A systematic approach for assessing climate vulnerabilities and adaptation options in large property portfolios: influences on property owners’ transformative capacity

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Abstract. Climate change and urban densification pose major challenges to the built environment. In Swedish cities, fluvial and pluvial floods risk being aggravated, necessitating adaptation efforts to make the build environment more resilient. A recent governmental inquiry states that owners are primarily responsible for adapting their property, and that the existing built environment is particularly tricky. Property owners often lack tools and approaches to strategically adapt to climate risks. This paper presents and tests a structured approach intended for large property owners to assess and visualize flood vulnerability in both individual buildings and the property portfolio, and organizational adaptive responses. The approach was developed and tested using the municipal housing company Hyresbostäder in Norrköping, Sweden as case. The study builds on workshops with staff, a systematic flood vulnerability mapping of 575 buildings, and in-situ inspections of the 85 most vulnerable buildings. The vulnerability and need for adaptation of individual buildings were visualized on a map, and adaptive avenues were identified. The approach was found useful for identifying the most vulnerable buildings, concrete adaptation measures and five broad adaptation avenues: risk-focused adaptation investments, area-focused adaptation, regular inspection and maintenance, informed collaboration and tenant dialogues. The property owner’s transformative capacity was improved by creating a shared vision, empowerment and learning, innovation capacity, gaining overview supporting transformative leadership and external cooperation likely to contribute to meeting SDGs 13 and 11. In further studies the approach will be tested by other large property owners under limited research support.

1. Introduction
Climate change and urban densification pose major challenges to the built environment. Urban stormwater systems are often incapable of withstanding current fluvial and pluvial extremes, resulting in increasing costs [1-2]. Since both urban fluvial and pluvial flood risks are expected to aggravate with climate change [3], the need to adapt the built environment is large and increasing [4]. The bulk of climate adaptation policy and research in Sweden have mainly concerned the public sector, despite the pronounced importance of private companies, individuals and property owners [5]. A recent governmental inquiry concluded that property owners in Sweden are responsible for adapting their property, and that adaptation of the existing built environment is particularly tricky [6]. Improving property owners’ capacity to assess risks and adapt to floods is also important for meeting SDG 13 “Take urgent action to combat climate change and its actions” and SDG 11 “Make cities and human
settlements inclusive, safe, resilient and sustainable” [7]. There is, thus, a need to direct more attention to climate adaptation for private sectors, particularly property owners.

Studies of how the built environment in Sweden is impacted by fluvial and pluvial floods, and how adaptation is approached, are growing. Hydrological, radar and insurance claims data have been used to analyse what types of floods cause the most severe impacts [2,8]. These studies conclude that not only total precipitation amount, but also duration and intensity are important to assess the degree of impacts on the built environment. Moreover, Grahn and Jaldell [9] surveyed 1143 property owners in flood-prone residential areas, concluding that they viewed public adaptation to flood risk as inefficient and that they lacked knowledge about their responsibility to adapt and adaptation measures.

Focused on supporting various actors’ adaptive processes, many information platforms, tools and guidelines have been developed the last decade. Examples are climate adaptation portals at European, national and sub-national levels, focusing predominantly on public adaptation processes [10]. Another strain is websites providing different types of climate services. Though less common, tools and information intended specifically for property owners have also been developed, e.g. the VisAdapt tool aiming to support adaptation among Nordic house owners [11] and 3D climate scenarios to support risk analysis among Australian property owners [12]. Though the amount and ways of presenting such adaptation information is growing, great challenges persist on how to sufficiently contextualize information and support capacity development without user interaction [13]. Thus, using such top-down produced information is challenging for property owners [14]. Supporting property owners’ capacity to assess their own risks and adaptation needs is in this study proposed as an alternative way to aid their adaptation action. To the best of our knowledge, few methods or approaches for doing this in large property portfolios currently exists [15].

