Stuck in experimentation: exploring practical experiences and challenges of using floating housing to climate-proof waterfront urban development in Sweden

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Abstract
With climate change already underway, cities are looking for ways to deal with its effects. To balance urban waterfront development and climate adaptation, floating housing is presented as a promising solution—however it has not been studied sufficiently. This paper explores floating housing as urban climate experimentation, targeting vision/motivation, practice and upscaling in a national context where support mechanisms and traditions are absent. Interviews with innovation entrepreneurs and municipal planners involved with planning and building floating districts show that, with one exception, the Swedish initiatives are at odds with the theoretical assumptions behind urban climate experimentation. Initiatives are neither challenge-led in terms of climate risk nor inclusive and community-based. Rather, the small-scale private entrepreneurs are pioneers in offering unique living on water as one-off innovations. While allowing experimentation, municipal planners are less convinced by the effectiveness and appropriateness of upscaling. Floating housing may contribute to local identity building and place marketing, but are riddled with implementation challenges regarding shoreline protection, privatization/accessibility, limited market interest and urban development fit. While the floating houses themselves withstand flooding, thus safeguarding individual house owners, they do not protect the land-based city with its vulnerable waterfront development patterns. Results thus suggest the limitation of floating houses in shifting development pathways and strengthening urban climate proofing.

Keywords Climate adaptation · Climate-proofing · Cities · Waterfront development · Urban climate experimentation · Floating housing
1 Introduction

Climate change is an integral part in the pursuit of wider urban agendas (Bulkeley & Betsill, 2013). Although coastal cities are highly vulnerable (IPCC, 2014) they are also seeking to increase their waterfront attractiveness and to gain competitive advantages by intensifying coastal exploitation, which further aggravates the risk of vulnerability (Dyckman et al., 2014; Granberg et al., 2016; Harvey & Smithers, 2018; O’Shaughnessy et al., 2020; Rulleau & Rey-Valette, 2017; Storbjörk & Ugglà, 2015). This creates a need to balance urban development and climate adaptation concerns in spatial planning (Francesch-Huidobro et al., 2017; Jeuken et al., 2015; Storbjörk & Hjerpe, 2014). By maintaining a strict division between land and water, thus “holding the line”, cities are currently seeking to combine waterfront development with protective measures, thus choosing a strategy of living with water and turning threats into opportunities (Lu & Stead, 2013; Storbjörk & Hjerpe, 2021). Strategies of attack allow cities to step seaward and expand urban development onto the water by artificial land creation, stilted or floating structures, where climate risks are considered in the design (ICE, 2010; Nicholls, 2011). Floating architecture has been presented as an important innovative measure for responding to sea level rise, space-replacing lack of land, extending costal city centres, creating new and innovative tourist destinations and the potential of green planning on unclaimed sites (de Graf, 2009, 2012; Lin et al., 2019; Moon, 2014; Penning-Rowsell, 2020). Floating architecture could thus, by its proponents, be considered an example of urban climate experimentation. Such experimentation is defined as being specifically “designed to respond to the imperatives of mitigating and adapting to climate change in the city” (Bulkeley & Castán Broto, 2013: 361). These expectations are also manifested on the international policy scene. For example, UN-Habitat recently held a roundtable on ‘sustainable floating cities’ to share cutting-edge ideas, inform policy, and inspire collective action for innovations, implicating floating housing as a potential element of urban climate planning and management (UN-Habitat, 2019).

Experimental floating housing was conceptualized and partly tested by architects already in the 1960s and 1970s, with the aim of overcoming overpopulation and environmental degradation, and culminating in the Oceanic Marine Expo at Okinawa, Japan in 1975. The prototypes were neither integrated in urban development nor made competitive compared with terrestrial developments (Kaji-O’Grady & Raisbeck, 2005). Since the new millennium, there has been a worldwide revival of conceptualizations for floating housing, stretching from individual houses to floating districts and cities, against the background of the ongoing climate crisis. Architectural visions like Vincent Callebaut’s Lilypad, András Györfi’s Swimming City, or BIG’s Oceanix City have been produced alongside concrete plans for floating settlements. Ongoing designs include Baca Architects’ floating village of 50 homes and businesses in Newham, UK, and the Seasteading Institute’s Floating City Project in French Polynesia. There are also numerous experimental pilot projects such as the floating ‘Ar-che’ houses in Lake Geierswalde, Germany, the floating district of IJburg, Amsterdam, the Maasbommel amphibious and floating houses in Nijmegen, the Netherlands, the floating cultural centre Some Sevit in Seoul, Republic of Korea, and the floating exhibition pavilion in Rotterdam, the Netherlands.

