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Lauren Withycombe Keeler

School for the Future of Innovation in Society, Arizona State University

Fletcher Beaudoin

Portland State University, beaudoin@pdx.edu

Amy M. Lerner

Laboratorio Nacional de Ciencias de la Sostenibilidad, Instituto de Ecología, Universidad Nacional Autónoma de México

Beatrice John

Faculty of Sustainability, Leuphana University of Lüneburg

Richard Beecroft

Faculty of Sustainability, Leuphana University of Lüneburg

See next page for additional authors

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Authors

Lauren Withycombe Keeler, Fletcher Beaudoin, Amy M. Lerner, Beatrice John, Richard Beecroft, Kaidi Tamm, Arnim Wiek, and Daniel J. Lang

Article

Transferring Sustainability Solutions across Contexts through City–University Partnerships

Lauren Withycombe Keeler ^{1,2,*} , Fletcher D. Beaudoin ³, Amy M. Lerner ⁴, Beatrice John ² , Richard Beecroft ^{2,5}, Kaidi Tamm ⁵, Arnim Wiek ^{2,6} and Daniel J. Lang ²

¹ School for the Future of Innovation in Society, Arizona State University, Tempe, AZ 85281, USA

² Faculty of Sustainability, Leuphana University of Lüneburg, D-21335 Lüneburg, Germany; beatrice.john@leuphana.de (B.J.); richard.beecroft@kit.edu (R.B.); Arnim.Wiek@asu.edu (A.W.); Daniel.lang@leuphana.de (D.J.L.)

³ Institute for Sustainable Solutions, Portland State University, Portland, OR 97201, USA; beaudoin@pdx.edu

⁴ Laboratorio Nacional de Ciencias de la Sostenibilidad, Instituto de Ecología, Universidad Nacional Autónoma de México, Ciudad de México 04510, CDMX, México; amy.lerner@iecologia.unam.mx

⁵ Institute for Technology Assessment and Systems Analysis, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany; kaidi.tamm@kit.edu

⁶ School of Sustainability, Arizona State University, Tempe, AZ 85281, USA

* Correspondence: lauren.withycombe@asu.edu

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Abstract: The urgency of climate change and other sustainability challenges makes transferring and scaling solutions between cities a necessity. However, solutions are deeply contextual. To accelerate solution efforts, there is a need to understand how context shapes the development of solutions. Universities are well positioned to work with cities on transferring solutions from and to other cities. This paper analyses five case studies of city–university partnerships in three countries on transferring solutions. Our analysis suggests that understanding the interest, the action on sustainability, and the individual and collective sustainability competences on the part of the city administration and the university can help facilitate the transfer of sustainability solutions across contexts. We conclude that the nature of the city–university partnership is essential to solution transfer and that new and existing networks can be used to accelerate progress on the 2030 United Nations Sustainable Development Goals.

Keywords: sustainability; cities; universities; city–university partnerships; sustainability solutions; capacity-building

1. Introduction

While only one of the seventeen United Nations Sustainable Development Goals (SDGs) explicitly focuses on cities, the need for urban sustainability transformation underpins many of the other goals [1]. Municipal governments through their civic mandates and their long-term planning perspectives are the primary institutions capable of addressing climate change impacts, decarbonizing transit systems, transitioning to renewable energy, ensuring food access, and building more resilient and sustainable communities for their inhabitants and visitors [2]. While the focus of this paper and the case studies described is on cities, action by cities governments can have important implications for regions, the structure and function of which are central to SDGs. The complex and uncertain nature of current and future sustainability challenges and the transitions they require can be at odds with the organizational logic of municipal structures and often require novel funding and planning mechanisms to be effectively addressed [3]. To meet the SDGs by 2030, city administrations need to better utilize

their existing assets and build their capacity for transformation, and part of that capacity building involves learning from other cities which have undergone similar transformations.

This paper explores the role of city–university partnerships (CUPs) in overcoming some of cities' challenges in addressing the problems of sustainability and resilience they experience. Universities with sustainability expertise can be strong partners for cities interested in and incumbent to implement sustainability measures [4,5]. CUPs are increasingly common in sustainability science and practice and represent a new functional paradigm for both partners [6,7]. Through CUPs, university actors and city administrations produce scientific and action-oriented knowledge that contribute to addressing local sustainability challenges. Networks of universities and CUPs can facilitate the transfer of novel solutions to other locales [8]. However, context does matter. Universities and cities alike are unique in their composition, competence, and enthusiasm relative to engaging in sustainability problem-solving. We hypothesize that key contextual factors exist across CUPs that, when understood, provide guidance for the transfer of sustainability solutions between CUPs with different cultures, geographies, and demographics. To test this hypothesis, this paper inductively analyzes five sustainability-oriented CUPs in three countries. However, in advance of the case study analysis, the paper expands on the new role of the university implicated by CUPs and how such partnerships can help universities deliver on promises to generate social good.

Universities have traditionally been seen as producers of knowledge that is taken up by civil society through formal and informal means of knowledge transfer. However, academia, and specifically the scientific community, have been charged with a “new social contract” that urges science to tend to the most urgent problems and generate knowledge to inform action [9]. Trencher and colleagues [10] describe a complimentary shift, the augmenting of the university function beyond societally relevant research to include knowledge co-production for sustainability with other societal actors that directly attempts to transform specific geographic areas or sectors. Crow and Dabars [11] write about the New American University which, similar to the global trend, recasts American, public research universities as fundamentally responsible for the thriving of the communities in which they are embedded and, as a result of this responsibility, to generating knowledge that can address societal challenges writ-large. In the 21st century, many universities are seeking to go beyond consultation and embed themselves in their communities and co-produce transformational knowledge for sustainability [12].

