vehicles. Smart lighting, sustainable energy supply and soil sanitation, optimization of heat provision in existing buildings. One of their agenda is Smart mobility and as this project is about studying smart and

sustainable mobility transitions, I chose to concentrate on this. This real-life setting is useful in bringing real world challenges and feedbacks. Strijp-S collects data from its users providing encryptions to it and as it is partner with Eindhoven Municipality and other public bodies through which it gets funding and aid in upscaling transitions. Thus, it is technology, citizen and transition driven Lab in one. However, the manager personal calls it a citizen and transition driven Lab.

When asked about the ecosystem or setting at which Strijp-S Living Lab operates (planning at co-governance or community development), "*so really what we try to stimulate the people they can cooperate with us. So, with the PPP, [00:08:51] for example, we also we we did a city tender, two years ago there we challenged companies but also people to come up with new ideas to which they [00:09:06] think would create a better quality of life. Within strijp as so there are a lot of ideas generated by that. So, we really strive to stimulate to bring up ideas from residents but also companies who are [00:09:21] situated over there*." (W. Beelen, personal communication, July 3, 2020). This informs that the lab strives to involve residents and indigenous businesses to make transitions possible through designing the services according to their lifestyles. One such example is extension of parking facilities across the district to accommodate the ever-growing offices & residents and making the district free of cars on roads. Additionally, promoting electric cars is a successful achievement at Strijp-S as it has more charging points that the Netherlands has. Thus, also providing bike sharing facilities according to the specific group of people and at specific buildings like near the office building has observed to be successful. For this they set a research (data collection) team to customize the mobility services at Strijp-S.

In this Quadruple helix as mentioned in participants content, the process starts at the TU/e where theoretical hypothesis to test and to validate the new products is developed. Then at the Brain port industry campus the final product is made and at the Automotive campus the testing of the product takes place. As all this happens with Brain port region and located 10 to 15 mins away, they collaborate with each other in technology development. Once the technologies are developed at Strijp-S they design it to implement in the real lab setting and evaluate the progress. Later on, at the testing phase they extend it to Helmond Living Lab making the unique Brain port region (W. Beelen, personal communication, July 3, 2020).

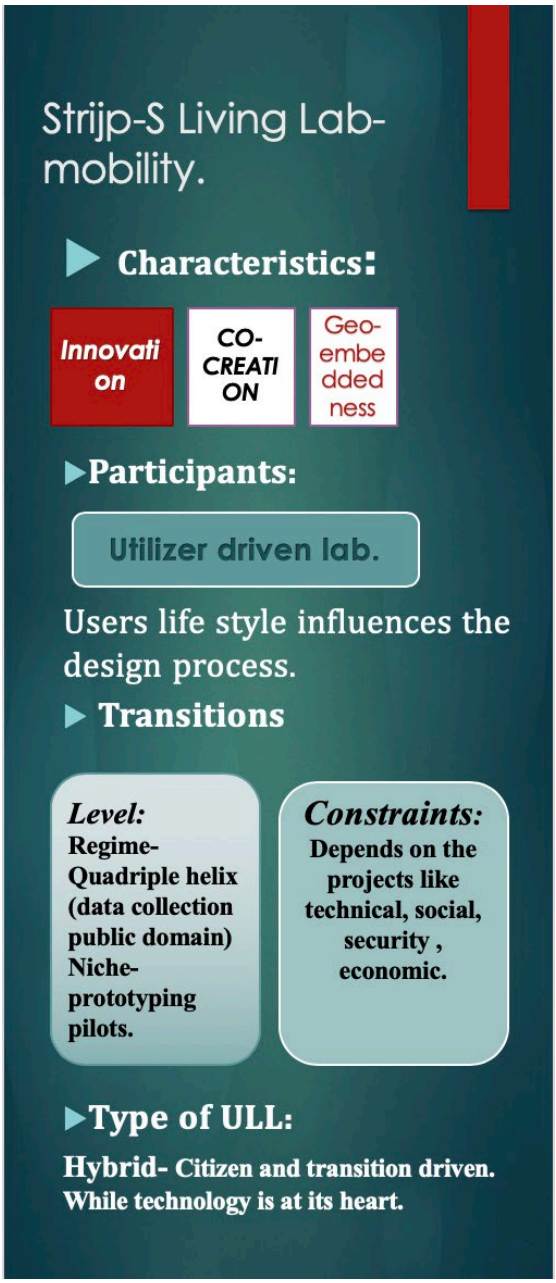
At Strijp-S, they promote all types of (sustainable) mobility alternatives like car sharing, enabling smart parking, and booking alternative shared transportation like bicycles, scoters etc. These changes are made possible by the consistent upscaling and upgradation of the developed technologies thus, making innovation and cooperation its mantra (bee smart city website). These key analysis and observation are made from the case study Strijp-S and the initiative taken in cooperation with key stakeholders and the fostered innovation to solve the area specific problems like to preserve the historical identity and character of the neighborhood and to make it a sustainable and progressive locality for the new users is how it answers the questions 1 & 2.

Thus, ULLs that promote such smart and sustainability initiatives particularly to promote alternative mode of transport in Dutch cities aid in upscaling the transitionary process and serving the respective communities.

So far, the ULL at Strijp-S is observed as Citizen, (technology), transition driven living lab. Citizen driven because of its niche experimentation with cooperation from users and companies in the area where products are developed, refined, disassembled, replicated and upscaled. In a way it can be seen as transition driven as its major objective to see the multi-level transitions taking place (Upscaling) is another driving force behind the successful setup of living lab. The living labs emphasizes on the usage of smart technologies to provide a cleaner air and energy saving.

Finally, Smart city is about both vertical columns and horizontal layers interlinked together to make a complex city work sustainably. Like for example Strijp-S in its organizational structures in PPP (Public Private partnership) with Volker Wessels and municipality of Eindhoven, there many vertical columns that are operated by different departments like parking, public lights, waste management. However, the horizontal layers that connect different departments with their own expertise to the bigger picture that is the sustainability transition. The key characteristics play a crucial role depending on the vision of the ULL and the issues its dealing with. "*At Strijp-S, we strive hard for and everything that we do has to improve the quality of life."* (W. Beelen, personal communication, July 3rd, 2020).

