1. INTRODUCTION: Experimenting for sustainable development? Living laboratories, social learning, and the role of the university

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With ongoing urbanization, over half of the human population now lives in cities. Rapidly growing cities present pollution hotspots and challenges for resource provision. New approaches to organizing social life, infrastructures and research and technological innovation are urgently required. The quest for such new approaches is often framed by 'Sustainable Development', which seeks to reconcile economic activity with social progress and environmental protection. The rationale is that biophysical limits to growth demand more resource-efficient approaches to production and new patterns of consumption, with attention to social equity – across the globe. A tall order! Given their considerable resources and durability, universities have a pivotal role to play in addressing sustainable development. As research institutions they have the capacity to generate robust and innovative alternatives to our fossil fuel driven society, while as centers for teaching and community engagement they can promote social change. This book develops approaches for universities and all involved in higher education policy and science and technology policy to engage in sustainable development and mobilize leaders and change agents.

Experimentation has long been recognized as a key requirement of sustainability (Dryzek, 1997), and universities are playing a central role helping policymakers, researchers, businesses and communities to experiment with new low carbon technologies and ways of living (Bulkeley and Castan-Broto, 2012; Evans, 2011). These experiments increasingly take place in bounded spaces in cities or on university campuses, termed 'living laboratories', which promise to generate knowledge that is applicable to real world situations. Living laboratories provide a space for multiple stakeholders to address local challenges, by jointly framing issues and producing new knowledge deemed by all an adequate basis for concerted action. The purpose of living laboratories is not only to allow novel things to be tried that would not be possible in conventional urban settings, but also to carefully monitor their social and physical impacts in order to provide a robust knowledge base for learning. In addition to addressing specific local challenges, such as improving the energy-efficiency of building operations or promoting less polluting transport choices, living laboratories can serve as platforms for visioning processes to define needs, what progress means and how to realize it, with the power to stimulate changes beyond their boundaries. As such, living laboratories are a key mechanism through which universities are seeking to contribute to a wider societal transition to sustainability.

The objective of this book is to better understand how universities are establishing living laboratories for sustainable development, exploring the communication networks and knowledge infrastructures that underpin impact both on and beyond the campus (Powell, 2011). The book presents thirteen case studies from universities on four continents, which are actively fostering social and technological change resulting in improved use of natural resources, or reduced pollution. Directing attention to what enables and constrains learning in communities of multiple and very diverse stakeholders in such laboratories can contribute to a better general understanding of factors influencing the chance of success (or failure), and the institutional arrangements, norms and values that accompany it. The book therefore contributes to an increasing literature across disciplines on social learning processes for sustainable development.

This introductory chapter outlines a research agenda for living laboratories, setting them within the theoretical context of socio-technical transitions for sustainable development. First, it considers living laboratories as a governance tool that links the academic capacity of universities with the sustainability challenges facing cities today. The chapter then considers the idea of 'transition' to outline how social learning in living laboratories might drive a wider shift to sustainable development.

The final section translates these insights into a set of key concerns that guide subsequent chapters, and provides a brief overview of each.

1. Universities, cities, and the emergence of living laboratories for sustainable development

Historically speaking universities have enjoyed a degree of intimacy with the cities that host them, but climate change and, in the West at least, successive public funding cuts have led urban decision-makers to actively seek educational partners to help address the challenges facing them. At the same time as cities are pursuing technologies and scientific knowledge for more sustainable development, universities have become more entrepreneurial in their pursuit of research that has real world impact and the funding streams that accompany it (Clark, 1998). Between the poles of the 'ivory tower' and academic capitalism lies a reality in which much university research is becoming increasingly pragmatic (Slaughter and Leslie, 1997). These trends have made science more 'visible as a transformational agent' in the competitive fortunes of cities than ever before (Perry, 2006, 202).

An EU report on future prosperity outlines a vision for the role of universities in transforming cities that resonates with much of the work in this book:

> 'it is time to re-invent the future for Europe, but the gap between latest research knowledge and real life practice is huge… so, cities must become real implementation fields, creating platforms for change where universities, public bodies and those from private and third sectors must operate together in a new and creative mood' (Committee of the Regions, 2011).

Turning cities into 'real implementation fields' where diverse stakeholders come together to generate new forms of urban living is exactly what living laboratories promise do, and drilling down into the EU vision outlined above helps to explain their current proliferation. Living laboratories provide a mechanism through which academics from various disciplines whose research and teaching have applications for urban environmental sustainability can engage with real world challenges in an applied setting (Goddard and Vallance, 2013; Evans and Karvonen, 2013). Cities can position themselves as leaders in innovation for sustainable development, while universities are able to hardwire real world impact in to their research. Beyond their allure to universities and cities, living laboratories promise public and commercial organizations access to free or heavily match-funded research capacity and testing facilities. On top of these individual wins, and perhaps most importantly, the living laboratory provides a focal point around which stakeholders can work together, generating communities of interest that may well outlive and transcend the living laboratory itself.