The paradigm of the embedded university developed alongside and helped support sustainability science as an academic discipline with constituent research, educational, and outreach mandates. Throughout the world there are university departments, centers, and degree-granting programs oriented towards sustainability, where students and faculties take on more active roles in applied research, capacity building, and communication of knowledge to the public [13,14]. Societal actors, too, are reframed from passive recipients of knowledge to knowledge creators and essential partners in an educational and research agenda capable of leveraging many forms of knowledge in service of better, more sustainable futures. Sustainability science is situated in this paradigm and under this new social contract between science and society in which societal values shape the scientific agenda and science provides knowledge of use to society, often through co-production [15], and in strong alignment with the 21st century university.

New institutional settings, such as (urban) transition labs, real-world labs, and science shops, are on the rise [16–19]. These partnerships, spaces, and methodologies facilitate transdisciplinary sustainability science while providing sustained support to solutions research and allowing for the integration of knowledge from diverse cases over longer periods of time. The smart city movement has also viewed cities as test beds for smart technologies [20,21]. New research seeks to integrate smart and sustainable cities concepts and urban labs have been developed that utilize smart technologies in the service of sustainability objectives [7,22]. To close the gap between knowledge generated in the lab and the knowledge necessary for action in the real-world, these “living labs”, “transition labs” or “real-world labs” are developed at the university–city interface [2,17,23]. These collaborations between universities, cities, and sometimes corporate or non-profit partners allow researchers to study

the features and functions of sustainability-relevant systems in real-world settings and monitor their impact. These types of transformative planning and research approaches have been identified as central to integrating and transforming both science and public policy to achieve the SDGs [24].

Partnerships between cities and universities challenge researchers to engage deeply with local context in order for their work to contribute to sustainability. For the SDGs, this means utilizing scientific methods to understand what moves cities and regions closer to achieving the goals, rather than detailing how sustainability problems manifest. However, a focus on local barriers and success factors can limit the generalizability of insights produced through these partnerships. Sustainability science has been prolific in generating theories of urban system functioning, transitions, and transformations but has struggled to achieve the vision of a transformational science that inspired its establishment [25]. Achieving this vision is central to delivering on the SDGs. As the university–city interface becomes crowded with labs and shops and partnerships, clarity is needed on what actually creates sustainability outcomes. Additionally, to accelerate progress on sustainability challenges, universities and cities need to learn from others, rather than unnecessarily repeat the mistakes of their peers.

In this research, we hypothesize that key contextual factors exist across CUPs that, when understood, provide guidance for the transfer of sustainability solutions between CUPs with different cultures, geographies, and demographics. This transfer of solutions can accelerate progress on sustainability and create the empirical link between the locally-embedded research university and its global impacts [8,26]. To test this hypothesis, this paper inductively analyzes five sustainability-oriented CUPs in three countries. The five case studies are part of the CapaCities project, a network of CUPs funded by the Global Consortium for Sustainability Outcomes (GCSO) (sustainabilityoutcomes.org) to (i) build capacity for transformational sustainability action in city administrations; and, (ii) transfer and scale insights across different cities and universities. In analyzing the partnerships and their distinct efforts at sustainability capacity building we derive a framework for understanding CUPs that transcends context. We demonstrate how the framework facilitated the transfer of insights across CUPs within the CapaCities network and provide recommendations for other universities and cities interested in establishing such partnerships for sustainability.

2. Materials and Methods

To analyze the city–university partnerships (CUPs), the CapaCities project team conducted two focus groups. These focus groups, held at the midpoint and endpoint of the year-long collaboration, included university researchers who presented their research along with relevant contextual information. Input from researchers followed the framework developed by Keeler and colleagues (2016) [8] and included a presentation and accompanying table to facilitate synthesis and comparability of insights. Tables 1 and 2 are an abbreviated version of that table.

Five case studies of CUPs for sustainability are described below. As a part of the focus group, each university partner was asked to give a summary of the actors involved in the project, the project goals, project process, their concept of sustainability capacity building, and the broader context for their work (e.g., cultural, political, and geographic factors). Each partnership was focused on its own sustainability problem and had developed a capacity building-focused solution, several of which included stakeholder engagement workshops and one that included a sustainability walk, in response to the problem at hand and the nature of the partnership. Tables 1 and 2 summarize each CUP involved in the GCSO collaboration and the embedded sustainability capacity-building research that was undertaken in year 1 of the CapaCities collaboration.

Table 1. Summary of city–university partnerships to build sustainability capacity: Arizona State University and Tempe, Karlsruhe Institute of Technology and Karlsruhe, and National Autonomous University of Mexico and Mexico City.