Infographic 1: Strijp-S Living Lab.



Source: Author (2020)

Driven: Helmond Living Lab

Driven Helmond City of Smart Mobility is an initiative of Helmond city council with the objective of linking activities, projects and organizations in the field of smart mobility in and around Helmond (Driven: Helmond City of Smart Mobility, (n.d.)).

Helmond as a city has emerged as the hotspot for smart mobility in the Netherlands and they aim to be a global hotspot. This is supported by being at the center of brain port region which is known to be one of the most technologically innovative zones in the Europe. Helmond is logistically embedded in that it is home to Automotive Campus NL with plenty of test facilities and laboratories to bring innovative technologies into reality. Stakeholders and participants in this innovative space which is leading sustainability mobility transitions in a smart setting are the reason for the growth of this living lab. Here, the government adopts the innovative ideas produced and try to help in upscaling the niche scale projects to regime level by bringing out policies that support whole of Helmond (Driven: Helmond City of Smart Mobility, (n.d.)).

Goal: Goal of the Helmond Living Lab is to connect all type of smart mobility activities, projects and organizations in and around Helmond (Driven: Helmond City of Smart Mobility, (n.d.)).

Basic information: This Automotive Campus NL is located in Helmond and currently covers an area of around ten hectares. However, it is estimated to grow into 25 hectares field in few years. It consists TNO, Benteler and TASS International such organisations along with small and medium scale companies that work in sustainable and smart mobility sector. There are currently around 500 people working at the campus. There are 750 number of students at the campus ((Driven Helmond City of Smart Mobility Brochure, n.d.). It is spread over 11.000 m2 of offices, workshops, and labs with 25 labs and test facilities with 10,000 visitors annually (Brabant Brand Box, August 2019). The four key focus areas are: green mobility using alternative fuels, smart mobility, Triple Helix which is through a collaboration between government, knowledge institutes(universities), and businesses and finally creation of a favorable business climate in terms of infrastructure availability, accessibility and living environments and the image/reputation (Brabant Brand Box, August 2019).

Figure 10: Map depicting Brain port area with automotive campus. Source: Automotive Campus official website. Retrieved from: https://www.automotivecampus.com/nl/ .

The municipality of Helmond received international award for smart mobility at the the ITS Local Government Award during the ITS World congress in Singapore as the city provides the practical approach by bridging the gap between research and deployment, where both research institutes and the business community work together to put ITS (smart) technologies into use. The municipality said that the city is literally a living lab, where the innovation is tested in daily practice and seeking continuous integration of residents to test the projects (VISIT BRABANT Convention Bureau.com).

According to the official website of AutomotiveNL, the main reason to choose studying the Helmond Living lab 'DRIVEN' is it works with AutomotiveNL which is an independent cluster organization for the Dutch automotive industry, mobility sector, the automotive education sector and has around 170 members. It has a base in AutomotiveCampusNL which also in Helmond. Their Mission is to focus on Green and Smart sustainability. Helmond living lab and its partnership with AutomotiveNL allows and supports innovation, the transmission of knowledge created through the projects handled. Netherlands particularly has a thriving automobile industry working on innovating in the smart and green mobility and associated supply chains (AutomotiveNL official website. (n.d.)).

According to the official website, "In Helmond we just don't think, we do" is the slogan they use to elucidate the transitions in action. It's a government organization as specified in its Facebook page.

Partners- They work with many partners such as AutomotiveCampus, Automotive NL, hurks, POLIS, Provincie Noord-Bradant, WaterstofNet, ERTICO, DITCM innovations and Gemeente Helmond. The key partners of the lab are mentioned on the facebook page of Driven Helmond Living Lab.[6]

TNO: One of the key knowledge institutions Helmond living labs work with is TNO. It works to produce knowledge particularly in optimizing the developments in new mobility systems. They specifically focus on technology in the car, communication between them and their surroundings, road safety and driver behavior along with legislation and regulations. Additionally, tackling these challenges on three levels- that are the vehicle, the mobility system, and the societal impact. In TNO' words,

"Our solutions are a highly innovative export product. If it works here, it will work anywhere." (TNO website, n.d.)

Retrieved From: https://www.tno.nl/en/tno-insights/articles/smart-mobility-systems-in-the-global-spotlight/

In addition to its partners, the Driven living lab is situated in the center where all activities or developments related to sustainable and smart transportation took place and a platoon of traffic moves between Eindhoven and Helmond city center. TNO's test centre came to the campus in collaboration public-works' Traffic control centre for the south-east Netherlands.

Dutch Integrated Testsite for Cooperative Mobility (DITCM): Helmond city along with 20 other companies, road authorities, and knowledge institutes from the mobility domain identified a permanent testsite for smart mobility in Helmond region. Here they work jointly programme, develop, test and invest in solving traffic related issues (traffic management) and ITS and corporative systems.

This ***unique cooperation*** between DITCM and the living lab shows the commitment to working in cooperative environment where bundling of knowledge, innovation and testing take place at the same time. Another characteristic of the living lab is ***joint innovation*** by working with each other on operating a cost-effective testsite.

Projects: The following are the projects that are handled by Helmond Living Lab in collaboration with various organization working in mobility sector. Most of these projects are successfully implemented and under process to be upscaled.

