FUSE – Pune Activities Update

April, 2021

Introduction

The FUSE project is addressing Food-Water-Energy challenges, opportunities, and solutions, with a major focus on the Pune, India region. The project duration is from mid-2018 to mid-2022. In February 2019, a series of workshops took place in Pune, where more than 80 stakeholders and policy experts shared visions, challenges, coping strategies, and potential policy solutions. Subsequently, the FUSE project team has been developing a systems model, integrating the information gathered during the workshops and exploring the efficacy and likely impacts of the proposed solutions. During this time, exchange with stakeholders and policy experts in the region was maintained and collaboration continued in the form of data collection activities. We prepared and conducted surveys, and organized a FUSE-Update workshop in January 2020 in Pune. Here we present an overview of FUSE's third project year, its progresses and team updates.[1]

FUSE in a nutshell

FUSE (Food-water-energy for Urban Sustainable Environments) is a transdisciplinary research project involving the Food-Water-Energy nexus in Pune (India). The project will develop a long-term systems model that can be used to identify viable paths to sustainability. It brings together natural and social scientists from Stanford University in California, USA, IIASA (International Institute for Applied Systems Analysis) in Laxenburg, Austria, UFZ (Helmholtz Centre for Environmental Research) in Leipzig, Germany, and ÖFSE (Austrian Foundation for Development Research) in Vienna, Austria. The project is a not-for-profit research effort and is part of the Sustainable Urbanisation Global Initiative of JPI Urban Europe and the Belmont Forum. Each of the national teams is supported individually by its own national science funding agency.

More information: https://fuse.stanford.edu/

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FUSE – the third year

The FUSE project is now approaching the end of its third year. Of course, looking back over the past year one cannot help but mention that it was a challenging period due to the COVID-19 pandemic. We are aware of how stressful the pandemic has been in India and in Maharashtra in particular. All of us hope that you and your institutions have found a productive way to navigate through this terrible crisis. We trust that the situation will improve in the next few months. From our project's perspective, the FUSE team had to adapt to the new circumstances with consequent delays in our work. We are grateful to be able to present here the project's progress.

Model development

Progress this year: Since the initial set of workshops, much of our team's effort has gone toward constructing the modules of the model, and recently we have begun the process of model integration. The model consists of a hydrologic module that determines the state and flow of freshwater resources, an agriculture module that quantifies crop production, land use and water requirement, and an urban module that simulates the urban growth, and associated resource demand. Integration involves coupling those modules to represent interactions and feedback among the modules. The systems model will be run under future conditions through the year 2100. Consideration of the future involves

1 The report of FUSE's second project year can be found here: https://fuse.stanford.edu/sites/g/files/sbiybj13226/f/update_fuse_2020_jan_pune_actvities.pdf

scenarios to represent driving forces that are either not under the control of the region or otherwise cannot be predicted with certainty, such as climate, land-use and demographic changes. In the future we will evaluate various interventions, such as a new water allocation system, a different tariff or subsidy structure, and changes in agriculture practices – all within the context of a range of scenarios.

From stakeholder input to model development: In FUSE we are convinced that the development of an integrated systems simulation model that can effectively inform policymakers and practitioners needs to be based on actual challenges faced by local stakeholders. This is why a collection of *FWE Challenges* under given *Driving Forces* was co-created during the workshops in 2019. To integrate them into the model, a substantial reduction in complexity was required. We thus clustered, validated, and translated the initial collection of 57 challenges in several steps. At the end, 18 challenges remained. For each of these, we determined if and how our model can address it. Some challenges are best represented in the model in the form of scenario inputs such as climate and demographic change. Others are investigated in the form of potential policy interventions to anticipate their effect (e.g., changes in pricing schemes for water). Submodules and dedicated indicators account for another group of FWE Challenges. Eventually, two challenges (water pollution and pressure on rural livelihoods) could not be integrated (fully) into the model in its current form. Figure 1 illustrates this approach.