While universities traditionally tend to be core stakeholders in urban development as important property owners and developers, living laboratories are distinctive because universities engage their research capacity and expertise to setup, monitor and evaluate real life experiments (Evans and Karvonen, 2011). In their manifesto for the sustainable university, M'Gonigle and Starke (2006, 155) quote the founder of Harvard's Green Campus program, who suggested that 'the physical campus is the hard-wired identity of the university'. Such rhetorical claims on the part of educational institutions, they suggest, are mirrored increasingly by campus landscapes that are not only sustainable but that seek to develop new forms of sustainability. From numerous living laboratory campus initiatives around the world, they highlight Kyushu University's new campus in Fukuoka that is designed as an ecological experiment and the Lyle centre at California Poly in Pomona, which hosts a living laboratory for regenerative studies. In the field of sustainability, it would be disingenuous to distinguish too rigidly between campus and city living laboratories, as both generally aim to produce knowledge that is applicable to the wider urban landscape. Living laboratory type initiatives that use the university and city or parts of them as places to experiment with sustainable forms, technologies and lifestyles

have become hugely popular around the world precisely because they have the power to harness the academic capacity of universities to address the challenges of sustainable development.

Given its popularity with university and city leaders, it is perhaps surprising to learn that that the living laboratory concept originated as a corporate methodology to generate ICT innovations. The idea was to transform an entire urban environment into a laboratory to prototype and test new technology applications and foster innovation in real places (Kominos, 2008). It is worth quoting the EU Living Labs network, the largest and most well-funded living laboratory initiative in the world, at length here:

> A living lab is a city area which operates a full-scale urban laboratory and proving ground for inventing, prototyping and marketing new mobile technology applications. A living lab includes interactive testing, but is managed as an innovation environment well beyond the test-bed functions. As a city-based innovation resource the living lab can take advantage of the pools of creative talent, the affluence of socio-cultural diversity, and the unpredictability of inventiveness and imagination in the urban setting (Living Lab Europe, 2007).

At stake here is the move from a closed style of innovation typical of traditional corporate Research and Development, to a more open collaborative style in which innovation is knowledge-based and takes place in a wider community of stakeholders. Open approaches to innovation are often advocated on the grounds that they are more intelligent, where in intelligence connotes the ability to figure out 'what to do when you don't know what to do' (Calvin, 1998). In allowing space for novelty and surprise, living laboratories are particularly valuable when real alternatives are required to business as usual, as is certainly the case in relation to sustainable development.

In practice, living laboratories institute bounded spaces, often governed by university-led public-private partnerships, for innovation and learning which emphasise formalized knowledge production processes (Evans and Karvonen, 2011). Developing parts of cities or buildings as spaces for knowledge production promises relevance and social salience because it takes account of circumstances in real people's lives. This form of knowledge production accepts the need to understand locally-situated, context-dependent knowledge, adopting a relatively sophisticated learning process through which technologies and social norms are co-produced. As Gross and Krohn (2005) have argued, social experimentation has a lineage that can be traced from the writings of Comte and Mill, through the Chicago School of urban sociology and the social policy approaches of the 1970s. In the knowledge society the idea of the city or society as laboratory has come back to prominence, as a 'form of innovation, where scientific research increasingly erases the received institutional boundaries between science and society' (ibid, 76). For universities this has been reflected in the emergence of issue-driven inter-disciplinarity, which recognizes the limits of disciplinary theories and methods in characterizing complex systems in which material and social circumstances are intertwined and embedded in specific local contexts (Gibbons et al. 1994). Within living laboratories, the iterative application of research outcomes and the resulting improvement of technologies and practices constitute the primary source of legitimacy for the resulting knowledge (Robinson, 2008).

Living laboratories are, compared to hermetically sealed science laboratories, messy, multivariate open systems, raising the question of whether they are really laboratories in any meaningful sense at all, or merely trade upon the scientific credentials of the term. Exploring this question is fruitful as it reveals how the knowledge producing power of living laboratories is facilitated by their institutional, spatial and political characteristics, but first requires a brief recap of how traditional laboratories permit the production of scientific knowledge. Traditional laboratories have been characterized as artificially controlled environments that allow the manipulation of variables and testing of hypotheses (Knorr-Cetina, 1995). Control in laboratory spaces is provided by the ability to record, report and repeat experiments, and the legitimacy of the results is derived from the power to reproduce the experiment

in an appropriate laboratory anywhere. The resulting knowledge is thus conceived as universal and transferable, independent of local circumstances and practices.

The epistemological approach underpinning knowledge production in living laboratories is that rather than measure specific variables, data can be collected on almost every aspect of the experiment with sufficient accuracy to identify patterns and make robust causal inferences (Evans and Karvonen, 2011). In that they are instituted as spatially bounded areas, living laboratories seek to transform a part of the city into a laboratory by saturating it with monitors and sensors, relay stations, and social engagement processes (Evans and Karvonen, 2013). While the importance of built form and bounded space in facilitating such processes has largely been ignored by urban and regional researchers (van Heur, 2009), making physical interventions and installing the experimental infrastructure capable of monitoring a real environment in this level of depth raises a series of legal and institutional challenges. This is why many living laboratories comprise spaces that are owned and managed by key stakeholders in the living laboratory, and why, more often than not, universities are obvious partners with the resources to fulfill their institutional and scientific requirements.