[6] Driven by Helmond Facebook Official page. Retrieved from: https://www.facebook.com/drivenbyhelmond/photos/?ref=page_internal

Freilot: This project deals with negative consequences of the freight traffic which is drives our economy. In order to improve the traffic flow of freight traffic and to reduce Co2 emissions, this project was initiated in Helmond and three European cities in 2009. Freilot is a project that test the Intelligent Transport system (ITS) along with 20 other companies and organizations. The project has been successful and showed promising results. The pilot focused on fourteen traffi c lights on the route Deurneseweg - Kasteeltraverse - Europaweg. In this route around 2000 lorries travel up and down every day. This project is the reduce the co2 emission by cutting down on the fuel consumption (13% less) which is also practical and achievable smart and sustainable mobility initiative. By using smart communication tools installed in the lorries and traffic lights the drivers can maintain appropriate speed and stress less journey. After the success of this the Helmond city council wanted to establish this system permanently in the region and European commission has also taken into consideration (Driven Helmond City of Smart Mobility Brochure, n.d.).

Compass4D: In the past 2014, they introduced a pilot project called Compass4D to test cooperative traffic systems in order to demonstrate that they ensure improvement in traffic safety using warning for forward collisions (FCW).The Compass4D is also partly financed by the EU and the consortium consist of 31 parties from 7 countries. One of the major partners is ERTICO-ITS. The main expectations are to improve smart and sustainable mobility conditions by buses will drive be on time, electric vehicles can travel long distances, emergency vehicles can arrive faster and safer, Drivers of lorries, taxi's and busses will travel slower over the junctions that are fitted with Compass4D technology (Driven: Helmond City of Smart Mobility. (n.d.)).

Users/participants: The target group of Compass4D are drivers of busses, emergency vehicles, lorries, taxi's, electric vehicles and cars. The information gathered during the project will lead to these vehicles driving more safely, with less stress and with greater energy efficiency. The projects include around 574 users and 344 vehicles in Helmond-Eindhoven, Bordeaux, Copenhagen, Newcastle, Thessaloníki, Verona and Vigo. Especially in the case of Helmond-Eindhoven, this service has been installed over the entire route in Helmond via the A270 to Eindhoven Central station (Driven Helmond City of Smart Mobility Brochure, n.d.).

DITCM: Dutch Integrated Testsite Cooperative Mobility is an organization where government agencies, corporate companies, and educational institutes work with a goal to develop smart mobility systems. They focus to deal with traffic flow, road safety and less impact on environment. They are motivated in working toward sustainable world with solutions that benefit all and open innovation is the key.

This project has 30 partners working for enhancing the better floor of traffic in cities. These innovative systems will be installed in vehicles and traffic lights soon they will be established as the simple traffic

lights. And Helmond city acts as a living lab where TNO, the city council, TU/e, TomTom, DAF, the ANWB, Rijkswaterstaat (Ministry of Infrastructure and the Environment). All the new developments that are yielded through the partnership with above mentioned organization can be immediately tested in a 'real life' setting. According to the Helmond Living Lab, "So it is possible to see directly if and how new cooperative systems can be incorporated into daily reality." Development of a testsite for smart mobility with DITCM parties (Driven Helmond City of Smart Mobility Brochure, n.d.).

One of the visions of the Helmond Living Lab, is to make it ***electric vehicle*** friendly city. The city council is working hard to contribute to the 1 million electric vehicles goal by 2020 in The Netherlands. This is a long-term implementation plan which is divided into 4 categories: vehicles, infrastructure, development & innovation. Citizens and business are all necessary to bring this vision into reality. Helmond works with BrabantStad in a work group that deals with electric (green) mobility. Their aim is 'place to be' in the field of electric driving by making the transition visible in terms of the no of vehicles on road, air equality, reduced emissions. The municipality is trying to attract the residents to make a conscious choice of using electric vehicles (Driven Helmond City of Smart Mobility Brochure, n.d.).

Electric public transport is another area where the Helmond city council wants to prove its advanced expertise in the sustainable mobility technology. At the moment Helmond is participating in several feasibility studies and pilots to investigate different solutions with respect to vehicles, charging infrastructure and business models. The Helmond based company VDL Advanced Public Transport System is currently developing a fully electric version of its 24-meter advanced public transport system called "Phileas". The Automotive campus in Helmond will be used to develop and test the 'Primove' inductive charging system. IXION project is about introducing the public transport buses using small batteries in the City of Helmond and the city region Eindhoven (SRE) by Bluekens, Heliox, Enexis, Hermes, Schunk en Hermes with financial support of AgentschapNL (Driven Helmond City of Smart Mobility Brochure, n.d.).

Hydrogen fueling station which is re-locatable in a partnership with Helmond by WaterstofNet by Ballast Nedam IPM, whereas the hydrogen generator is supplied by Hydrogenics as one of the outcomes of a European Interreg Project "Hydrogen Region Flanders/ South-Netherlands" and the city of Helmond financially contributed to the project by facilitating the connection to electricity and water. WateraofNet supports the development of various shydrogen-based applications: VDL Fuel Cell City Bus (by APTS and VDL Bus & Coach) and a garbage truck (by E-Trucks Europe) will start using the hydrogen fueling station for testing purposes in the living lab (Driven Helmond City of Smart Mobility Brochure, n.d.).

Participants:

Users- The citizens of the Helmond city also play a key role in conducting the test and act as sources for data creation through their vehicles on the road thus creating value. Students from partner knowledge institution like TNO, TU/e involve in bringing to table their innovative skills and help in analyzing the data for surveillance of the projects. Decisions are made mostly by the municipality and the conductors in terms of the key stakeholders like TNO, TU/e as knowledge institutes of the Living Lab. Many other stakeholders are mentioned in the above sections under projects. Thus, this lab can be considered as a utilizer driven lab as the decisions and power lay in the hands of the municipality and companies in the format of Public-Private Partnership (Driven: Helmond City of Smart Mobility, (n.d.)).

Experimental setting: The Helmond Living Lab is a real world setting in the city of Helmond and involves real time users on the highway. They introduce new technologies at appropriate distances on the highway to regulate and contribute to better flow of traffic. Along with this they continuously gather information through the instilled systems in the vehicles and also established a test site in collaboration with DITCM. Thus, the implementation and evaluation of the projects further enabling the systemic transitions. As TNO is involved it is a national scale lab that is working on projects not just at the Helmond city level but also embedding in the larger national sector (Y. Araghi, personal communication, June 26th, 2020.)