Confronted with growing flood risks and lack of approaches to strategically adapt, this study develops and evaluates a structured approach intended for property owners to assess and visualize flood vulnerability and adaptation options in large property portfolios. The approach was developed and tested in cooperation with the housing company Hyresbostäder in Norrköping, Sweden, and is intended to support assessment of both individual buildings and the entire property portfolio. The approach is held generic enable usage for other property owners, and aims to support; organisational capacity development, identification of detailed risks and adaptation needs, recurrent maintenance and strategic investments. Two research questions have guided the study:

- What steps and information needs are required for housing companies to make contextually relevant climate vulnerability assessments of large property portfolios?
- How do such assessments influence housing companies’ transformative capacity?

2. Assessing vulnerability to floods and climate adaptation in built environments

Anticipated climate change effects pose major risks for the built environment via e.g. intensified precipitation, heat and storms, rising sea levels and higher humidity [16]. In northern latitudes, flood impacts caused by high water levels in lakes and streams due to snowmelt have historically generated great damage, while urban floods generated by cloudbursts as e.g. in Copenhagen 2011 have generated high costs the last decade [17]. Also, non-climatic factors as urban densification, location of buildings and organisational preparedness influence the vulnerability of the built environment and must therefore be incorporated when assessing risks and adaptation needs [18]. Taking an integrated vulnerability perspective, focusing on exposure, sensitivity and adaptive capacity can thus capture different aspects of climate vulnerability, but also different ways to adapt [19].

Related to actors’ ability to respond, Urban Transformative Capacity (UTC) is an analytical framework that pinpoints components influencing an organisations’ capacity to transform in order to e.g. mitigate and adapt to climate change [e.g. 20]. In this study selected UTC components are applied to evaluate how the cooperating housing company’s capacity to adapt are influenced by the presented and tested assessment approach.

2.1. Factors shaping flood vulnerability of building stocks

In urban vulnerability assessments, Wilhelmini and Hayden [19] stressed the need to distinguish between neighbourhood and building characteristics as well as the experiences and characteristics of
the people residing in the buildings. Also, De Risi et al [15] argued that assessing flood vulnerability of property portfolios requires broad screening combined with detailed collection of individual building data. In this study, we build on these studies, distinguishing between neighbourhood and building characteristics, sensitive equipment and people, organisational readiness and availability of flood response measures and combining vulnerability mapping of all buildings and detailed inspections of the most vulnerable buildings. **Neighbourhood characteristics.** Assessments of flood vulnerability in urban settings have identified topography, vegetation cover/share of impervious surfaces/infiltration capacity and capacity of the sewerage system as key for determining neighbourhood flood risk [2,21-23]. **Building characteristics** is critical for analysing the risk for water intrusion through openings, low elevation of the ground floor or basement or from sewerage pipes, because of backflow intrusion, or cracks in the foundation [15,24-25]. **Flood-sensitive equipment and people:** Several technical installations are usually placed in basements, e.g. main power switches, elevator shafts and heating centrals [25]. It is also important to consider whether particularly sensitive people, such as elderly and functionally impaired reside in the building [22-23]. Small children, most notably infants [22], are also considered sensitive to floods because they are more exposed to the impure water. **Organisational readiness** affects the ability to respond to a flood event. Availability of flood warning systems, flood contingency plans, regular inspections of flood risk [26], staff’s knowledge about flood prevention measures [9] and availability of flood response equipment all are viewed to shape a property owner’s ability to respond to a flood event.