To summarize then, living laboratories are an increasingly popular model through which universities and cities are engaging with each other to generate practical solutions to applied problems. But how do they interact with the wider world? The next section draws on the idea of socio-technical transitions to better understand their potential to stimulate sustainable development beyond their own boundaries, and argues that social learning is integral to this process.

2. Living labs, socio-technical transitions and the importance of social learning

M'Gonigle and Starke (2006, 177) suggest that the transformative potential of living laboratories lies in their ability to invigorate a new model of economy and culture to 'break the macro gridlock'. The question of how to achieve systemic socio-material transformations for example from fossil fuels to renewable energy, which is critical to the project of sustainable development, is captured by the concept of 'transition'. This section considers how living laboratories fit into the model of socio-technical transitions, which originates in the work of Dutch technology scholars but is increasingly influential in both academic and policy circles. It then considers social learning as a central yet overlooked driver of transition that living laboratories have the potential to deliver.

The literature on socio-technical transitions provides a multi-level perspective within which living laboratories can be conceived as niches for innovation that can foster change beyond their boundaries (for example, Geels 2002). The model distinguishes between three levels: socio-technical landscapes, socio-technical regimes and niche-innovations. Landscapes form a broad, slow-changing backcloth of macro-economic patterns, political structures and cultural values, while regimes are established and stabilised fields of technology and behaviour. Niches provide protected spaces for experimentation that are sheltered from wider political and economic pressures, in which genuinely different technologies, lifestyles or practices can prosper. Change occurs when innovations break out of niches into the wider regime. So, for example, the development of electric cars on its own is not enough to prompt a transition away from gasoline powered vehicles, but requires changes at the regime level in terms of policies designed to encourage uptake of the new technology (for example, off-peak electricity subsidies for overnight charging, conversion training schemes for mechanics) and the material infrastructure capable of fixing and charging cars. While the reliance on fossil fuels driven cars is hardwired into the economic, political and cultural logic of most developed societies, changes at the regime level will gradually lead to shifts at the landscape level. (Whether electric cars are a wise priority investment for 2013, where short term strategies for carbon emission reductions and alleviation of road congestion may be required – is another debate not entered into here). The applied branch of socio-technical studies, transition management, thus emphasises not only the creation of niches for innovation with regime change potential, but active engagement with organisational fields

that are constituted by interacting networks of organisations, including for example firms along a production chain, regulatory agencies and competitors (Di Maggio and Powell,1983; Geels et al., 2008).

Transition theory draws on structuration theory (Giddens, 1984) to study transition at the level of larger and more stabilized social structures and at the same time consider perspectives of actors whose actions both shape and are shaped by social structures they are embedded in. Building on structuration theory, actors are embedded in social structures including institutions and rules that provide flexible guidance and are open to manipulation, but also reproduce and change structures by enacting them. The multi-level approach of transition theory helps to consider the ordering of social processes to understand and act upon complexity in specific places, and the relation of actors to the structures such as institutions and rules they are embedded in. The distinction of social systems (social practices, social interaction) and social structures (institutions, rules and resources) helps to situate more actor and agency centred insights on the co-production of new technologies and social practices and norms from Science and Technology Studies in transition theory (Grin et al., 2010, p.42; Geels, 2010).

One branch of transition theory, which focuses on empirical investigations of strategic niche management, has identified patterns on how to modulate emergence of niches with strong potential for sustainable development. In this research, niches are conceived as emerging communities that share cognitive, normative and regulatory rules and thus as protected spaces for experimentation allowing for co-evolution of technologies, user practices and regulation (Kempt et al., 1998). Research on strategic niche management has identified that more effective niches involved at least three recurring strategies: (i) joint articulation of expectations and visions to direct the learning process; (ii) formation of heterogeneous networks also for resource provision (however too much diversity in networks may hamper emergence of stable rules and contribute to fragmentation and of resources and uncertainty about varied commitment); and (iii) learning in multiple dimensions including about technical and design aspects, cultural and symbolic meaning, marketing and user aspects, societal and environmental impacts, regulation, infrastructure and maintenance networks, and industry and production networks (Grin et al., 2010).

Living laboratories fit neatly into this framework, as niches that have been created explicitly to host experiments in different types of sustainable living. Socially robust learning by heterogeneous groups in the context of application has been highlighted by scholars as an ideal type situation for producing new knowledge for sustainable development (Gibbons et al., 1994; Nowotny et al., 2004). Brown and Vergragt (2008, 110) conceptualize niches as small-scale experiments that facilitate incremental learning through developing, testing and introducing new technologies and services, but argue that , 'little systemic study has been done on defining the learning processes in experiments, monitoring them, assessing their societal impacts, or examining the conditions under which learning does (or does not) occur, and by what mechanisms.' Like adaptive governance, the epistemology of living laboratories is iterative, whereby new approaches are tried, monitored and then learnt from in order to inform successive experiments. Although these kinds of iterative, adaptive, models are very much in vogue, the processes through which learning takes place and generates wider impacts demand more attention (Grin, 2008). Evolutionary economics provides the motor for change in the socio-technical transitions model, whereby successful experiments will outperform in the market place and thus proliferate, but much of this work considered historical examples of change, like the shift from sail to steam technology in the nineteenth century shipping industry (Geels, 2002). In the field of sustainable development, where transition management actively seeks to steer change by creating niches like living labs, learning is critical to establishing the social conditions that allow experiments to break out and prompt regime change (Brown and Vergragt, 2008; Evans, 2012).