Figure 1: FWE Challenges under given Driving Forces

Hydrologic Model: Our team member at IIASA developed a hydrologic model for the Bhima basin that accounts for rainfall, reservoir operations, surface and groundwater abstractions, as well as water delivery from reservoirs to fields (see Figure 2 for administrative boundaries). Crop consumptive water use is accounted for and is the major water 'sink' in the system. The model also accounts for water supplied to the Pune metropolitan area. The model is an application of the open-source hydrologic model CWatM coupled with the groundwater model Modflow with specific developments for the Bhima basin (e.g., differentiation between dug wells and tube wells, Figure 3). In addition, IIASA developed a farmer model that simulates the economic behavior of farmers based on their costs and benefits and results in changes in cropping patterns over time as rainfall and costs vary over space and time. This will be very important in the future as climate change and economic growth occurs.

Figure 2: Hydrology – Administrative boundaries and basin

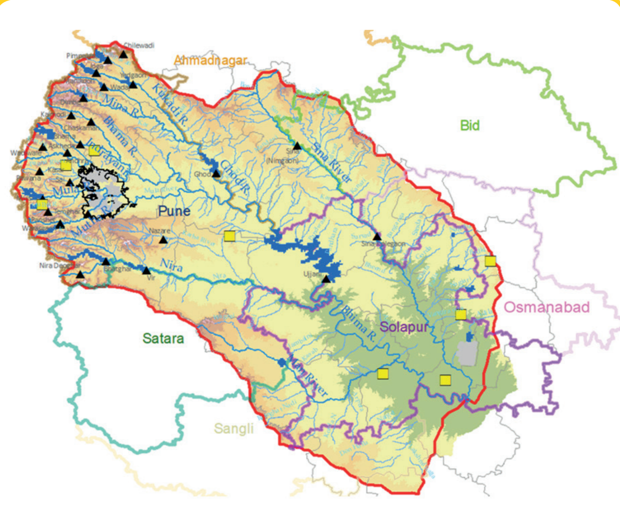
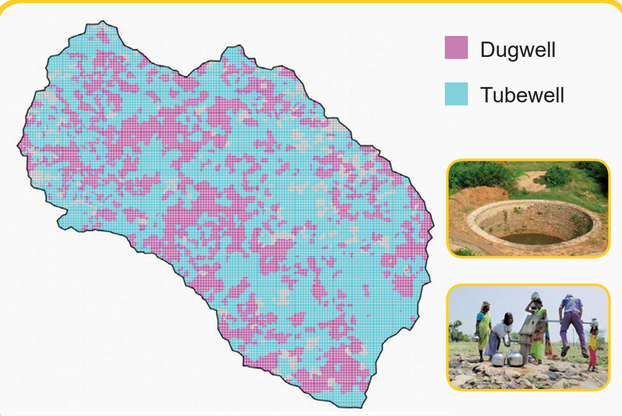
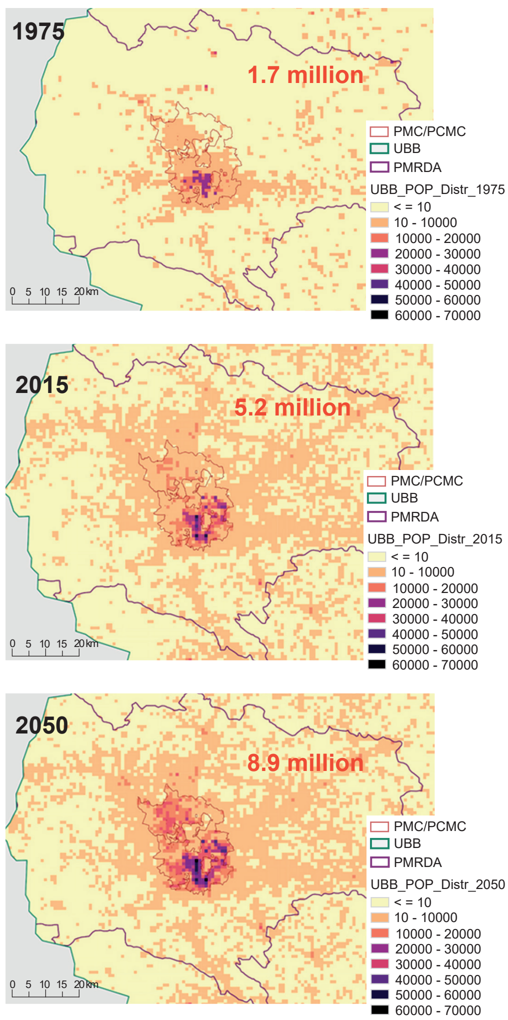