2.2. Evaluating property owners’ Transformative Capacity
Ziervolg et al. [27] define UTC as “the capacity of individuals and organisations to be able to both transform themselves and their society in a deliberate, conscious way”. The UTC framework describes components affecting the ability to transform by e.g. changing governance modes, supporting citizen and company initiatives, lead change processes and collaborate across organizational boundaries [20]. The UTC framework has been applied foremost to urban areas and local governments, but in this study, we apply it to an organisation, i.e. the public housing company. To delimit our evaluation, we have isolated the eight UTC components deemed as most central for portraying property owners’ transformative capacity based on [20] in a similar way as in [28]. These are used to structure the evaluation of how the housing company’s transformative capacity was influenced by our vulnerability approach. These UTC components are: 1. Create shared visions, described as turning adaptation needs into clear and internally shared visions about organizational change [20,29]; 2. Transformative leadership that entails leadership committed to drive change and to promote and anchor the vision of the climate-resilient organization [20,30]; 3. Engage stakeholders referring in this context, to the ability of a property owner to engage and incorporate views from residents in the implementation of adaptation [28,30]; 4. Cooperation with external actors here means the capacity to initiate and coordinate collaborations with external actors, e.g. infrastructure owners and other businesses [28,30]; 5. Innovation capacity here implying the ability to experiment with novel adaptation measures in residential areas [29]; 6. Empowerment and learning relates to the ability of an organization to systematically learn from and act on new information and tested actions [20]; 7. Scaling-up refers to the ability of an organization to implement successful adaptation experiments to be used in other areas and/or for other purposes [20,29-30]; 8. System overview is described as the ability of an organisation to generate knowledge about system dynamics and to monitor progress [20,29-30].

3. Research design
This study reports results from collaboration between researchers and a housing company, aiming to improve their capacity to adapt their property portfolio to climate-related flood risks.

3.1. Norrköping: flood risks, climate adaptation and Hyresbostäder – the municipal housing company
Norrköping is a mid-sized Swedish municipality (pop 140000) sitting on the south east coast. Currently, population increase is causing both urban densification and expansion. Norrköping is exposed to fluvial floods, stemming from high water levels in the Baltic Sea and the river Motala Ström, and pluvial floods due to low-lying areas and deficient capacity of the urban sewerage system.
[31]. For this study, two flood-risk maps: a fluvial flood risk map based on a 100-year flow in Motala ström and a pluvial flood risk map based on a 100-year cloudburst were used to identify exposed buildings [32]. Since 1946, Hyresbostäder is a public housing company, owned by Norrköping municipality. At the time of the study, it owned 575 buildings with over 10000 apartments and 300 facilities spread throughout Norrköping. Hyresbostäder’s goal is described as providing comfortable, safe and well-maintained housing for all by being an innovative and attentive landlord [33]. The annual revenue was about 80 million Euro and renovation costs about 30 million Euro in 2018 [33].

3.2. Method
The collaboration included four workshops, presentations to the board and management and continuous contacts from Sep 2017 to Sep 2018. From Oct 2018, the researchers have met the adaptation coordinator of the housing company regularly and a follow up discussion was held in Dec 2019, about a year after the vulnerability assessment. All workshops lasted 1.5 to 2 hours and notes were taken to facilitate further work. At Workshop 1, seven staff spanning facilities, safety, maintenance, adaptation coordinator and archive evaluated whether a range of indicators grouped into five vulnerability components were viewed relevant for Hyresbostäder and how data could be collected (final list of indicators is displayed in Table 1) assisted by three of the authors. The indicators were derived from scientific and grey literature divided into neighbourhood and building characteristics, sensitive equipment and people, organisational readiness and availability of flood response equipment. Data covering all indicators for all 575 buildings were then collected by one of the authors in Jan – Mar 2018 and entered into an Excel spreadsheet, coded as described in table 1. Workshop 2 analysed the overall pattern, based on the desk study, and to determine consequences that the housing company viewed as particularly important to avoid, if a flood event should occur. The staff also established weights for individual indicators, presented in table 1. Based on the data collected and the weights, flood vulnerability was calculated for each individual building. At Workshop 3, staff could view which buildings were the most vulnerable and what factors mainly caused it visualised manually on a map. In summer 2018, 85 buildings were inspected by one of the authors, following a protocol jointly developed by the researchers and staff. At Workshop 4, the results from the inspections were presented in the form of pictures of select main causes of vulnerability e.g. external stairs, main power switches and impervious surfaces/vegetation as well as a table displaying common sources of vulnerability. Staff discussed how these vulnerabilities could be reduced and potential avenues for adaptation. In October 2018, the results of the vulnerability assessment, the inspection and the main avenues for adaptation were presented to the board of Hyresbostäder.