The recent literature on low carbon experiments offers little evidence of effective learning in practice. Projects aiming to produce new knowledge often end up as simple demonstration projects, in which technology is simply dropped in to a locality, rather than instituting processes in which local communities are engaged in developing technologies (Hodson and Marvin, 2009, While, 2011). Many high profile eco-cities cast themselves as living laboratories without considering learning in any robust manner. Whilst realising significant energy-savings, these projects also manifest symptoms of a technology-driven and utilitarian framing that neglects social issues and equity considerations. Although the user is involved in technology development, the role is somewhat reactive - receiving feedback from the monitoring technologies on their behaviour and providing feedback on further development in a process largely framed by economic and environmental perspectives. While the living laboratory approach is intended to be user-centric, many projects fall short of more sophisticated conceptions of knowledge production that consider how social norms and technologies are co-produced in an explicit manner. This is important, as attending to co-production also helps to sensitize participants to the fact that the development of technological fixes alone is not the most effective way of achieving real transition, directing attention to the cognitive, material, social, and normative ways in which we construct our life styles (Jasanoff, 2004).

One of the major motivations of this book is to clarify the knowledge-production processes that underpin wider sustainability transitions. Brown and Vergragt (2008) suggest that successful learning occurs either when an experiment meets initial expectations and is then widely replicated, or when it facilitates higher order learning among the participants. In this spirit, learning and concomitant knowledge production is better conceived of as a collective process that unfolds through a wider community of stakeholders, than as some individual process of self-discovery. Living laboratories can be seen as a space for the constitution of learning communities that include academics of diverse disciplines, practitioners, and users of the space who jointly engage to produce locally situated knowledge to help the transition to more sustainable technologies and practices. Different professional communities can work together if they share a common problem definition, 'which is not only an expression of what those involved do (and do not) value, but also one which they expect to work' (Grin, 2008, 57). In bringing diverse stakeholders together around a common problem living laboratories transmit a sense of urgency to multiple actors. Learning is a social process for issue formulation, monitoring, assessment and evaluation, negotiation, conflict resolution, agreement, and coordination of action among multiple interdependent stakeholders (Steyart and Jiggins, 2007; Ison et al., 2007), and these processes of social learning may eventually drive institutional reform. While traditional bureaucracies operate in a linear fashion, sustainable systems require a dialectical mode that 'can continuously uncover, challenge and refashion outdated assumptions that lead to destructive goals and results, and that can then create new directions' (M'Gonigle and Starke, 2006, 158). In terms of understanding how niches break out into the regime level, such institutional change is critical.

Conceiving living laboratories as niches for innovation, then, allows us to understand their potential in relation to a wider transition towards sustainable development. Socio-technical transitions can gather pace when shared learning serves as basis for concerted action. While not suggesting that effective learning can only take place in partnerships in which universities are involved, the proliferation of living laboratories indicates that universities are playing a pivotal role in fostering such social learning processes through education, research, and community engagement. Focusing on social learning opens up useful insights on how to enhance the capacity of niches to drive regime level change beyond their local environs.

3. The approach and structure of this book

Our argument so far contends that living laboratories represent niches with the potential to stimulate the kinds of transformative change required by sustainable development, and that a key research question concerns understanding the role of universities in fostering social learning. This edited collection brings examples of living laboratory initiatives from around the world together to investigate exactly this question. But what can we learn from looking across a highly diverse and international set of case studies of universities from four continents? How can we bring together diverse perspectives from academics of diverse disciplines and practitioners in diverse institutional settings for analyzing factors enabling or constraining learning for change in communities? In order to serve as a suitable substrate for such an analysis, and building on the analytic framework of social learning, each chapter pays attention to four components of transformation:

- *Framing of the problem and definition of the challenge to be addressed / ecological constraints*: Each chapter identifies the specific challenge(s) that was/were addressed and why. Choice of technologies for management and representation of knowledge matters for effective mobilization of diverse groups, and can reveal or conceal uncertainties and complexities. Given diverse perceptions on stakes and approaches, how can a shared understanding be built as basis for concerted action, and what role do science and research play in this process?

- *Institutional setting and policies*. A university's stance on sustainable development is institutionalized in policies, organizational structures and commitments, and constitutes a framework for deliberative community learning processes. Organizations can be conceived as a network of roles and behavior and a system of rules and procedures that present a first basis for coordinated action. Values and social norms promoted in such frameworks effect problem framing and the setting of priorities and selection of issues to be addressed through collective action, as does the history of the issue and its institutionalization. Participatory deliberative processes on the other hand, can lead to changes in the existing institutional framework, challenging legitimacy and power relationships. M'Gonigle and Starke (2006) suggest that innovation enablers in universities need informal and flexible governance structures to be able to remake organizations from within. How do institutional frameworks enable or constrain concerted action for change?