Figure 3: Dugwells and Tubewells



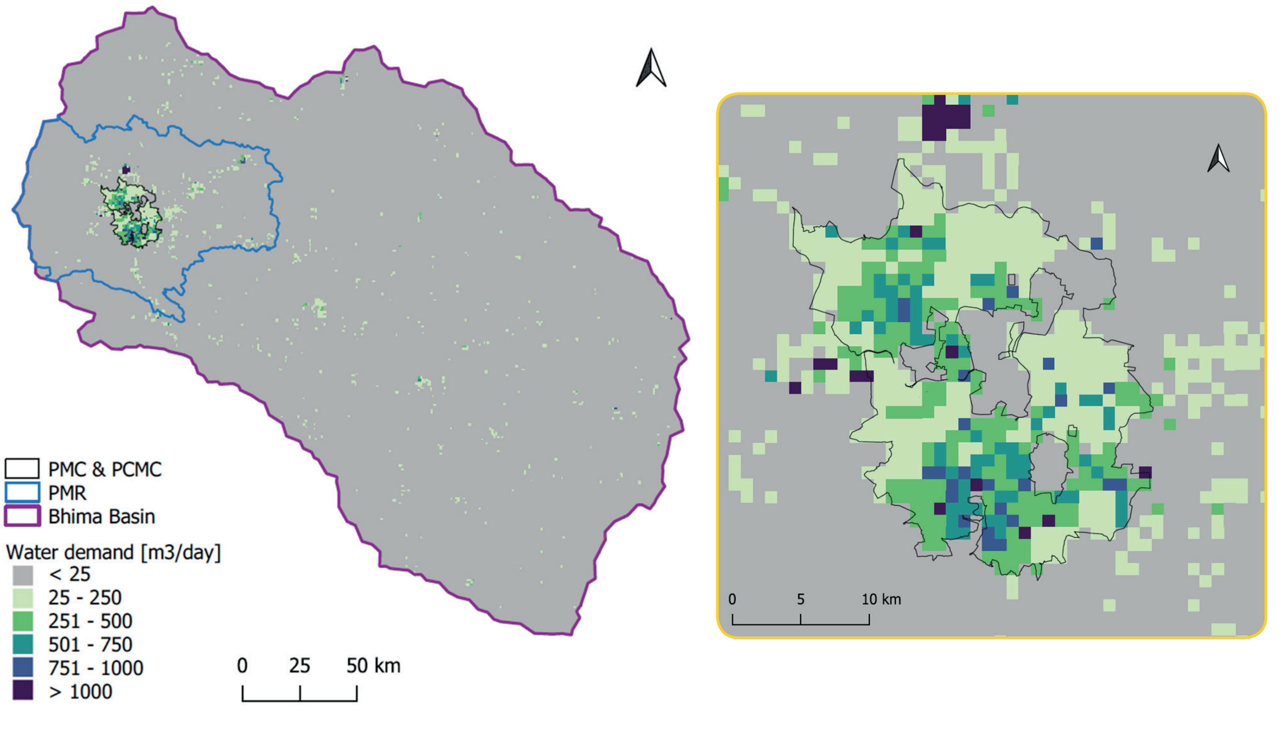
Human Models: The 'human models' are in differing states of development. UFZ has developed a method to project land-use change into the coming decades. The key change is projection of urban sprawl based on increasing population and the agglomeration of urban centers over time (see Figure 4). UFZ is also in the process of developing an urban water use model, again based on access to water, population change, and urban expansion. We hope to be able to simulate the impact of a 24/7 piped network system on the water system and how it might affect or be affected by agricultural water use in the future. Coupling these models that comprise the human modules to the process-based models of water and agriculture will enable us to evaluate the role of inequitable water delivery on supply and economic well-being, particularly of those households with lower income. The integrated model will also enable us to evaluate the impact of tanker-truck water transferring groundwater from agricultural areas to urban households, especially during drought periods.