In an interview conducted by smart city world news team about the Helmond as a smart city, "Sustainability is important for us and that's why we've been looking for ways to save energy and reduce the CO2 footprint," added Groote. They emphasized on the importance of lighting in making livability of the city better. Helmond city us known as knowledge hub and an active ULL for the automotive industry that's home to 90,000 people and has more than 25,000 lighting points to provide smarter living to the citizens (SmartCitiesWorld, December 11, 2017). This explains us that the ecosystem in Helmond as the Living Lab is real world setting where the Municipality and other stake holders involved constantly world towards improving the well-being of its citizens. With the automotive lab and the smart lighting that consistently provide smart lighting according to the presence of citizens on roads aids in reducing CO2 emissions and sustainable.

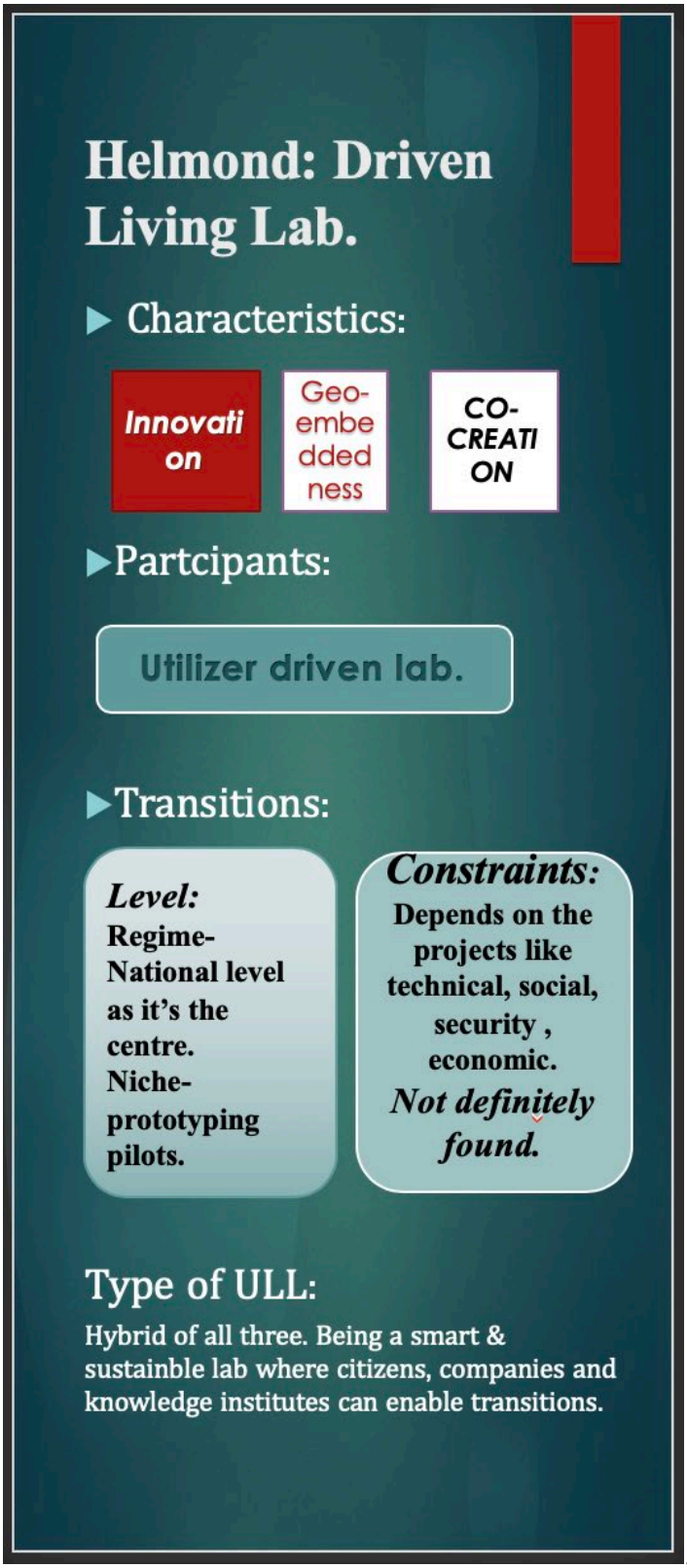
Time frame: Living Lab is planning to work in long term as the sustainability transitions in the mobility sectors take a time to upscale. However, the different pilots have different timespan.

In the above-mentioned projects, some pilots are already over and are to be upscaled into permanent projects in the city. Whereas other are still being tested and yet going through changes in formulation. The focus is to find smart solutions by taking small steps to become big leaps.

European commission from 2016 reimburses the municipality for the administrative hours spent on the projects awarded. In the field of green and smart mobility Helmond Automotive Campus has grown into a prominent center of knowledge development and innovation. This can be supported by the granting of European subsidy for four major projects that are partly carried out on the Automotive Campus confirms the good reputation Helmond has built. In consortium that includes companies, government bodies and knowledge institutes applied for the subsidies. The European subsidy programme Horizon 2020 focuses on innovation in many areas, including the development, testing and marketing of Intelligent Transport Systems (31 August 2016 Wednesday). Thus, the Helmond Living Lab is funded by the municipality of Helmond, subsidies and grants by European commission.

In Helmond living lab, the emphasis is laid not just on the experimentation but on the transmission of the projects from the creation, testing, to analyzing the knowledge produced and recorded by the educational institution that are partnered with the lab. This results in the transition from the niche experimentation to the regime policy implementation. The characteristics that are specified in the literature review called Co-creation, Innovation and Geo-embeddedness are observed in this case study. Another important characteristic of the living lab is that they would want the model developed in this lab is contextualized to be applicable elsewhere in world thus taking a globalized approach. Finally, it builds a pathway to upscaling to other levels in transitions and other places (van Worth, et al, 2019).

The impediments in upscaling in the Helmond are not clearly found. However, one of the key constraints can be financial investments and the will of Helmond municipality to upscale is another.