	Arizona State University—Tempe	Karlsruhe Institute of Technology—Karlsruhe	National Autonomous University of Mexico—Mexico City
Actor Summary	City of Tempe administration, senior department heads from all departments, sustainability manager	4 city bureaus of Karlsruhe, 1 Consortium for Sustainability Outcomes (CSO), KIT students and 3 units of KIT, 1 master student as accompanying research.	Resilience Agency (new official govt. office) in the Environment Secretariat of Mexico City; others at local (borough) scale and across other sectors of the city; NGOs
Goals	<ul style="list-style-type: none"> • Increase sustainability literacy among senior city officials. • Increase sustainability competence among senior city officials. • Identify goals for sustainability in Tempe among city administration. • Identify actions that support sustainability goals that have support among the administration. • Identify key partners in the administration for actions. 	<ul style="list-style-type: none"> • Support inter-bureau discourse on sustainability and cooperation with external partners. • Foster a broader understanding of sustainability. • Make sustainability more visible in the KIT and the City of Karlsruhe. • Contribute to long-term cooperation city-KIT. 	<ul style="list-style-type: none"> • Assisting in capacity-building in themes related to resilience for a greater implementation of the Resilience Strategy of Mexico City, with a focus in one case-study where there is a planning process occurring for better management of the area (Xochimilco). • Capacity-building includes system, futures, & collaborative thinking. • Assisting the creation & implementation of a Reconstruction Plan after the September 19 earthquake in the local case-study.
Project Process	<ol style="list-style-type: none"> 1. Consult with sustainability manager, co-define objectives; 2. Design workshop; 3. Test workshop design; 4. Develop and deploy pre-work (discussing sustainability competencies); 5. Conduct workshop; 6. Analyze results; 7. Prepare and disseminate report; 8. Repeat. 	<ol style="list-style-type: none"> 1. Prepare in consultation with city bureaus; 2. Design and develop in a transdisciplinary project course; 3. Adjust and implement with CSO partner and in the real-world lab context; 4. Public disclosure and reflection. 	<ol style="list-style-type: none"> 1. Project facilitated three workshops to assist in the implementation of the Resilience Strategy for Mexico City (launched Sept 2016); 2. The National Laboratory for Sustainability Science (LANCIS-IE), UNAM, has a strong relationship with the Resilience Agency and is an associate of the Strategy but had not facilitated activities yet.

Table 2. Summary of City University Partnerships to build sustainability capacity: Leuphana University and Lüneburg and Portland State University and Portland.

	Leuphana—Lüneburg	Portland State University—Portland
Actor Summary	City Sustainability Manager; individuals from 4 city departments; a variety of local actors (businesses, community groups, associations), local press	4 different bureaus working on asset management within the city. ~6 other bureaus that support asset management activities and coordination.
Goals	<ul style="list-style-type: none"> • City-wide visioning exercise for the year 2030, facilitating conversations on the local interpretation of Sustainable Development Goals. • Cross-departmental conversation on feasibility and adaptability of good practices. 	<ul style="list-style-type: none"> • Increasing inter-bureau conversations/understanding related to asset interdependencies under climate change and seismic scenarios. • Empowering and activating individuals within those bureaus to collaborate together on cross-bureau planning and investments.
Project Process	<ol style="list-style-type: none"> 1. Project is city-led and funding by the German Federal Ministry of Education and Research secured by the city administration; 2. City drew on a long-standing collaboration of many research projects between university and city; 3. Conduct visioning exercise with ~200 citizens and 700 undergraduate students; 4. Analyze city activities, analyze best practices, actor analysis; 5. Five workshops for five core topics evaluating feasibility of best practices, challenges, conditions, and resources; 6. With results select actions and design urban lab and experiments within the city. 	<ol style="list-style-type: none"> 1. Project conceived out of cross-bureau asset managers group; 2. Group lacked time to engage, a point person to run it and resources to support engagement of other bureaus; 3. First meeting brought together 25 actors across 8 bureaus and helped frame the concept and rationale for future workshops; 4. Conduct 15+ interviews with bureaus to gather perspectives and values; 5. Conduct two workshops, on cross bureau dialogue and planning on climate resilience, and on seismic resilience; 6. Present information to all bureau directors, summary report with opportunities for building capacity; 7. Establish disaster resiliency advisory group.

2.1. Leuphana University of Lüneburg and Lüneburg, Germany

The city of Lüneburg and Leuphana University of Lüneburg (Faculty of Sustainability, Professorship for Transdisciplinary Sustainability Research, Lüneburg, Germany) are engaged in a project to realize the UN Sustainable Developing Goals on a local scale. Despite the long-standing partnership, this is so far the largest collective transdisciplinary backcasting approach undertaken within the city and includes a variety of actors at the science–society interface. The project addresses five core topics, namely (i) joint planning and decision making, (ii) facing climate change, (iii) joint economic collaboration, (iv) networking and provisioning, and (v) crafting city life. The layered organizational project structure leverages the specific resources and expertise from each partner and ensures ownership and commitment for the shared goal. The project steering committee consists of the sustainability manager of the city, the local newspaper, as well as representatives of the civil society and the research team. Topic specific field teams involve the research associates of the university, academic experts, selected city departments, and partners from civil society. Additionally, two field teams involve student research projects taking over the tasks of the research associates. The research team works in close proximity to the city departments from a shared office space. In the first phase the initial visioning process was dedicated to developing a shared vision for the city for the year 2030 and beyond, engaging in a dialogue about the Sustainable Development Goals and their meaning for the city of Lüneburg. During the second phase, intense preparation research by the university members included a series of interviews to evaluate the city’s ongoing activities, and research to build a database of worldwide good practices. A series of workshops for each core topic aim to evaluate together with city departments, researchers, and members of local businesses and associations the feasibility and adaptability of best practice to Lüneburg. They also allow for cross-departmental conversations about challenges, institutional and legal conditions, as well as resources. The results inform directly the development of concrete actions to achieve the vision and are supposed to initiate urban labs to set up respective experiments.