- *Sites for directed social interaction, stakeholders and stake-holding*: Chapters will give a dynamic conception of the affected parties, their interests and understanding of the situation and how they change over time. Moreover, social relationships between groups alter the dynamic of understanding of issues at stake in each group, and create diverse view points on priorities for action. New stakes can emerge from social interactions, and new stakeholders can emerge, and transform the legitimacy of other stakeholders. What sites for social interaction helped to give a common direction to the allocation of attention and resources across organizational boundaries?

- *Facilitation of learning and coordination among stakeholders*: Finally, each chapter asks which activities, tools and skills of facilitators helped to guide learning processes among multiple independent stakeholders, including how science was drawn upon in the learning process.

The book comprises two parts: Part Ion campus as living laboratory: engaging communities in experimentation; and Part II on the challenge for universities to foster sustainable development across multiple scales. Chapters present one or several cases describing a university project that resulted in concerted action within a community to better address a particular challenge of sustainable development. Each chapter presents some facets through which the projects can usefully be conceived as living laboratories for experimentation, adaptation and social learning to address complex environmental situations. Chapter conclusions highlight what enabled or constrained a successful learning process with diverse stakeholders reaching a shared understanding of the issue as a suitable basis for concerted action. An advantage of presenting cases in a fairly free narrative form is also that they can capture complex interactions between agency and changing contexts, time

and event sequences, changing identity and learning. Some chapters complement their practical case description with a theoretical basis that is deemed pertinent for interpretation of the case description.

The selection of chapters was largely motivated by the authors engagement in the International Sustainable Campus Network, which offers a platform for exchange and analysis of approaches by which Universities engage in fostering social and technological change for sustainable development across continents. Most of the cases were presented for discussion at the 2010 ISCN Symposium 'Better campus, better city' held in the Luxembourg Pavillion at the Shangai Expo and the Tongji University.

4.1. Campus as living laboratories: engaging communities in experimentation

Part I of the book on campus as living laboratories presents seven cases of Universities developing campus as site for social interaction and engagement resulting in knowledge production across organizational and disciplinary boundaries.

In the case of the University of British Columbia (UBC) in Canada sustainability is conceived as "the emergent property of a societal conversation about the kind of world we want to live in, informed by an understanding of the ecological, social and economic consequences of our individual and collective actions" (Robinson, Berkhout, Cayuela and Campbell, Chapter 2). One prime role of the University is to ask how human activity can actually improve both environmental conditions and human quality of life, by pursuing regenerative sustainability. The UBC sustainability initiative is organized as a coordinating institutional space for integration projects that does not resort to hierarchical traditional ways of resource allocation, but relies on a horizontal and process based approach. It thus provides a platform for project negotiation and co-creation with researchers from diverse departments, local and regional government and multi-nationals. By aligning ideas about requisites for societal transition outside and inside, and presenting a platform for establishing collaborative projects with public and private partners, the University can effect wider changes beyond the campus boundary. Apart from emphasizing that clear contractual arrangements for diverse organizational commitments are helpful, the authors also emphasize that it is helpful if individuals take autonomous decisions to engage, in order to "collectively build the knowledge, legitimacy and trust that ultimately create authority for a project in its own right." Thus learning in the UBC living laboratory can transcend campus boundaries. On campus, research, education and campus design and operations are effectively connected for accelerated transformation. The physical space on campus should include landmarks and inspire to excel. Another key goal of the initiative is to change social relations by reallocating room for assuming new responsibilities, for example by engaging inhabitants in defining their own conception of in-door comfort. The recently inaugurated CIRS building that is regenerative in four dimensions by providing for energy in the grid and water for green spaces, and improves human well-being by offering a high quality work environment. Monitoring technologies with public displays at strategic places will help to direct attention at common goals and learning about progress towards achieving them. One main challenge recognized in this somewhat decentralized model for Universities to build living laboratories is how to sustain allocation of resources and attention over time, as the number of projects grows and the sphere of participation extends over an increasing number of organizations across multiple governance levels. Sustaining change within the University is thought of as much of a challenge as across diverse organizations, including multi-national corporations and multiple governance levels.

Chapter 3 by Hua posits the challenges of sustainability as largely a social challenge which requires processes to find out of the box solutions for complex problems that are not constrained like most

traditional analytical approaches by common place assumptions about the world we live in. Cornell University focusses on supporting and meeting targets of reductions in carbon dioxide emissions in the context of political discourses on climate change and target setting. The engagement of diverse communities across disciplinary and organizational boundaries in processes that foster divergent thought highlighting complexity as well as convergent analysis reducing challenges to actionable issues are required for effective societal transformation. Design thinking processes include inspiration, ideation, prototyping and implementation phases and are iterative to ensure continuous learning and improvement over time. Tacit knowledge embedded in routines and practice and explicit conceptual knowledge is distinguished, and, building on Nonaka (1998) Hua advocates that places and processes for knowledge creation should be designed accordingly to facilitate conversions between tacit and explicit knowledge by individuals and organizations. The development of a climate action plan at Cornell highlights how campuses offer a great setting for composing and testing solution scenarios in a process akin to design thinking processes that take into account a range of challenges including land use, buildings, transportation, energy supply. College campuses should take the larger community they are embedded in into account. Work on infrastructure and community actions and long term strategy across all levels of the organization simultaneously address the organizational changes necessary in order to align the sustainability goals with the missions and long-term plans of a university. The more recent proclamation of campus as living laboratory is expected to direct greater attention at strategies including data collection and monitoring as a basis for joint learning, and the need for institutional change based also on design and implementation of places and processes for knowledge creation**.**

Chapter 4 describes the Campus building energy management system that was establishment at Tongji for wider use in Chinese Universities. The system comprises an ICT technology platform for collection and storage of monitoring data on energy and water use, and an associated governance structure. The data base facilitates directing attention across the organization allowing for consensus building on resource allocation to retrofitting programmes. This case as well as the case on Brown University in Chapter 10 present compelling examples of how ICT technologies can effectively provide virtual sites as joint platforms for directing attention to develop common goals and measures and for coordination on resource allocation.