Figure 4: Population Density per Square Kilometer



In parallel to the development of the human models, the team has focused heavily on access to water and food in Pune, with a focus on the slum areas. Figure 5 illustrates how the water demand by commercial and industrial establishments can be estimated in a spatially explicit way.

Figure 5 Estimated water demand by commercial and industrial establishments in m3/day in Pune and the Bhima basin. Preliminary estimates.



Data sources: PMC 24x7 Detailed Project Report (2014), DES, 6th EC (2013), GHSL POP (2015)

Surveys in the Pune Metropolitan Region

As announced in the last FUSE newsletter, we cooperated with Dr. Vishal Gaikwad from the Gokhale Institute of Politics and Economics and conducted an in-depth survey (n=1872) on household water and energy use in early 2020 in the Pune Metropolitan Region (including both, Pune City and Pimpri-Chinchwad). According to the survey, more than half of the interviewed households receive every day piped water supply for less than 10 hours. Among those households, more than 90% are using water storage tanks as a coping strategy. 41.5% of the households from the observations own at least one water pump for various purposes, e.g., pumping piped water or tanker water into or from the storage, extracting well or borewell water. On average, the water pump is operated 1.3 times per day by households with an average duration of 62 minutes per use. The electricity use for water pumps is directly linked with piped water use due to the intermittent piped water supply, as the households commonly use electric water pumps for pumping piped water into and from the storage tanks. For the spatial distribution of households and an overview of the condition of piped water supply, see Figure 6.

Figure 6: *Spatial Distribution of Surveyed Households and Overview of Piped Water Supply Condition*

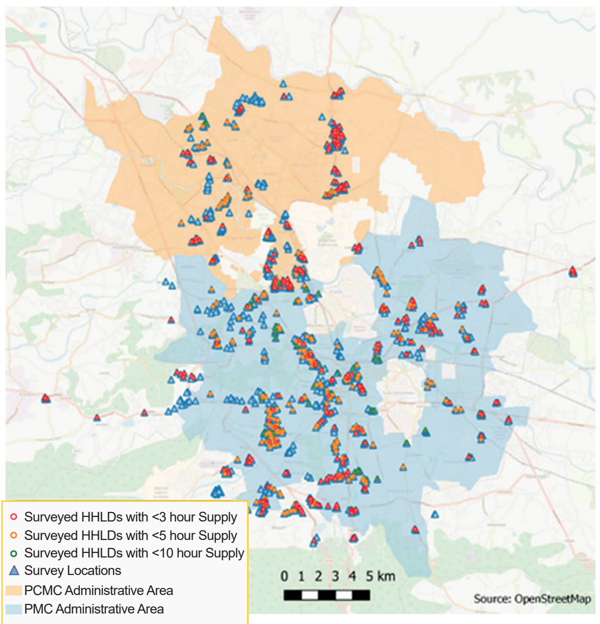
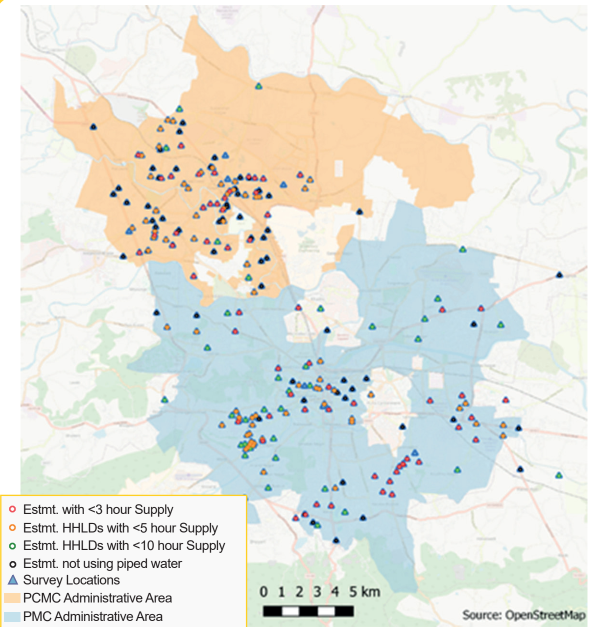