2.2. Karlsruhe Institute of Technology and Karlsruhe, Germany

Karlsruhe is a city of about 300,000 inhabitants in the southwest of Germany, a wealthy region with different industries. The city government has developed—partly in a participatory process—priorities for its integrated city development plan which is structured mainly along the topics of the German national sustainability plan which specifies the sustainable development goals for Germany. Based on this, Karlsruhe was voted the most sustainable German city in 2015. Despite this deep rooting of sustainability in city planning, day-to-day city development lacks an integrated understanding of sustainability beyond ecological aspects, and the quality of cooperation between bureaus and with civil society organizations (CSOs) varies widely. Karlsruhe Institute of Technology (KIT) is a leading engineering university in Germany, known for energy research and data sciences. Sustainability studies, though well established, are not yet as visible.

This project was led by the Karlsruhe School of Sustainability, in cooperation with the Institute for Technology Assessment and Systems Analysis (ITAS) and embedded in the real-world lab “District Future–Urban Lab”. It included partners from four city bureaus and one civil society partner. The aims were to (a) support inter-bureau discourse on sustainability and cooperation with external partners, (b) foster a broader understanding of sustainability beyond ecological standards, (c) make sustainability more visible in the profile of KIT both externally and internally, and (d) contribute to building a long-term cooperation between the city and KIT on sustainability issues.

The project has four phases: preparation, design and development, adjustment and implementation, and public disclosure and reflection. It established a sustainability walk in Karlsruhe, mainly through a transdisciplinary project course as phase 2. Teams of students co-developed the route, supported by researchers and external partners, to address abstract sustainability issues in a tangible, memorable way. Including city staff in this format is an unobtrusive capacity building process, nevertheless addressing different, interconnected urban sustainability challenges and offering recurring

opportunities for engagement. The project has been successful in establishing a broad understanding of sustainability and in strengthening cooperation between KIT and the city, while supporting inter-bureau discourse has been a moderate success. Enhancing visibility of sustainability within and beyond KIT is part of a larger goal for the project, as faculty and students from KIT seek to establish long-term, sustainability-focused collaborations with the city government.

2.3. National Autonomous University of Mexico (UNAM) and Mexico City, Mexico

The goal of the National Laboratory of Sustainability Science in the Institute of Ecology of UNAM (LANCIS-IE) is to conduct transdisciplinary research and facilitate sustainability education to link science and decision-making which can lead to sustainability transitions in the country. This capacity-building project links LANCIS-IE UNAM to the Mexico City government, specifically the newly formed Resilience Agency which has emerged from Mexico City's participation in the Rockefeller Foundation's 100 Resilient Cities initiative. The purpose of the capacity-building is to train Mexico City government employees in implementation capacity, to execute the new Resilience Strategy for the city. Specifically, the Strategy calls for targeted resilience and sustainability planning for Xochimilco, one of the 16 boroughs (*delegaciones*) in the city which contains the last remaining wetland of the city (a current UNESCO World Heritage Site), and one of the epicenters of urban sprawl, often informal. The capacity-building focuses on government officials working at various scales and sectors in Xochimilco and, at the same time, assists in the planning process. The city actors most involved in the Resilience Strategy come from the Secretary of Urban Development and Planning, the Secretary of Environment, the Environmental and Regional Planning Attorney General's Office, the Commission of Water for Mexico City, and other local offices at the city and borough level. UNAM is the largest and one of the most well-respected universities in Mexico, which means that it has a high level of authority in providing information.

Competence-levels within the city government are generally quite low, reflecting the education system and party-politics of Mexico City (the party in government is more important than the capacities that they employ). City and borough governments rotate every 3–4 years which means that many of the employees are rehired with the change of governments, making long-term planning difficult. Despite these challenges, the current mayor positioned Mexico City in the 100 Resilience Cities consortium and signed his support of the Resilience Strategy, which was launched in September 2016. UNAM has a new graduate program in Sustainability Science, LANCIS-IE, and a research Institute in Ecosystems and Sustainability, reflecting an overall university interest in sustainability. However, there are many barriers to interdisciplinary, transdisciplinary, and applied work as well as initiatives that do not result in publications, such as capacity-building and the facilitation of sustainability planning in the public sector.

2.4. Portland State University and Portland, Oregon

The project focuses on capacity building for infrastructure management bureaus in the city of Portland to execute collective planning and implementation efforts related to seismic and climate resilience. The work is being driven by the Institute for Sustainable Solutions (ISS) at Portland State University—a cross-university hub for fostering effective collaborations between partners in the community, and students and faculty at the university. Currently there is significant activity and planning that takes place within the individual bureaus related to resiliency, however, these planning efforts tend to be siloed and not fully connected to the opportunities and constraints that the other asset management bureaus face. This first phase of the project looked broadly at the bureaus that are working on resiliency, which occurred through a series of in-person surveys. The second phase was to host two workshops with teams from each of the infrastructure bureaus. These workshops focused on facilitating conversations and joint work across the bureaus as it relates to opportunities and challenges for seismic and climate resiliency. The workshops raise a series of opportunities for cross-bureau investments and planning as well as specific guidance catalyzing and growing

cross-bureau collaboration and planning on resiliency. ISS has provided convening expertise as well as time and expertise from students and faculty to help execute the interviews and preparatory work. When the effort began there was a small group of individuals from different bureaus interested in advancing cross-bureau collaboration on resiliency planning and implementation. Meaning that in this first phase the role of the university was closely focused on helping provide this group with support to crystalize a vision for the project and launch the idea. The workshops have created specific opportunities that can be acted on in future iterations of this project, which will provide opportunities to leverage other capacities and expertise at the university, such as faculty research, internships, and applied courses.