Infographic 2: Helmond Living Lab

Source: Author (2020)

SUMMALab:

SUMMALab works on experimenting innovative solutions in the field of mobility in order to use fewer modes of transport, reduce emissions and covering less areas. The main objective is to upscale the shared learning process between regions of promising solutions through bringing them together and advising them on various experiments, initiatives including startups, labs and to make cities accessible in the most sustainable way possible by considering the livability, accessibility and land use. Accelerating the speed of upscaling by achieving economies of scale (SUMMALab. n.d.).

"SUMMALab is named by a Latin word SUMMA it's a lab of labs. So, we are assessing around 30 living Labs, experiments and pilots within this project because we are looking at various Labs, So, we are SUMMALab." (Y. Araghi, personal communication, June 26th, 2020).

Thus, it's not an individual living lab but a *conglomerate of living labs* across cities to make the smarter and greener. Mainly it focuses on 1) 'Last mile' solutions such as automatic shuttle and mobile robots to aid the flow of people and goods additionally bicycle-sharing systems and micro mobility.

2) Door-to door solutions such as car sharing, carpooling, (M/TAaS) Mobility/Transport as a Service which aid in reducing the number of vehicles on road thus resulting in fewer emissions.

3). Urban built infrastructure such as parking facilities, loading/unloading locations for limiting area utilized or covered by transport systems and vehicles (SUMMALab. n.d.).

Aim and goal:

"We work as a learning space and with learning agendas. The most important target of the project is to access the Innovations in the mobility sector see how the cities can become more accessible (accessibility), livability, emissions, safety and health." (Y. Araghi, personal communication, June 26th, 2020).

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2) Door-to door solutions such as car sharing, carpooling, (M/TAaS) Mobility/Transport as a Service which aid in reducing the number of vehicles on road thus resulting in fewer emissions.

3). Urban built infrastructure such as parking facilities, loading/unloading locations for limiting area utilized or covered by transport systems and vehicles (Future Mobility Network. n.d.).

Activities:

The lab bases its approaches on building a sustainable city through these following pillars:

Maintaining the learning agenda through acquiring the knowledge (relevant) questions and providing a platform to share the knowledge collected and created from experiments at varied scales of innovation like pilots, starts-ups, scale-ups. Further on refining this knowledge to provide advice on setting up, evaluating and scaling up experiments (Future Mobility Network, n.d.).

In turn the attention will be given to technical aspects, business models to make the plan sustainable in long run and in turn include participation of citizens and shopkeepers' associations and finally to evaluation and upscaling methods (SUMMALab. n.d.).

Thus, the main characteristics the lab embraces are the knowledge transmission and aid on co-operation, innovation. They act as a consultant in bringing the Living Lab in cities and researchers, technicians together in a Confederative character. They hold regular meeting 3 to 4 times a year with forth motioned stakeholders from the LLs/pilots to share the collected knowledge. Small workshops to LLs are conducted to provide on geo-embedded issues by introducing other successfully generated knowledge. Upscaling is the key pillar as they work putting it to practice and reintroducing them to new local experiments thus giving the scientific underpinnings and methodologies as seen in the following figure 11.

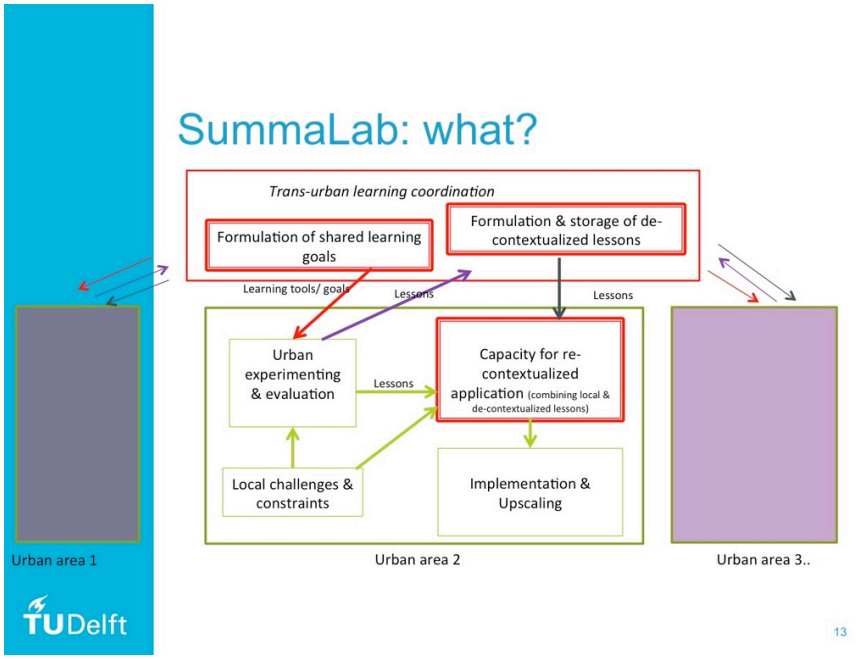


Figure 11: Organisational Framework of SUMMALab. Courtesy: SUMMALab website.

"The diagram illustrates, it starts from the what challenges are locally raised then they are discussing it. at urban level and evaluating it and then they go for application. Oh, yeah. When they apply it in the capacity for recontextualized application that means when they applied in the pilot level and they at the end they give an upscaling evaluation." (Y. Araghi, personal communication, June 26th, 2020).

Location: SUMMALab currently covers 4 urban areas in The Netherlands and plan to cover more cities in the future. The municipalities of Rotterdam, Hague, Delft and Amsterdam Metropolitan Area are involved.