Figure 7: Spatial Distribution of Surveyed Commercial Establishments



During September-October 2020, we continued co-operating with Dr. Gaikwad's team on a commercial establishment survey, which was conducted via telephone interviews due to COVID constraints. Similar to the household survey, the commercial establishment survey is based on a well-structured questionnaire, aimed at 1) collecting quantitative data from different types of commercial establishments on the water and energy use as well as basic organizational and infrastructural information for the commercial water-energy demand estimations, and 2) gathering information for validating the model simulation results regarding water and energy use in the commercial sector. Eight enumerators were selected based on their performance in the household survey and received one-week online training for the commercial establishment survey. In total, 373 establishments, e.g., restaurants, retail stores, and training institutes, were interviewed (for their spatial distribution see Figure 7). 72% of the interviewed establishments use municipal piped water, while the average hours of piped water supply they receive are less than 5 hours per day. 47% of the interviewed establishments have also used alternative water sources such as tanker water and well water during the past twelve months preceding the interview. Large water storage tanks accompanied with electric pumps are commonly used as a coping strategy. More than half of the interviewed establishments use electric pumps for water-related purposes.

Publications and Team Updates

- **American Geophysical Union meeting 2020**

The FUSE team gave a series of talks on individual topics at the international American Geophysical Union meeting. The title and abstracts of these talks are posted on the FUSE website.

- **Journal Publication: Water-Food-Energy Challenges and Political Economy of the Sugar Industry**

Ju Young Lee and co-authors – Roz Naylor, Steven Gorelick, and Anjuli Figueroa – published a paper in *Environmental Research Letters* in July 2020, which is titled "Water-Food-Energy Challenges in India: Political Economy of the Sugar Industry." This paper uses "a nexus approach to assess India's interconnected water-food-energy challenges, with a specific focus on the political economy of the sugar industry in Maharashtra, one of the country's largest sugar-producing states. This work underscores three points. First, the governmental support of the sugar industry is likely to persist because policymakers are intricately tied to that industry. Entrenched political interests have continued policies that incentivize sugar production. As surplus sugar has been produced, the government introduced additional policies to reduce this excess and thereby protect the sugar industry. Second, although the sugar economy is important to India, sugar policies have had detrimental effects on both water and nutrition. Long-standing government support for sugarcane pricing and sales has expanded water-intensive sugarcane irrigation in low-rainfall areas in Maharashtra, which has reduced the state's freshwater resources and restricted irrigation of more nutritious crops. Despite its poor nutritional value, empty-calorie sugar has been subsidized through the public distribution system. Third, the Indian government is now promoting sugar-based ethanol production. This policy has the benefit of providing greater energy security and creating a new demand for surplus sugar in the Indian market. The analysis in this paper shows that a national biofuel policy promoting the production of ethanol from sugarcane juice versus directly from molasses may help reduce subsidized sugar for human consumption without necessarily expanding water and land use for additional production of sugarcane."