2.5. Arizona State University and Tempe, Arizona

The Arizona State University—the city of Tempe project focuses on building sustainability literacy among city staff, developing a common language with which to discuss sustainability problems and solutions, defining sustainability goals for the city and inventorying actions the city can and would like to take to achieve those goals. At Arizona State University, the primary partners were the School for the Future of Innovation in Society and the School of Sustainability. The collaboration took the form of three workshops, which used games to help build capacity for sustainability ways of thinking. Participants were all department heads and project leaders with sustainability foci within the city administration. In the first workshop, participants played a collaborative game called Future Shocks and City Resilience [27] in which teams worked together to address chronic city issues and achieve strategic priorities while responding to an unexpected social or environmental shock. The game introduces sustainability ways of thinking and common sustainability vocabulary to participants and helps build a culture of sustainability. In the second workshop, participants played a collaborative role-playing game, AudaCITY, in which they reconstructed a strategy that was able to transform their city into a model of sustainability. The game teaches players about the impact of achieving sustainability goals on the urban environment and people's lives and introduces players to the kinds of actions available and necessary to make sustainability transformation a reality. In the third workshop, a group of students in a global sustainability research course at ASU adapted AudaCITY for use in developing a sustainable food economy for Tempe, a theme that emerged from the second workshop. The third workshop included city and non-city actors and workshopped transferring local food economy solutions from other parts of the world. The capacity building in the three workshops served as the internal educational foundation for the city's first Climate Action Plan, which is due to be completed in 2019.

3. Results: Transferring Sustainability Solutions across Contexts

Analysis of the focus groups centered on the question of how these partnerships can learn one from one another. The first focus group began with extensive sharing of demographic, historical, and geographic information on the cities. While interesting, these factors proved less relevant for understanding how solutions could be transferred between partners. Through dialogue followed by inductive analysis of the cities and the universities involved in each CUP and the rationale informing the structure of each partnership, the CapaCities team produced an inductive framework for specifying key contextual factors when attempting to transfer solutions between partners. Tables 3 and 4 demonstrate how the framework was applied to the CapaCities CUPs. Following the development of the framework and the application to the case studies, we demonstrate how conclusions about structuring sustainability solution interventions can be informed by the framework.

Table 3. Assessment of key contextual factors for Arizona State University and Tempe, Karlsruhe Institute of Technology and Karlsruhe and National Autonomous University of Mexico and Mexico City.

	Arizona State University—Tempe	Karlsruhe Institute of Technology—Karlsruhe	National Autonomous University of Mexico—Mexico City
City Interest	Strong interest among key staff, support from leadership.	Moderate interest in sustainability, interest in the CUP starting low, growing over the project.	Strong interest at the city level (Resilience Agency) and at the local level, also internationally because the local case, Xochimilco, is internationally recognized (UNESCO, RAMSAR).
City Individual Capacity	Key individuals with high sustainability competence. High domain-specific expertise related to sustainability (e.g., water, public works).	High to low, depending on bureaus.	Generally low across departments at the city and borough level.
City Collective Capacity	Low though the strategic management office is implementing a cross-department effort to build strategic competence.	Medium (established procedures covering minimum standards, low cooperation on further-reaching plans).	Low collaborative competence, little conversation across sectors and often between scales.
City Action	Low—the commitment to sustainability at the city is relatively new.	Concentrated in one department with strong ecological focus Integrated city development plan addresses several sustainability issues.	Little coordinated formal action, a lot of informal decentralized action (both in conservation and in informal urbanization and other threats).
University Interest	High, university has an explicit commitment to sustainability and to community-benefitting research.	Moderate, the university has a profile focusing on basic research in engineering and data sciences, sustainability is often reduced to eco-efficiency Institute for Technology Assessment and Systems Analysis is nevertheless a major research institute for sustainability science.	Moderate, university has supported the creation of a new graduate program in Sustainability Science and National Laboratory in Sustainability Science.
University Individual Competence	High, there are a number of individuals with high sustainability competence across a range of domains at the university.	High, but with low visibility for the city.	Low to high, new graduate program in Sustainability Science, a National Laboratory for Sustainability Science, and research institute for Ecosystems and Sustainability. University is extremely large, competence varies.
University Collective Competence	High, the university supports sustainability, has a school of sustainability, and considers it core to its mission.	High in ITAS and some other institutes, otherwise limited to technological aspects.	Moderate, there are generally high barriers for interdisciplinarity and traditional evaluation measures (articles and impact factor) that can deter inter and transdisciplinary work.

Table 3. Cont.

	Arizona State University—Tempe	Karlsruhe Institute of Technology—Karlsruhe	National Autonomous University of Mexico—Mexico City
University Action	High, the university is a testbed for sustainability and supports solution-oriented sustainability research.	Moderate, study programs on sustainability, campus transformation measures and research receive praise but insufficient funding. The real-world lab is being developed to a center for transformative science.	Moderate, there are individual or small-group initiatives that have not reached university-wide implementation.