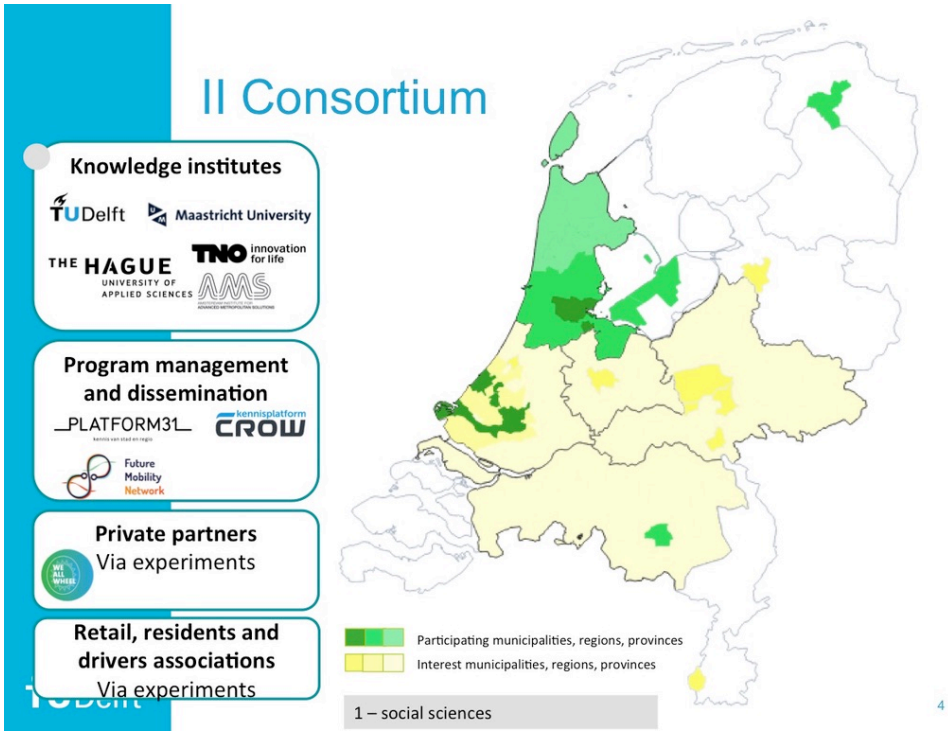


Figure 12: Locations and stakeholders of SUMMALab. Courtesy: SUMMALab website.

Partners: The major partners in this lab currently are TNO, Maastricht University, TU Delft, The Hague University of Applied Sciences, AMS as Knowledge institutes. The programme management and dissemination is Future Mobility Network, CROW, _Platform31_. The Lab also collaborates with private partners via/ respective to the experiments.

TNO is the key player in this lab as it deals with ULLs across cities and private companies and it's the obvious choice as it works as an impartial body that develops tools and application tests for assessment(evaluation) of the ULL by customizing according to the pilots. Participants or users of the lab are the residents, retailers, businesses, drivers' associations in all the respective areas covered. The participation of municipality of the 4 cities are varied as seen in the figure 12. Thus, this case study is enabler driven or guided lab as SUMMALab acts as a body that provides knowledge, methods of research and evaluation.

As forth mentioned SUMMALab is a learning circle. In order to support this setting learning goals while meeting half yearly as Learning space with participants present. The first learning space of SUMMALab took place on 6th March 2020. In this meeting the usefulness of the learning agends in experimentation process is discussed. One of the key questions they dealt with are in similarity with my Thesis questions:

'What can we learn from the experiments with mobility innovations and about their contributions to accessibility and livability of the city?

And to what extent are these experiments socially inclusive, affordable and scalable?' (SUMMALab Learning Space bijeenkomst, 6 March 2020)

During this meeting the learning agendas of the 4 cities are discussed and interactive session was subdivided into accessibility, livability, affordability and scalability are discussed. Drawing up local learning agendas are said to aid in formulating and monitoring the answers to the learning questions posed at the lab. Thus, evaluation of the experiment and the progress trajectory of the LL can help in sharing the created knowledge to new experiments. They follow a systematic description and categorization of each project thus enabling comparison and providing appropriate advice and support to different projects efficiently. However, the framework for SUMMALab is not available yet, they are in the process to refine the results and put forth in concrete information for future and existing ULLs to adopt (SUMMALab Learning Space bijeenkomst, 6 March 2020).

A comprehensive learning strategy has to be developed and followed aiming at capturing and monitoring knowledge creation and for this making people-to-people(physical) interactions in order to upscale the ongoing projects, for this SUMMALab has framed learning spaces and agendas where people can meet up, yielding comprehensive and tactic-knowledge (Guildines for upscaling). This is done in the form of formulated joint learning plans addressed in chapter 2 or 3 to anticipating constraints in ULLs respectively.

"We are in the starting phases of assessing these living labs. It will run until end of 2022." (Y. Araghi, personal communication, June 26th, 2020)

According to Yashar Araghi, All the Living Labs are driven by citizens, technology as they are testing with technical innovations especially in Smart and sustainable mobility. Additionally, transitioning in the form upscaling are all important criteria for the Urban Living Labs. It's the same with the labs that are aided by SUMMALab. Here, accessing the up scalability is the key focus.

Joint learning goals are formulated in the SUMMALab depending on the area specific challenges and in collaboration at work with the different experts.

SUMMALab thus, acts as 'broker' and connector for the stakeholder involved in this Quadriple helix collaboration by making sure all stakeholders can contribute by facilitating and providing information, bringing them altogether in the form of workshops, establishing learning goals etc[7].

Additionally, about the criteria for up scalability of the Living Labs under SUMMALab: When asked about the criteria to upscale the projects,

"Upscale what you want to do is if a project qualifies for any of these aspects, so if it increases the social inclusiveness if it increases the livability or accessibility of an area then we definitely want to upscale it." (Y. Araghi, personal communication, June 26th, 2020) It's about ticking the boxes of the 6 set criteria to upscale any project. As impediments to Up scalability, are key part of understanding the sustainability transition in smart and sustainable cities and as in this particular case study the lab deals with four major cities in the Netherlands the expert in the SUMMALab that works with TNO which is an organization that works at the national level in assessing the transitions and developments.