Water-Food-Energy challenges in India: political economy of the sugar industry, (2020), Lee, Ju Young; Naylor, Rosamond; Jain Figueroa, Anjuli; Gorelick, Steven M., *Environmental Research Letters, vol.15, n.8, 084001*

- **New team member: Ankun Wang, Stanford University**

Ankun Wang joined the FUSE team in the Fall of 2020. As a FUSE member, Ankun Wang continues Anjuli Jain Figueroa's work on the integrated model development. Ankun's role is to construct an integrated multi-agent model to incorporate the urban Food-Water-Energy Nexus for the Pune region in India. She also works on integrating narratives of further changes in climate, population, economic development, and policy interventions into the model.

- **Internship cooperation: Gokhale Institute of Politics and Economics + FUSE**

The Gokhale Institute of Politics and Economics (GIPE) has been a valuable partner for the FUSE project and its team members from the beginning. In spring 2021, GIPE and ÖFSE agreed to deepen this partnership and to organize an online internship for ten undergraduate students of economics from GIPE from May-July 2021. Led by Ashish Kulkarni and Saylee Jog from GIPE, students will work on FUSE-related topics such as impact of COVID-19 on policies and strategies within the FWE nexus. They will contribute to the project by carrying out various tasks such as media analysis, surveys and interviews, including with some of the stakeholders who participated in the FUSE workshops. Coordinated by ÖFSE, FUSE team members will support the interns in their research by exchanging expertise and ideas.

Plans for this year

The FUSE team is deeply engaged in the model integration process (see Figure 8). This involves converting the process models into modules that are interconnected. Making sure that the interconnections and feedbacks are properly represented is a challenging and time-consuming task, requiring intense engagement of our modeling team. Our aim is to consider a set of scenarios that involve business as usual and the ones that subject the region to scarcity due to population change and even future periods of reduced water availability. Under these scenarios we will evaluate future interventions that consider a range of practices and policies. They range from continuing historical conditions to exploring the impact of a 24/7 piped supply system. These scenarios and interventions will give rise to a set of alternative futures. These futures will be evaluated based on metrics of resource vulnerability, resilience, inequity, and economic well-being. These results will be presented during a 2nd set of workshops to our Pune stakeholders and policy experts in the form of narratives and reactions will be elicited and discussed. COVID-19 permitting, we hope to hold these workshops toward the end of 2021 (see Figure 9).