4. Results

4.1. Preparing the flood vulnerability mapping
At Workshop 1, the staff discussed vulnerability indicators and how the indicators should be measured (Table 1) and how the specific data should be collected. For neighbourhood characteristics, the staff agreed that elevation, share of impervious surface and location in an area with combined sewerage system would provide an adequate representation of the building’s flood risk. For each indicator, the staff proposed three response options, for instance if the building was in high or low elevation or flat or within a flood risk area. For building characteristics, the staff suggested two indicators covering underground access to the building: car access and external stairs and one indicator representing the building’s flood history. For external stairs, the staff agreed to distinguish between covered and uncovered stairs and for flood history they distinguished between occasional floods and reoccurring floods. For flood-sensitivity, the staff proposed ten indicators capturing a range of technical and social characteristics. The technical installations were main power switch, heating central, IT-equipment, elevator, grease separator and basement drainage pump. The staff also viewed that the building was more sensitive if there was a caring unit in the building, since this implied that particularly vulnerable groups such as elderly, sick, functionally impaired and children would reside in the building permanently or part of the day. Likewise, if there was a rented facility in the basement, this indicated higher sensitivity. Apartment storage and garage were also seen as indicating higher flood-sensitivity,
because they imply presence of valuable items. For organisational readiness, the staff agreed that flood warning system, systematic flood inspection, internal routines for flood preparedness and information of flood response measures all were valid. The staff also agreed that access to evacuation facilities for tenants, access to pumps, alternative access for emergency services and whether the building was equipped with a backflow blocker were indicating ability to respond during a flood.

The staff reported that data for measuring the indicators were available in various formats and that some data only would be accessible through personal contacts. Therefore, the researchers and the staff jointly decided how the data would be collected. Data for indicators 1-5 and 24 were collected through GoogleEarth; indicators 7-9 and 12-14 from technical drawings; indicators 10-11 from other Hyresbostäder documentation; indicators 6, 10, 15-26 through personal communication with staff responsible for key functions; indicator 3 from staff at the municipal sewerage utility; indicators 17-23 were provided by the staff participating in Workshops 1-2.

4.2. Mapping flood vulnerability

The results of the flood vulnerability mapping are displayed in the results column in table 1. For neighbourhood characteristics, about 17% of the 575 buildings were low-lying or within a flood risk area and 25% of them were mostly surrounded by impervious surfaces, indicating high flood risk for these buildings. Moreover, about 14% of the buildings had combined sewerage system. For building characteristics, 21% of the buildings had external stairs to the basement, whereas 11% were uncovered. Also, 13% of the buildings had external access to garage in the basement. About 6% of the buildings had been flooded occasionally and only 0.3% of them recurrently. For flood-sensitivity, 67% of the buildings had the main heating central and 48% the main power switch placed below or at ground floor, indicating high flood-sensitivity. Moreover, IT equipment (45%), elevator equipment (25%) and apartment storages (48%) were also common in basements. The mapping found that there were facilities in the basements of 22% and caring units in 9% of the buildings, whereof 4% of to a large extent. About 13% of the buildings had garages in parts of the basement, whereof 2% in the whole basement. The mapping also established that there were basement drainage pumps in 3% and grease separators in 2% of the buildings. For organisational readiness, the housing company did not have access to flood warnings and consequently did not distribute flood warnings to staff or tenants. Also, organisational routines and regular flood inspections were lacking and detailed information about preventive flood measures were not available to staff. The mapping also found limited evacuation capacity, that there were few or no pumps available and that no buildings were equipped with backflow blockers. About 3% of the buildings were identified as hard to access during a flood.

4.3. Assigning weights to indicators of flood vulnerability

At Workshop 2, the overall pattern of the vulnerability mapping was analysed and consequences that the staff viewed as particularly important to avoid during a flood were identified. The staff elaborated on and assigned weights (Table 1, column weights) for individual indicators and which indicators that best represented key vulnerabilities. The staff assigned high weight to all neighbourhood indicators. For building characteristics, flood history was seen as influential for flood vulnerability, while external access was assigned medium weight. Even if car access is larger than stairs, they were assigned the same weight because all garages were separate from the rest of the building.