"There are economic factors are involved who is going to invest it on this. Is it financially feasible if the upscale and this may be something is very safe and perfect for the society like automated vehicles, but it slows down the network, so Much that it really makes everything difficult in the form of congestion? So, it's not even worth upscaling. Yeah, maybe scaling it will cause a lot of Financial loss. You're thinking about is it worthwhile to upscale in the interest of the society and have difficulties to upscale. Does it require a lot of procedural regulations? Does it require a lot of privacy?" (Y. Araghi, personal communication, June 26th, 2020).

Simply put, the impediments to upscaling according to Dr. Araghi are:

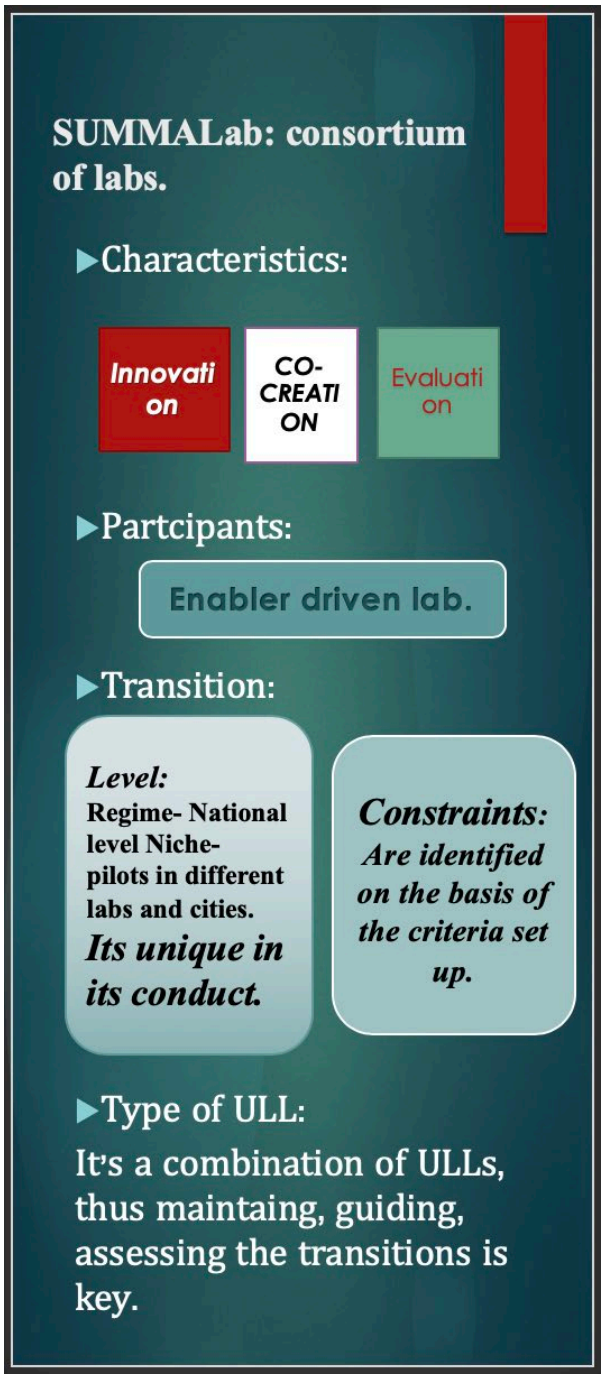
Government funded pilots: Governments like municipality when in collaboration or funding the Living Lab generally tend to not allow the transitioning to regime level because of the commercialization of the project by involved stakeholders. However, the government is interested in seeing/ checking out the how the pilot is performing, if it's up scalable or not.

Financial feasibility: The pilot in order to upscale has to be financially feasible in terms of whether the ULL is economically viable. In order to cover larger area and people that are going

[7] Quadruple helix mentioned in chapter 2.

to be directly or indirectly affected and served with multiple functions. Other obstacles are if it's in the interest of society to see its usefulness and immediately serves the society and brings transformation. And the other is difficulties of upscaling a project should be as hustle free as possible (Y. Araghi, personal communication, June 26th, 2020).

Infographic 3: SUMMALab.



Source: Author (2020)

Chapter 5: Conclusion & Recommendation.

In this final chapter, the final conclusion and recommendations for further research are discussed. In the conclusion part, all the observation made in the form of findings are summed up to answer all the main and sub questions in the premises of theoretical framework.

Conclusion:

In this thesis, the major focus is laid on how the ULLs can aid in sustainability transitions in terms of upscaling the projects/pilots handled in the smart and sustainable mobility sector in order to answer the main question: How does living labs aid or (contribute) in sustainable transition particularly in the field of smart & sustainable mobility?
For this reason, I chose three case studies that are active in the Netherlands to understand this phenomenon. Two of the case studies that are Strijp-S Living Lab and Driven: Helmond Living Lab are established Urban Living Labs in real-life setting whereas the SUMMALab is a conglomerate of the ULLs spread across four cities that acts as management and evaluator body. Through using this intriguing combination of the Living Labs and after studying the pilots and key characteristics that encompass the goals, participants and activities. One of the key factors is understanding upscaling/transitions and the impediments to transitioning.

The systemic literature review has given insights into constructing the theoretical part of this thesis where the difference between Urban Living Labs and Living Labs, characteristics of the labs and the theories to study upscaling as wells as the impediments. Only, by studying these I figured out the key variables to study to answer the main and sub-questions. The main question on the role played by ULLs in Sustainability transitions is answered through the proving the hypothesis that is to enable transitions an efficient ULL which is formulated and evaluated through embracing its nature and key characteristics can aid in first locating the transition level, type of the ULL thus, finally providing a solution to adopt. All the sub-questions are thus framed to support the main question. The following paragraphs explain all key takeaways from this research.