Table 4. Assessment of key contextual factors for Leuphana University and Lüneburg, and Portland State University and Portland.

	Leuphana University—Lüneburg	Portland State University—Portland
City Interest	Moderate continuous interest, awareness and understanding	Strong interest in more inter-bureau conversations in this space, but lacking the resources and leadership to make it pervasive
City Individual Capacity	High to low competence of individuals within some departments in the city administration	High to low (high with some bureaus (water and environmental services) low with others (like parks))
City Collective Capacity	Moderate collaborative competence in form of networking, and shared understanding	Low (some conversations across bureaus, very little joint planning)
City Action	Little consistent, integrated, comprehensive actions across all departments Continuous actions in specific core topics High coordinated frequency of actions of partners in the community	Little action that effectively integrates across the bureaus; but significant action from individual bureaus on climate and seismic planning
University Interest	High, sustainable development and social responsibility is integrated into the university-wide strategy	High, the university has built up considerable expertise in sustainability research and education and also has the motto “let knowledge serve the city” which speaks to the university’s strategic alliance with the city
University Individual Competence	High, sustainability manager at the administrative level, numerous individuals engage in sustainability topics in teaching and research across faculties	High, centered within the Institute for Sustainable Solutions, that connections to over 140 faculty fellows working on sustainability and 350+ student fellows
University Collective Competence	High, project placed within the Faculty of Sustainability; direct support of 2 sustainability science project seminar	High, the university has a coordinating unit for sustainability research and education, and 150 sustainability fellows and over 400 student fellows
University Action	High, the university fosters sustainability action and student associations and supports sustainability research and study programs	High, the university continues to invest significant resources into sustainability research and education efforts

3.1. Key Contextual Factors for Transferring Insights across CUPs

In exchanging knowledge as a part of the CapaCities project, the CUPs identified four key, contextual factors that once understood, facilitated the transfer of insights and solutions between very distinct universities in very different cities, these include: interest in sustainability, individual and collective sustainability competence, and action on sustainability. Interest refers to a university or city's expressed attention to and concern for issues related to sustainability. Individual competence is the sustainability knowledge, skills, and attitudes possessed by an individual in an organization [14]. For sustainability solutions, individual competence refers to the knowledge and skills to design, test, and implement sustainability solutions of researchers or city staff that are engaging in or could be engaged in the partnership [6]. This is differentiated from collective competence which is defined as the knowledge and skills possessed writ-large in an organization to implement sustainability. As sustainability efforts in cities often involve many different departments (e.g., parks, transportation) and many different focal areas (e.g., food, water, energy) understanding the collective sustainability competence of the organization is key to designing interventions that can be feasibly executed. Similarly, some universities have individual experts in aspects of sustainability who can partner with city governments while others have sustainability departments or degree programs that offer a breadth of sustainability expertise. It is critical to understand the relationship between individual and collective sustainability competence in both cities and universities to understand how a partnership can be developed and be effective at increasing the quantity and quality of sustainability actions in a city. Finally, it is critical to understand what kind of sustainability *action* cities and universities have already been engaged in. Previous actions can act as pathways for future action (e.g., a green bond worked for updating water infrastructure let us try it for a light rail extension) but can also create path dependence with which new solutions will need to contend. Table 5 expands on the framework above, including guiding questions to analyze the individual and collective sustainability competence, interest, and actions of universities and cities interested in partnering.

The framework presented above and exemplified through the case studies below provides foundational questions for assessing partnership opportunities and potential sustainability solutions. This assessment begins by looking at key contextual factors on both sides of the partnership, understanding their history of working on sustainability, their capability to support effective partnerships, and their interest in collaboration. Understanding the collaborative history of working on sustainability issues helps ensure that the solutions chosen, in these cases—how sustainability capacity is built—can be executed by the university and fit the needs of the city. The assessment of the contextual factors for each case study are summarized in Table 3.

Table 5. Framework for identifying contextual factors in CUPs for sustainability.

Key Factor	Definition	Guiding Questions for University	Guiding Questions for City Government
Interest	The attention and concern for sustainability exhibited by individuals or an organization.	Has the university or its researchers expressed a commitment to sustainability research, teaching and/or community engagement?	Does the city have dedicated personnel working on sustainability issues? What kinds of commitments toward sustainability has the city made (e.g., plans, policies, projects)?
Individual Competence *	The sustainability knowledge, skills, and attitudes exhibited by individuals.	Does the university have individuals with key sustainability competencies	Does the city have individuals with key sustainability competencies?
Collective Competence *	The sustainability knowledge, skills, and attitudes possessed by an organization.	Does the university have a sustainability department or other dedicated unit/institute? Does the university have individuals with a range of sustainability competencies?	Does the city government have staff with a range of sustainability competencies?
Action	The sustainability actions taken by an organization.	Does the university have individual researchers who are currently engaged in sustainability science research with local actors (e.g., city government)? Does the university support embedded, action-oriented sustainability research?	Has the city taken explicit action for sustainability? Does the city currently have sustainability plans, projects, and/or policies?

* Competence here references the key competencies framework identified by Wiek and colleagues (2011).