The staff identified three consequences that were important to avoid during a flood: power outage, effects on critical operations/activities, and decontamination. Avoiding power outage during a flood was deemed most critical because it was viewed as decisive for allowing tenants to stay, as was protecting particularly vulnerable tenants, consequently both these were assigned very high weight. Hence, the combination of high neighbourhood flood risk, external stairs and critical equipment in the basement was viewed to indicate high vulnerability. Since immobile people reside in many elder care and caring units and infants that are particularly exposed to pathogens and impurities in the water, the staff agreed that these buildings should be assigned high weight. Decontamination after a flood event was also viewed important and involved location in a combined sewerage area and/or of the presence of grease separators (low weight) combined with no backflow blockers installed. Also, presence of a drainage pump was viewed to indicate high sensibility. Rented facility, main heating central, IT
equipment and elevator in the basement were assigned medium weight. IT-equipment was only seen as critical for the company headquarters, since it would seriously impact data storage and communications during a flood event. Apartment storage was assigned low weight, since it was not viewed critical for staying in the building during a flood.

Table 1. Vulnerability indicators, response options, results and weights assigned for the 575 buildings.

| Vulnerability component | Vulnerability indicator | Response options | Results | Weights |
|-------------------------|-------------------------|------------------|---------|---------|
| Neighbourhood Flood Risk Characteristics | 1. Building’s elevation (in relation to surroundings) | 0 = High elevation/hill, 1 = Flat, 2 = Low /flood risk area | 0 = 16%, 1 = 67%, 2 = 17% | 0, 5, 10 |
| | 2. Share of impervious surfaces | 0 = Most green space, 1 = 50/50, 2 = Most impervious | 0 = 12%, 1 = 63%, 2 = 25% | 0, 4, 8 |
| | 3. Combined sewerage system | 0 = No, 1 = Adjacent, 2 = Yes | 0 = 86%, 1 = 0,2%, 2 = 14% | 0, 3.5, 7 |
| Building characteristics | 4. External car access to basement | 0 = No, 1 = Yes | 1 = 13% | 0, 6 |
| | 5. External stair to basement | 0 = No, 1 = Yes, covered, 2 = Yes | 0 = 79%, 1 = 10%, 2 = 11% | 0, 3, 6 |
| | 6. Flood history / experience | 0 = Never, 1 = Occasional, 2 = Reoccurring | 0 = 94%, 1 = 6%, 2 = 0,3% | 0, 5, 10 |
| Flood-sensitivity: How much is at risk in the building? | 7. Main power switch in basement/low | 0 = No, 1 = Yes | 48% | 0, 20 |
| | 8. Main heating central in basement/low | 0 = No, 1 = Yes | 67% | 0, 6 |
| | 9. IT/Broadband in basement/low | 0 = No, 1 = Yes, ground floor 2 = Yes | 0 = 6%, 1 = 50%, 2 = 45% | 0, 3, 6 |
| | 10. Basement drainage pump | 0 = No, 1 = Yes | 3% | 0, 10 |
| | 11. Rented facility in basement | 0 = No, 1 = Yes | 22% | 0, 6 |
| | 12. Apartment storage in basement | 0 = No, 1 = yes | 48% | 0, 4 |
| | 13. Garage in basement | 0 = No, 1 = Yes, partly, 2 = Yes, whole | 0 = 87%, 1 = 11%, 2 = 2% | 0, 3, 6 |
| | 14. Elevator | 0 = No, 1 = Yes | 25% | 0, 6 |
| | 15. Caring unit in the building | 0 = No, 1 = Yes, partly, 2 = Yes, most | 0 = 91%, 1 = 5%, 2 = 4% | 0, 10, 20 |
| | 16. Grease separator in basement/low | 0 = No, 1 = Yes | 2% | 0, 2 |
| | 17. Inspection of building flood risk | 0 = Yes, 1 = No | 0% | 1 |
| | 18. Routine or checklist for floods | 0 = Yes, 1 = No | 0% | 1 |
| | 19. Information about preventive measures | 0 = Yes, 1 = No | 0% | 1 |
| | 20. Flood warning system | 0 = Yes, 1 = No | 0% | 1 |
| Adaptive capacity: Organisational readiness | 21. Access to evacuation facility | 0 = Yes, 1 = No | 0% | 1 |
| | 22. Backflow blocker installed | 0 = Yes, 1 = No | 0% | 1 |
| | 23. Access to pumps | 0 = Yes, 1 = No | 0% | 1 |
| | 24. Emergency service access during flood | 0 = Yes, 1 = No | 3% | 2 |