The key characteristics which have been chosen to do this research have been found to play a crucial role specifically when it comes to assessing the Living Lab's progress in other words while assembling or assessment of the lab to create knowledge for future ULLs i.e., 'applicability elsewhere factor'. They are observed in three case studies and **co-creation** is observed to be in all three case studies as an important characteristic that bridge other characteristics like innovation, co-production, knowledge creation. Geo-embeddedness is a foundational characteristic that leads the development of the nature of the ULL. Further embracing other characteristics aid in enabling the ULLs to create knowledge and customize their structure and formulation according to the new labs accordingly as in the case of Strijp-S, Helmond and SUMMALab which specifically works on several labs to bring the experts and conductors of the labs together under workshops and provide better criteria and solutions (based on findings).

One of the key observations made as dealt in the theory is the types of ULLs. The chosen ULLs all three of them are seen as hybrid of Technical, Technological and Citizen driven Living Labs. The labs all exhibit the characteristics of at least two of the either types of labs as answered by one of the experts, Dr. Araghi said its quite unlikely to find a lab which is not a hybrid and technology will be a key factor in driving the ULL that works in sustainable and smart mobility transitions. This has been identified through the identification of key words for citizen driven LLs is citizen empowerment, participants role and developing the neighborhood, for technology driven living lab is becoming smart city, and technological innovation and for transition driven living lab is sustainable development, transition or upscaling, and governance.

Additionally, to figure out if the decision power is democratically distributed to all actors involved in the lab the role played by different participants/stakeholders is important. Thus, it has been found that in the case of Strijp-S Living Lab and the Helmond Living Lab are utilizer driven labs as the municipality and the private companies, (city-)entrepreneurs work in Public Private Partnership. Whereas, the SUMMALab consists of participants that work as enablers where they provide knowledge in the form of workshops, methods of research as in the structure to formulate the ULL and the evaluation according to criteria set.

As the Transition theory is used to understand ULLs, it has supported the argument to recognize the necessity for multi-stakeholders' collaboration as explained in the above-mentioned paragraphs about the types of ULLs and Participants that drive the course of the ULL's

transition. Additionally, the basic feature of the ULL is co-creation and pointing out the problem at hand to construct the nature of the ULL. Thus, Multi-level perspective (MLP) aids in recognizing the socio-technical transitions like smart and sustainable mobility transitions while using the ULLs. In these case studies most, pilots introduced by the Living Labs especially in real world experimental setting like Helmond and Strijp-S have been mostly successful at the niche level. However, there has also been ascent to regime level seen in both ULLs as they co-operate within the Brain port region to disseminate the knowledge created through customization to other regions. Thus, existing systems in these two places have seen developments in terms of being flexible according to ULLs ecosystem. Like in both the cases the smart technologies like mobile applications, technical systems installed in cars, car charging points etc. have been deployed to other areas within the Brain port region as the system is encapsulated in Quadra-helix collaboration. Thus, ensuring the transition in interns of reproducing existing systems. Although this research has not successfully dealt with the role played by institutional theory in conceptualizing transitions, nevertheless it deals with structural changes in progress. Like in the case of Strijp-S, when asked about the role played by institutions in shaping the behavior it has been pointed by the interviewee that the users and resident's lifestyle directs the nature of services provided in the ULL. Thus, emphasizing the conflicts that can arise between organizational fields demanding prioritization, reinterpretion of particular logics finally, putting the individual user's lifestyle forward.

Additionally, destabilization and deinstitutionalization are at the heart of transitions at regime level. In the case studies you can find this phenomenon in terms of innovation happening at the regional level. Following, Upscaling is the common goal in all three Living Labs thus, the transition of the innovation and technologies implementing them, testing and finally, evaluating it in real world settings and after ticking all the criteria boxes producing an upscaling report to government is the complete framework of these labs.

The impediments to upscaling are identified as mentioned in the theoretical review part of the chapter. Following are the observations made: Financial feasibility is found to be one of the key impediments as its always a matter of brining investments to developments in a larger scale area. The power structure inside the ULL as the communication strategy used to reach all type of participants could be better developed as in the case of Strijp-S although there is communication using mobile applications and other sources the lab make sure it involves all stakeholders and users through igniting their creativity for better and sustainable development in their neighborhood through conducting activities. Sticky Urban assemblage is another factor where decisions taken at high political level like the governments at municipal or provincial

level can constrain the ULLs from upscaling as they have to take into account larger population and their interests. Quadruple helix is also observed in three case studies as an organization tool to structure and formulate the lab by developing innovations, collecting data, testing it and evaluating it all the while including all types of participants thus, establishing a platform (increasing possibilities) to upscale to regime level.

Although this thesis could not answer the questions from the user's perspective as intended first still the expert interviews from the labs helped in understanding the basic structure, goals and the obstacles faced while transitioning in the smart and sustainable mobility sector. I believe the findings though are minimal can contribute to realizing the crucial role played by the problem that lab is dealing with, how it confers its nature through characteristics recognized and the impediments in upscaling from the niche to regime level. Thus, answering all three questions.

Recommendations:

As this thesis helped in understanding the role played by key characteristics however, much concrete research can be done on the reason behind the nature of the ULL and how it impacts in embracing the characteristics.

Secondly, further research can be done on the use of studying ULLs and transitions that happen in them through institutional theory to do the behavior analysis of the individual users.

Thirdly, there is still room for future research on the obstacles to upscaling in ULLs that deal with smart mobility. Emphasizing on upscaling as key criteria for ULLs can be studied in future researches.

Fourthly, the type of ULLs and the role played by participants can be further studied with much attention given to the new characteristics realized in the future labs. Additionally, figuring out the area specific problem, then realizing the context and finally understanding the nature of the lab will aid in identifying the type of lab benefiting in collaborating with appropriate stake holders will be my suggestion for the new ULLs.

Finally, the gaps between the behavioral role of the users/residents and formulation of ULLs have to be academically studied to aid the mushrooming ULLs. And as in the case of smart ULLs specifically dealing with mobility, privacy of the users (data collected) is another key factor to be tested if it can be embedded into the criteria for the ULLs. Further research can be done Quadruple helix and its contribution to sustainability transitions specifically when dealing with high technological innovations like in smart mobility. In the above cases this has been observed to be the source and guide to collect, test and evaluate knowledge.

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