Figure 8: Integrated Model Design

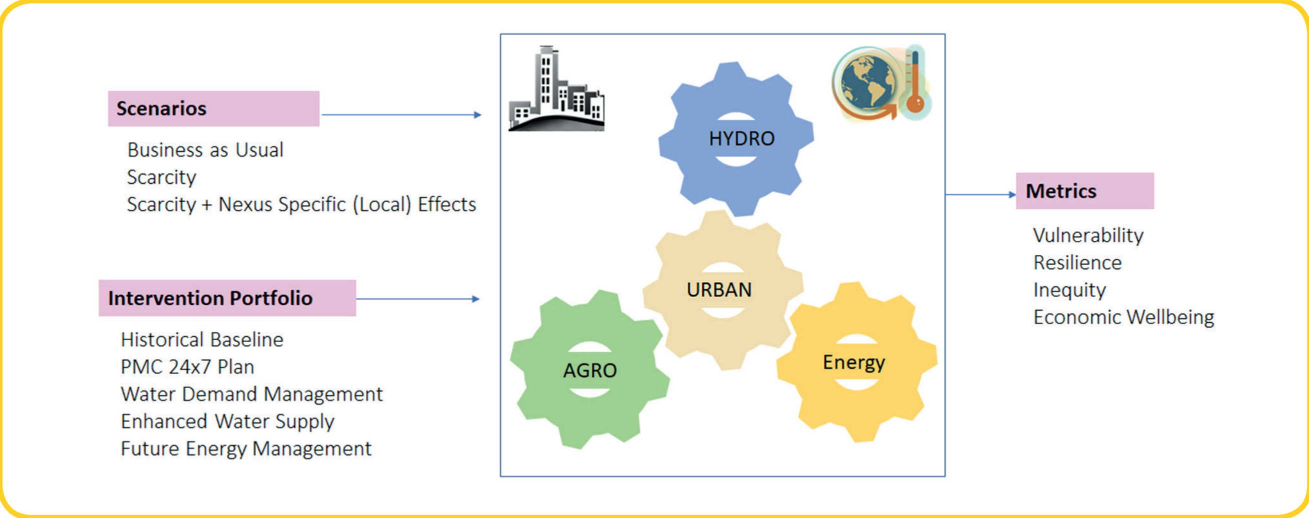
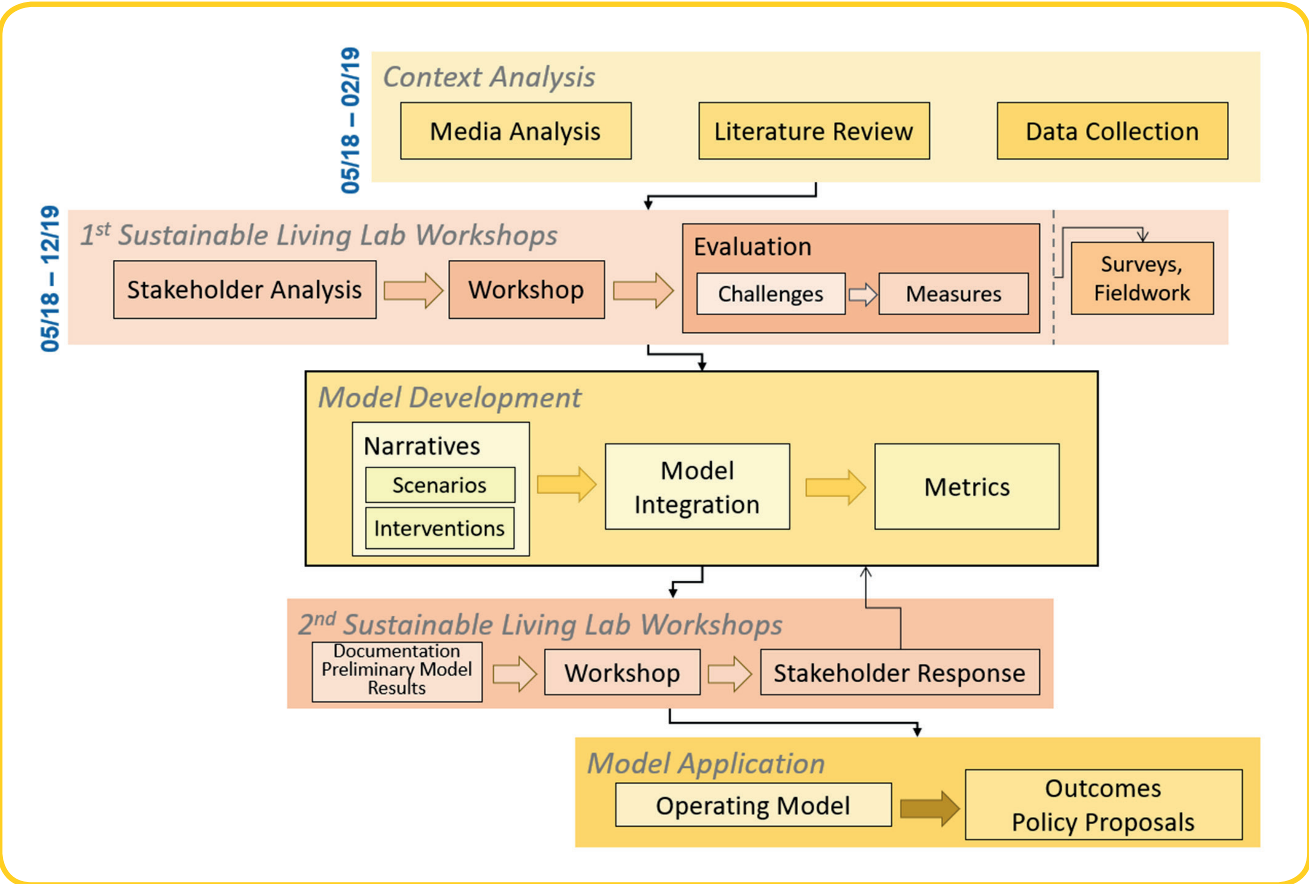