3.2. Assessment of Key Contextual Factors for Case Studies

In order to assess how universities and cities can function as partners in adopting and transferring sustainability solutions we describe the partnerships along each of the contextual factors and create CUP profiles based on combinations of factors. Profiles contain recommendations for transferring sustainability solutions developed by partnerships or cities with different profiles. These profiles are by no means comprehensive of the suite of CUPs that exist, but they are demonstrative of the way in which specifying the nature of the CUP can enable the transfer of sustainability solutions. The framework and profiles exemplified through the CapaCities CUPs demonstrate how contextual factors result in different design features for sustainability solutions research and different results in terms of sustainability plans, policies, and projects enacted. The discussion illustrates the framework aided transfer between CUPs and proposes how it can be utilized by other universities interested in establishing long-term sustainability partnerships with cities.

Arizona State University and City of Tempe have a strong partnership, particularly because of the mutually reinforcing interests and individual and collective competence. The city is interested in building capacity across the organization to implement sustainability and ASU has a faculty that is capable of designing and implementing such engagements and has an interest and institutional incentives to do so. While ASU has an established sustainability degree program, sustainability is a relatively new priority for the city government. In transferring solutions from other locales, this CUP should consider whether or not the solution requires collective capacity on behalf of the organization or a track record of sustainability action. If so, there may be need to have some intermediate steps, such as sustainability capacity building, and developing of pilot projects to boost sustainability action, to facilitate the transfer of solutions.

Portland State University and the City of Portland also have a strong partnership, with particular success in the reinforcing of sustainability actions. Portland State has the motto “Let Knowledge Serve the City” and has, over the last 10 years, established a robust partnership in the city that fulfills that call in the service of sustainability in the city. When transferring solutions to Portland, it is critical to consider whether the solution produces an outcome that has already been achieved within the city and whether or not there are, existing, in-city resources that could be leveraged to serve the goals. Complementarily, when adopting solutions from a city like Portland with an established, strong partnership it is critical to ask what activities preceded the solution and laid the foundation for its success.

Karlsruhe Institute of Technology and the City of Karlsruhe have a potential for partnership. Strengths including the high sustainability competence of the city and the university. However, the city does not recognize KIT as a strong partner for sustainability and Karlsruhe’s track record of external recognition for their sustainability efforts may not incentivize engaging in collaborations with the university. When transferring solutions to this CUP it is essential to consider what kind of relationship building is necessary to establish a strong, long-term partnership and enable successful co-development of sustainability solutions—informed by efforts in other CUPs.

Leuphana University of Lüneburg and the City of Lüneburg have a strong partnership with complementary interests and competence. Continuously engaging the city in transdisciplinary student research projects over the last eight years and several externally funded research projects established a strong partnership. This engagement draws a lot on the collective competence of the university and individual competences in the City of Lüneburg. In order to move this CUP forward, several steps might be necessary, such as strengthening the collective capacity in the city by drawing on the availability of the faculty of sustainability or aligning collective action of the partnership in order to increase the number of coherent sustainability actions in the city.

UNAM (and especially LANCIS-IE) and Mexico City also have a strong partnership, in the sense that the university has a strong tradition and role in local and national issues and is generally highly respected. However, this role is not necessarily directed specifically towards sustainability and resilience efforts. There are also different priorities within the city from the local to the city level,

which means that solutions must be co-produced and proposed with sensitivity given the different needs throughout the city. The university can assist in building alliances across sectors and actors with the Resilience Agency, and given its role, can even strengthen the agenda of the Resilience Agency. However, the Agency is only one office within a larger government, and there is still the challenge of engaging the broader city government at various scales.

Many of these partnerships begin with a catalytic activity that is important for building a working relationship and for both parties to better understand the culture of the other organization. In choosing a project, it is helpful to fit it into a larger framework of change. For example, Portland State has focused its partnership with the City's Bureau of Planning and Sustainability around the implementation of their Climate Action Plan—a 30-year vision for a low carbon and climate resilient city. This was chosen because it contains a wide and diverse set of projects that staff have the responsibility to implement, which helps ensure that projects have a strong and responsive partner (because the project is mission critical). The actions in the Climate Action Plan also line up well with expertise and interest of faculty and students at Portland State—ensuring that there is a supply of students and faculty to meet the demands coming from the city. Arizona State University and Tempe also have a partnership that includes students and is oriented toward generating a climate action plan. The partnership, though, is different and this informs how insights from Portland are transferred to ASU. ASU is a global leader in sustainability research and education and also has a strong desire to build meaningful and impactful partnerships. They have a partnership with the city of Tempe, which has limited experience with sustainability initiatives (when compared to other cities, such as Portland or Karlsruhe) and has some experience and interest in partnering with the University. In this case, ASU has the individual and collective competence and interest to take on more complex and advanced sustainability partnership activities, while the city may not yet be ready. Therefore, the focus is on capacity building to support the City of Tempe in understanding how climate action fits with the city's other strategic priorities, rather than on delivering the full breadth of expertise offered by ASU. In learning from PSU and the City of Portland, ASU–Tempe has been keen to adopt strategies from Portland that inform the process of creating a climate action plan rather than adopting the actions themselves. In contrast, Portland State University has high levels of capacity, interest, and expertise, and they are partnering with a city that also has high levels of interest, capacity and expertise. As a result, the partnership projects that are undertaken are more complex and oriented toward more ambitious sustainability goals than many other city–university pairs. For these two different cases, the framework helps clarify the context, constraints, and opportunities that face a partnership. This information can be used to quickly identify which approaches can be brought to or from another context, and which strategies would not be applicable. It is unlikely that a strategy can be directly transferred, meaning that some adaptations will need to be made to fit the unique context of the transfer site.