Omrcen, Lundgren and Dalbro in Chapter 5 make the case that implementation of the environmental management system has supported a change process including the entire University of Gothenburg, Sweden. The process is conceived as iterative with four straightforward phases of ‘plan-do-check-act’. The university's environmental work has addressed several areas which include core activities such as research and education, interaction with the surrounding community, student participation and operations as waste management, travel and transportation, energy efficiency, staff training, hazardous chemicals, environmental risks, and procurement and purchasing. Within such a large and diversified organization as the University of Gothenburg it has been a major challenge to get faculty, staff and students to work towards the same goal. The university is a ‘professional bureaucracy’ which means that implementation must take this into account and adapt to the prevailing culture. The chapter concludes that environmental management systems can serve as a catalyst for sustainability in higher education, in particular as audits and reporting help to direct attention and resources at common issues, as a basis for concerted action.

The contribution from Meehan at Australia National University posits the challenge of establishing sustainability as corporate value in order to ensure an alignment of ideas and goals as starting point for concerted action on reducing environmental impacts of the campus community (Chapter 6). The chapter explores how corporate values are formed with a focus on change management for mainstreaming sustainability goals within the organization. The challenge for any change agent lies in understanding the interplay between individuals and the activities across twelve organizational dimensions comprising institutional mission, culture, systems and structure, as well as individual skills,

performance, motivation and values**.** The importance of the physical place for co-production of knowledge, new projects and informal learning is also highlighted.

Challenges relating to tensions between more traditional remits of research Universities and fostering sustainable development are highlighted in Chapters 7 and 8. At Hong Kong University (HKU) the official framing of actions for sustainable development, similar to the cases of Tongji and the US Universities, is provided by the mainstream political discourse on climate change with the prime emphasis on the need to cut green-house gas emissions (Kildahl and Liao, Chapter 7). Other concerns visible in the overly densely populated island of Hong Kong, including concerns of water and waste management are added into the scope of urgent problems to address. The development of the new University Centennial campus helped sustainability to gain greater attention. The year 2012 saw the kick-off of a new participatory process to identify priorities that matter to the campus community for developing the next strategic action plan on sustainable development. But whether sustainability will be taken up explicitly among the core missions and vision and core values stated for the University, remains to be seen. As one of the Universities leading in international rankings on excellence in research and education, questions on trade-offs between the pursuit of excellence in rankings and a focus on sustainable development are raised. Measures of excellence in international rankings usually include publications in mostly disciplinary peer reviewed Journals, Nobel Prize Winners the organization has attracted, organization and attendance of international conferences, and the gain of competitive research grants. Not all of these pursuits are readily squared with saving natural resources and improved environmental management and interdisciplinary research connected to practice in order to better apprehend complex problems.

Chapter 8 on the University of Luxembourg also describes challenges including organizational barriers that hinder Universities to better address complex issues in research and education, in which the social and material are intertwined. The chapter describes how the development of the ISCN Charter in conjunction with a local strategic action plan on sustainable development by connecting the global with the local was instrumental to establishing sustainable development within the organization of the University of Luxembourg – up to a point. This chapter, just as the previous chapter also highlights that a physical move to a new place constituted by a new type of built-environment, in a new social context can be helpful to reframe the organizational identity and mission. In this case the University will be expected to engage more thoroughly with local and regional issues. However, deepening the Universities engagement further will also require a better understanding of the relation between producing situated knowledge for sustainable transformation and local change, and generalizing disciplinary knowledge production with mature social systems for legitimation tied to clear career reward structures in Universities. The challenge is to connect the natural and social sciences such that they cross-question each other's assumptions in view of promoting that new responsibilities for sustainable development can be assumed by individuals and organizations. For example the engineering concept of comfort defining indoor environmental quality as a universal standard deprives individuals of assuming responsibilities. Living laboratories can play a key role as sites for research on the relation of place-based or situated knowledge production processes and locally negotiated concepts and more standardized knowledge embedded in more general concepts and how this can or can't travel through networks and as such exert wider influence through space.

3.2. Connecting Universities with cities and regions: fostering transition at multiple scales

Part II of the book presents six cases in which Universities have taken a leading role in establishing networks for joint knowledge production on complex sustainability challenges across disciplinary and organizational boundaries designed on purpose to exert influence across multiple spatial scales, including campus, cities and regions. The focus in this part of the book shifts from the situation of

social interactions for joint knowledge production on campus to the constitution of networks, the places these are embedded in and their scales of influence.