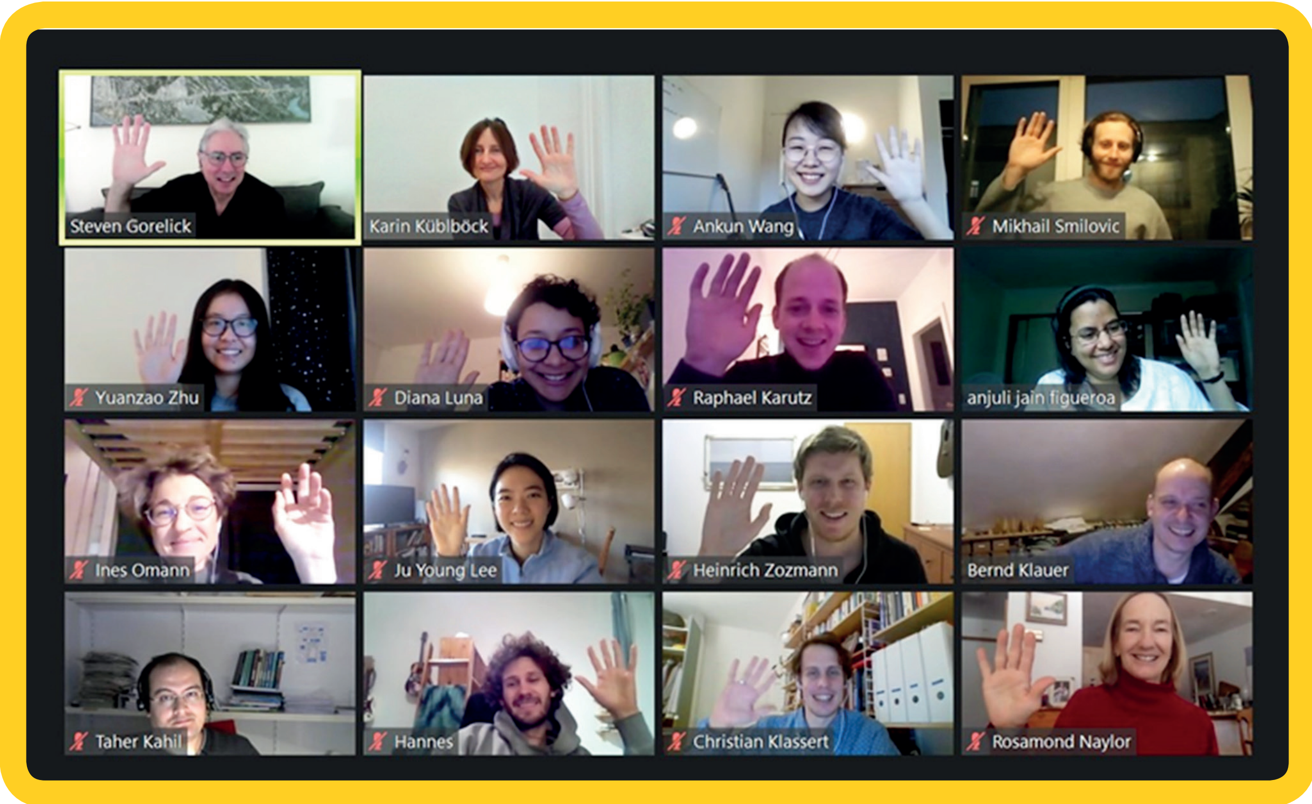


Figure 9: FUSE Progress and Timeline





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