4.4. Analysing flood vulnerability

The mapping and the weights were used to calculate both the degree of flood risk and total vulnerability for each individual building and the most vulnerable buildings were displayed on a map (Figure 1) and presented at Workshop 3. Of the 575 buildings, 315 (55%) were classified as low flood risk, 49 as some flood risk (9%), 126 (22%) as moderate flood risk, and 85 (15%) as high flood risk. Most high-risk buildings were located in the city center, which has a high share of impervious surfaces and combined sewerage areas. There are also individual buildings located in low lying areas and larger residential areas with several buildings that are at risk for the same main reason. Separate calculations were performed for the three consequences identified in 4.3 and presented at Workshop 3.
Of the high-risk 85 buildings, 60 had basements where the main power switch was located. In 21 of these buildings there were a caring unit with basement. For risk of contamination, 43 of the buildings were at risk, mainly due to location in a combined sewerage area.

The staff concluded that the mapping provided an overview of their need for adaptation. The division into categories based on degree of flood risk was found useful for enabling a discussion about the different reasons making them vulnerable and measures that could reduce the building’s flood risk. The staff found that detailed in-situ inspections were needed to validate the results obtained through the mapping, e.g. to measure at what height the main power switch was located.

4.5. Avenues to enhance adaptation using the assessment results
At Workshop 4, the main results were presented and discussed with company staff engaged during the assessment and the company’s steering committee to elaborate how the results could inform the company’s operations and strategic work to reduce flood risks. Five avenues perceived as central for reducing the found vulnerabilities were identified. 1. Risk-focused adaptation investments. Staff stated that the vulnerability assessment could be used to prioritize annual investments in adaptation measures for either individual high-risk buildings, or investments in specific measures central for many buildings such as measures to protect the main power switch by changing to flood proof doors. The steering committee emphasized the importance of securing buildings seen as key to operationally manage a crisis such as a cloudburst by e.g. securing power supply in the headquarters and the ability of leaders to coordinate evacuation and distribute work tasks. Also, buildings with vulnerable and immobile groups such as elderly and disabled were seen central to protect. 2. Area-focused adaptation. The vulnerability assessment was further enabling identification of residential areas that were both at risk and that have prerequisites to implement large-scale adaptation measures that protect many buildings. Five residential areas were seen as offering good possibilities to implement open stormwater systems due to its topography and surrounding green areas with high infiltration and storage capacity. 3. Systematic control and maintenance. The detailed risk descriptions were seen as useful for updating instructions for regular inspections and building maintenance, materials and technical systems both for their staff and external contractors. 4. Informed collaboration. Staff argued that the identification of residential areas with potential to implement area-scale adaptation measures opens up for strategic collaboration with e.g. infrastructure managers, municipal departments and other landowners on how they jointly can approach funding, design, implementation and management of adaptation. 5. Tenant dialogues. By showcasing how risks can be decreased in high-risk residential areas, staff expressed that it would become easier to involve tenants in the design of adaptation measures that can provide co-benefits as increased attractiveness and recreation.

4.6. Initial adaptation measures taken
Through continuous tuning meetings with the company’s adaptation coordinator, the first actions taken since the vulnerability assessment have been identified, which should be seen as indicative of how the company has advanced its adaptation action. After more in-depth investigations of some of the found vulnerabilities, the company took a directional decision on prioritized risks. Starting with
high-risk buildings, the company has first prioritized securing buildings housing vulnerable and immobile groups through installing pumps, backflow blockers and external flood protection. Installation is underway in one building, providing a model to be up-scaled. The company also decided to install backflow blockers in all buildings located in a combined sewerage area. Further, the company has identified a first pilot residential area for which a deeper collaboration with the municipal planning office and the water utility has been initiated. Through planning an open canal, flood risks in the area are planned to be reduced while also providing opportunities to increase the attractiveness of the area by creating more playgrounds and green areas. This area is also seen as a testbed before up-scaling. Ability to initiate strategic collaboration with external actors in residential areas was perceived as the most important, yet challenging, adaptive capacity aspect within the company by the adaptation coordinator, and thus seen a key ability to further develop.