In the Mistra urban futures centre for sustainable urban development in Gothenburg, a fundamental requisite for sustainable development in cities is to comprehend issues such as transport, energy-use, and social exclusion as complex and interlinked socio-technical challenges (Polk, Kain and Holmberg, Chapter 9). In order to achieve this, the authors stress that we first need to overcome the compartmentalized organization of our knowledge and implementing organizations in sectors/disciplines/cultures of industry, politics, administration, service provision, and science, each focussing on different scales and levels. Understanding complex social problems across such boundaries relies on long-term processes requiring long-term institutional commitments and funds. Mistra guidelines for joint knowledge production processes prescribe an iterative cycle of joint problem formulation, generation and implementation of new knowledge, and joint evaluation or impacts. First insights gained after eighteen months of engagement in such processes are that for institutions and individuals to absorb new insights p*ractical constraints and obstacles* such as time priority and career considerations have to be addressed. A formal mandate for individuals to participate from within their organizations helps. Furthermore, the knowledge production process needs to provide room for a*cknowledging and transgressing potentially incommensurable differences* among and between individuals and groups. Often notions of what mattered most, how new knowledge should be made and which of this was deemed legitimate, differed across participants, and *research on how best to foster mutual understanding across different organizational and disciplinary perspectives was found lacking.* Influencing decision-making processes at the level of the city and the region, in spite of engaging key civil servants and administrations in the project, proved difficult. This chapter questions the laboratory as 'bounded space' and argues that living laboratories have most potential if they are institutionalized as open systems in cities and at universities simultaneously, with participants from multiple governance levels. But how can such influence be described, tracked and accounted for? More research on new approaches to assess and evaluate the influence of such projects across participating organizations is required. For Universities three important building blocks for achieving positive societal change were identified: "to *create neutral arenas/organizations* active across the whole university involving multiple research groups to avoid lock-in effects; to *build on individual, bottom-up engagement and involvement* by respecting and taking advantage of traditional core values of the autonomous university, such as scepticism, curiosity and freedom of speech; and to c*ommunicate a clear commitment from the university's management team* by making such change processes an essential part of the overall vision and strategies of the university".

Chapter 10 by Powell presents the Energy Conservation Initiative at Brown University, where the focus on reducing greenhouse gas emissions parallels top level international and national political discourse. The chapter identifies in particular two critical success factors to achieving greenhouse gas emissions targets: team building and knowledge management tools and processes that were foundational to create a participatory project design and a decision-process that proved central to setting and achieving greenhouse gas emissions targets at Brown University. The conception of the 'forming, storming, norming and performing stages of the process are somewhat reminiscent of the design thinking process described in Chapter 3 in iterating divergent and convergent analysis. The Brown Energy Efficiency software application for knowledge management presents a common virtual platform enabling learning and coordination among diverse stakeholders in the campus at Brown University. This web-based data base tool was scaled up for application at the level of the city, facilitating coordination required to reach local targets across diverse organizations, such as the Emerald Cities Providence initiative. The exponential increase in complexity in attempting to address not only campus but city scale problems that have added dimensions such as social equity, the generation of local employment, and the added range of diversity of stakeholders, was noted as a key challenge in thinking about scaling tools and processes.

Chapter 11 on the cases of Copenhagen and Zagreb by the architects Baletić and Samsøe, describe how a physical space can present a site for developing joint visions for transformation beyond mere changes to infrastructure. Sustainable development is posited to require a shift in our awareness and values underlying our lifestyle choices, in order to achieve a fundamental change of how we relate to the world we live in. Space is a powerful medium and allows us intuitively to experience and become introduced to different worlds and diverse ways of thinking. New demands to Universities to act as platforms and meeting places for public and private actors engaging in lifelong learning and joint research are multiplying. Asking questions on the physical organization, functionality and design of spaces which constitute Universities, requires developing visions of what kind of life is going to take place in these spaces, what a sustainable university is and how it interacts with others. Physical planning is good at combining small scale details with large scale overview and it can be valuable when operating in messy, multi-variant open systems. The strength of the concept of living laboratories is its emphasis on a bottom-up approach to learning and planning, and the benefits of involving multiple stakeholders to create learning and joint action. This idea is closely related to a wide-spread contemporary urban planning discourse, which emphasizes learning and sees planning processes engaging individuals as a prerequisite for a sustainable transformation of city areas today. Indicators and measurement approaches of international certification standards of sustainability are helpful to limit complexity in planning. However, participatory planning as conceived of in architecture is a helpful complement to recognise complexity of the place and place-bound-issues and identities from plural perspectives. Thus the recurring theme of the complementarity of divergent and convergent processes for analysis is posited in this as in other chapters as a recipe for success. Planning for iteration of such processes will allow keeping the process flexible and alive over time. Integration and the permeability of boundaries between campus and city for knowledge creation processes transcending these spheres are central considerations in both cases. In both cases, the sustainable identity is crucial and both visible and non-visible aspects are emphasized. In Zagreb a large glass house for guerilla gardening activities in the community in which the campus is embedded has been chosen as a symbol for societal transformation for a sustainable future. In Copenhagen accordingly the non-hierarchical structures, bicycles, the care for design and the well-educated population are crucial for the identity of the University, but also of that of the city. In knowledge societies the identities of Universities and cities they are embedded in are increasingly intertwined. Physical campus planning is increasingly seen as a tool for raising a city's global profile in the face of rising international competition for highly educated and trained employees more innovation, for fostering knowledge transfer from research to business sectors, and for forging stronger links with international research and development. The weakness of the concept of living laboratories highlighted was that it is usually promoted as a tool for transition to a low carbon economy. Does this framing of our societies issues allow to think of change in the existing social and economic order in a sufficiently profound manner and does it really help to foster the required shift in awareness of how humans are embedded and depend on the planet's biosphere?