4. Discussion and Recommendations

The framework in this article can help support solution transfer from one city–university pair to another. We define transfer as a one-to-one relationship that enables an effective strategy from one place to be applied in another place/context. We find that the framework is a useful tool for continuous learning and improving efforts that occur between city–university cases and also within a specific case. Establishing a common language allows for different universities–city pairs to provide support to each other on sustainability solutions and approaches in a systematic way. In these projects, significant focus is placed on the capacity to be built within the city (such as supporting the development of a new plan or policy) and those outcomes are usually balanced by the outcomes on the university side (student experience, research, etc.). However, less focus has been placed on the capacity building at the university and the city for executing effective partnership work. From our specific analysis of these case studies we have several recommendations for other city university partnerships that wish to transfer insights from their peer institutions.

- First, if interest is high at the university but low at the city, focus on developing the key relationships with personnel in the city government while developing the university's own individual and collective competence. Focus on bridge building. Strategies include utilizing students as interns in the city who can perform essential functions and build relationships, demonstrating that the university can be a strong and consistent partner.
- Second, if interest is high but action is low (regardless of competence), the university can provide the city with a platform to discuss their work. The university may be able to help the city or people within the city elevate sustainability efforts, providing legitimacy.
- Third, if individual competence is high but collective competence is low at the university, there can be a focus on developing strong teams of students and conducting educational research activities, i.e., designing courses in which students conduct research on aspects of sustainability relevant for your city.
- Fourth, if competence is low at the university and low at the city but there is interest in sustainability action, university partnerships and networks can be leveraged to increase competence.
- Finally, if all features are high at both the university and the city and there is collaboration established, strike while the iron is hot. Seek to maintain stable collaboration, focus on building the resiliency of the partnership. Create redundancies in expertise and in relationships, overlap competencies and understandings about the partnerships, and establish a transparent flow of information where processes and results are documented in areas accessible to all partners. Provide expertise to other cities and universities to help them achieve their sustainability goals.

The importance of solution transfer between cities, as well as regions, is critical to accelerating progress on the SDGs because effective solution transfer can save time, financial resources, and political capital so that high impact, high value strategies can be pursued.

There are also a number of potential applications of the framework beyond solution transfer. First, the framework can be used to assist with partnership diagnosis and strategy development, continuous improvement and learning, strategy transfer, and strategy scaling. Second, it can be used to determine the solution-readiness the city, university, and the partnership by helping to identify where synergies and gaps exist in experience and competence. Third, it can serve as a guide for conversations about an overarching framework for a CUP to facilitate stable rather than episodic engagement [4,28]. Finally, the framework can serve as a common language that integrates across multiple cases of university–city partnerships for sustainability, amplifying the transfer of sustainability solutions.

The framework that was developed through our two focus groups and applied to the cases has a number of strengths as well as limitations that limit its generalizability. First, it was developed looking in depth at five case studies, but this analysis was primarily performed by the researchers, often with consultation from city partners. Research is ongoing to analyze the variance in partnership and project evaluation between city and university partners. Second, the framework did not examine the totality of relationships that each university has with each city nor did it focus on other important actors, such as those in civil society. For example, KIT has extensive partnerships ongoing with the City of Karlsruhe and civil society actors that are not directly related to sustainability, and this is true to varying degrees in each case. By focusing exclusively on sustainability-oriented CUPs, the framework may not account for some of the underlying political and partnership dynamics that shape how solutions are developed and partnerships are pursued. Third, each of the CUPs is focused on capacity building as a sustainability solution; so, there is a need to examine how the framework applies to other types of sustainability solutions. To this end, the recommendations in this paper have been fed back to the Global Consortium for Sustainability Outcomes to facilitate the transfer of insights across other CUPs working on different types of sustainability solutions. Monitoring the applicability of the framework in these cases is ongoing. Finally, these partnerships are explicitly focused on universities and city administrations and therefore do not address the critical relationships that both have with regions, which are a critical scale and point of intervention for making progress on the SDGs. The authors look

forward to and invite opportunities to further test and refine this framework with other cases and in collaboration with city partners.

5. Conclusions

As cities and countries strive to meet the 2030 Sustainable Development Goals, there is a need to accelerate progress by sharing solutions. While geography, demographics, and politics are relevant for developing sustainability solutions, the CapaCities projects indicate that there are more important factors that, once understood, can facilitate the transfer of solutions between very different locales. City–university partnerships (CUPs) are increasing in their prevalence and intensifying their focus on sustainability transformation. Sustainability and partnership networks (e.g., National Adaptation Forum, the Urban Sustainability Directors Network, the Network of Programs in Sustainability, the Association for the Advancement of Sustainability in Higher Education, etc.) can help share sustainability solutions, accelerating progress by allowing cities and universities to learn from one another. To transfer solutions, it is critical to understand the interest, the previous action on sustainability, and the individual and collective competences that exist at both the university and the city level. While there are a number of important factors that have to be re-specified when solutions are transferred, how such an initiative is inspired, developed, and implemented, depends profoundly on the knowledge, skills, and attitudes of the people involved. Through the CapaCities project, we have found that understanding the partners and the partnership is key to this acceleration. It is through these relationships that we are able to learn from one another and make progress on sustainability.

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