4.7. Perceptions on needed improvements of the tested vulnerability assessment approach
Based on the continuous tuning meetings and follow-up interviews with company staff, feedback on the jointly developed and tested vulnerability assessment approach has been collected to inform further developments. Overall, the approach was perceived as rather straightforward. Building on its main steps, staff expressed the benefit it gave in anchoring the issue internally and the shared learning it created, which were seen as vital to improve the company’s understanding of and expressing the need for climate adaptation on their own terms. However, as argued by the adaptation coordinator, the results of the assessment have and should not be seen as the recipe for adaptation. If having endless resources, he argued, the assessment could directly have informed such investments. However, due to tight budget frame, the company had to make strict priorities and assess the order in which measures should be implemented. By making adaptation a joint concern both for the staff directly involved in the assessment and the steering committee and operators, the assessment results were seen as a good base for mainstreaming adaptation internally and build an understanding of how climate-induced flood risks and adaptation is related to the company’s core business. A key aspect informing these discussions has arguably been e.g. photos taken during inspections of high-risk building that made risks tangible for managers, and the workshops discussing which of the found risks have the most drastic effects on the companies building portfolio and the continuous work tasks of their staff.

4.8. Influences on transformative capacity and the abilities to meet sustainable development goals
Departing in the presented UTC components, the jointly developed and tested assessment approach can further reveal how the housing company’s transformative capacity have been influenced. Not least, jointly conducting and interpreting the results of the assessment seem to have supported the creation of shared visions [20,29] by clarify how climate risks and adaptation are linked to its core business including maintaining their property portfolio. Likewise, the process appears to have supported transformative leadership [20,30] by initiating discussions within the steering committee on how climate risks can be managed in the long and short term, and which buildings, groups and work tasks is most important to protect. Partly this appears a result of internal empowerment and learning [20,29] on the issues at hand, influenced not least by the photos of vulnerable parts/equipment in buildings, and joint discussions on what risks are most severe for the company. The priorities and first adaptation actions taken also reveal that they have started to develop capacity to innovate [29] through developing test-beds to be up-scaled, and has understood the need for and began to collaborate with external actors within prioritized residential areas. Moreover, related to system overview [20,29] the company has begun to take a grip of the entire property portfolio, but do not yet have any systems for monitoring progress in place. The company has also recognized the need to engage tenants [30] in the design of measures to enable co-benefits of adaptation, but no such projects have yet been initiated.

The improved transformative capacity is likely to facilitate meeting SDG 13 by rising awareness, institutional and adaptive capacity to climate-related hazards (SDG 13.1 and SDG 13.3) and by enabling property owners to adapt, integration of climate-related flood risk management in policy and planning is also likely to be induced (SDG 13.2) [7]. By enhancing property owners’ capacity to respond to flood risks, economic losses and human welfare impacts are also likely to be reduced (SDG 11.5).
4.9. Next steps in developing the vulnerability assessment framework

The vulnerability assessment approach presented in this study is a first, yet promising, attempt to improve property owners’ capacity to assess climate-induced risks and adapt correspondingly. However, as conducted here the approach has required very active support by the researchers and work remains to make it more intuitive and thus easier for other property owners to use without such assistance. It is also unclear if the approach is suitable for property owners with other forms of ownership, property portfolio and structure. To straighten out such questions, the approach will be tested with five other companies, including owners of official premises, private tenants and owners of culturally marked buildings in 2020. By limited support by the researchers, these companies will themselves conduct the steps of the approach and interpret the results as a basis for adaptive actions.

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