In Japan, the Campus planning committee of the Architectural Institute of Japan recognises the University as an urban developer, and campus as a place for knowledge creation that can also serve to improve the quality of life of the community it is embedded in (Kurata, Ozasa, Ueno and Komatsu, Chapter 12.). A national policy on Universities makes three missions explicit: education, research, and social contribution and cooperation. Since then Universities have fostered problem-based learning and research programmes with local stakeholders. Accordingly, Universities are asked to respond to challenges of declining environmental quality; the needs of local communities for improving their quality of life given demographic changes and the promotion of life-long learning in a knowledge society that also affect enrollments; and the needs of the private sector and the economy by offering research for new industries that support the society and its needs through cooperation with the community. The Japanese experience and in particular the two cases of Hokkaido University campus and the Kashiwa-no-ha campus area suggest that a process of joint visioning and planning of campuses in cities gives a tangible basis to start off and frame joint knowledge creation processes

between Universities, local governments, private business and citizens. In the case of the development of the new Kashiwa campus near Tokyo, an urban design centre was created to serve as an official yet neutral platform to stage such a process of collaborative knowledge production and implementation for sustainable futures. This platform bears some similarities to the Mistra urban futures centre in Gothenburg, Sweden, described in Chapter 9. The key is to see campus as a place for joint knowledge creation processes for sustainable futures with a high quality of life that is permeable and embedded in the city and wider community; this serves to redefine the relationship between the campus and local communities.

In Chapter 13 Becker and Hesse take the development of a new campus in Belval Luxembourg as a case to explore how a new university campus might contribute to regional economic 'knowledge-based' development, how such effects might be assessed and particularly how the new campus can be integrated in urban planning terms. Related literature lists direct place-based effects that might be expected, including that the University is recognized as an 'urban developer', an 'employer', and a 'partner for community cohesion and social change'. Indirect economic impacts that have been associated with the arrival of a research-based University are likely to bring labour, new knowledge and entrepreneurship into the region. The authors are however cautious as to whether such effects occur in all cases, and in particular whether robust empirical evidence for such causal relations may be obtained. From an urban planning perspective, the Luxembourg Belval project presents challenges and opportunities for urban and regional development. This applies particularly to the site which is situated between a still operating steel plant and the urban periphery. Concerning its size and also governance issues, the project bears similarities with other large-scale and state-driven projects in Luxembourg, in which ministries and public agencies consulted little if at all with adjacent municipalities or future users. Points that require particular attention for future planning and implementation include: housing for students and researchers, environmental quality and amenity value of the campus and its surroundings, accessibility of the new urban quarter, and connecting the research campus with the development of Luxembourg City. For this purpose, the university developed the 'Belval Observatory' - an informal platform for the exchange of knowledge and the monitoring of the site and its impacts. Several dimensions of impacts that might be assessed and quantitative indicators suggested by the authors include proxies to assess changes in the regional labour market developments, entrepreneurship and innovation, regional expenditures, proportion of non-motorised traffic in total daily journeys, amenity values of campus. Effects such as community cohesion or knowledge creation are discussed and dealt with in more qualitative terms. The chapter concludes that a new focus of the university should lie on building *regional networks* and taking measures to ensure that *people and place interrelate* and that well educated, talented students and researchers remain in the region.

In this collection of cases, in which Universities are driving actors establishing living laboratories for societal transformation, problem framings diverge. Some cases acknowledge complexity and the intertwining of the social and material more explicitly than others. Some cases are described in more conceptual terms, others in a more practical manner. The over-arching aim of this book is to use the rich and culturally diverse compilation of cases to open up new insights on how effective change takes place within and beyond living laboratories, directing attention to what enables and constrains learning in communities of multiple and diverse stakeholders. The book's conclusion revisits the living laboratory concept, paying particular attention to the design of places that living labs are constituted of, processes for knowledge production that are staged within them, and networks that key actors in living labs are embedded in that serve for channeling knowledge and resources beyond organizational and disciplinary boundaries.

Of particular interest is the role of universities in establishing living laboratories on campus and in the city, and their success in driving wider changes. A major challenge for Universities involves

negotiating the institutional and disciplinary tensions between addressing applied sustainability challenges and the more traditional remit of universities to engage in blue skies research and train 'disciplined' thinkers. Living laboratories, it is argued, have the potential to reconcile these tensions by integrating research, curricula, pedagogical method and community engagement, offering new spaces for experiential learning in diverse communities. Finally, the conclusion returns to the broader question of the role of universities in achieving social and technological change for sustainable development, drawing together insights from across the chapters to identify a key research agenda investigating the ways in which new forms of knowledge can emerge and become legitimized, disseminated, contested or stabilized.

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