Despite these conceptualizations and experimental designs, research on how to use floating housing to climate-proof urban development is scarce. A few studies have illustrated the importance of floating housing and provided an overview of ongoing endeavours (Moon, 2014; Moon, 2015; Lin et al., 2019; Penning-Rowsell, 2020) or have documented
construction methods and technologies in pilot projects, predominantly from an engineering perspective (Ambica & Venkatraman, 2015; El-Shihy & Ezquiaga, 2019; Kim et al., 2012; Strangfeld & Stopp, 2014). Insufficient analytical attention has been given to challenges relating to planning and implementation. However, a recent paper provided a discursive exploration of opportunities and challenges in floating housing innovation (Penning-Rowsell, 2020). In terms of empirical studies targeting implementation practices, de Graaf’s doctoral thesis on urban water management innovations includes one case study of mechanisms for mainstreaming floating urbanization in the Netherlands, a country where water-based living represents a longstanding tradition and “a normal way of housing” (de Graaf, 2009, 2012; Huang-Lachmann & Lovett, 2016:39). In the Netherlands, there has also been a strategic national agenda with the National Congress on Floating Houses since 2008 (de Graaf, 2009, 2012). To explore the viability of floating housing as urban climate experimentation, studies are also needed on their function in national contexts where such traditions and support-mechanisms are absent. This involves illustrating contemporary processes of how urban experiments are conducted, who is involved, and their wider implications (Evans et al., 2016: 6). Also, challenges involved in using experimentation to govern shifts towards new ambitions or pathways and “generate real alternatives” (Evans et al., 2016:1; Juul Madsen & Hansen, 2019; Sengers et al., 2016; van Doren et al., 2016) must be analysed. This is where we intend to make a research contribution.

The aim of this paper is to explore conditions for using floating houses to climate-proof waterfront urban development in Sweden. This means pinpointing practical experiences and challenges of planning and establishing such urban climate experimentation in a national context where no previous traditions or support mechanisms for floating houses are in place. As a result of the international interest in floating houses, there has been considerable media coverage of this in Sweden since the new millennium, illustrating both architectural ideas and municipal plans for floating houses to climate-proof waterfront development trends. This media coverage was what initially spurred our interest in studying floating houses. Empirically we therefore chose to target five entrepreneurs involved in urban experimentation, thus acting as regime outsiders pushing for new innovative solutions (Sengers et al., 2019). We complement this main data with a smaller sample of planners in three municipalities currently engaged in constructing floating districts. We target the following research questions (RQs):

1. What are the visions and motives for floating housing experimentation? To what extent is climate change adaptation motivating such initiatives?
2. How is floating housing experimentation established in practice? Who initiates and drives the process of experimentation?
3. To what extent and how are floating housing experiments upscaled? What challenges are involved?
4. What is the potential for using floating houses to climate-proof waterfront urban development in Sweden?

The paper proceeds to present the analytical framework of urban climate experimentation in Sect. 2 and methodological considerations in Sect. 3. Thereafter follows the empirical analysis in Sect. 4, where 4.1 illustrates the five stories of urban floating housing experimentation and 4.2 analytically compares differences and similarities regarding visions and motives, initiating actors, and upscaling (RQ1–3). In the concluding Sect. 5 we problematize the practice of using floating housing to climate-proof waterfront urban development.
in Sweden. The Swedish case at large differs in its conclusions from international research and policy expectations; rather it is more in line with the few studies on floating housing innovation and practice. It can be seen as a ‘negative case’, allowing us to broaden and nuance previous research conclusions in this emerging field of study, thus enhancing scientific robustness.

2 Analytical framework: urban climate experimentation

Experimenting to achieve innovation and change has its roots in studies of socio-technical systems and sustainability transitions (Markard et al., 2012). Sengers et al. (2019) recently distinguished between five dominant conceptualizations of how experiments may trigger system innovation: niche experiments, bounded socio-technical experiments, grassroots experiments, transition experiments and sustainability experiments, each with their specific definition, normative orientation, theoretical foundation, analytical emphasis and identified main actors. However, one rapidly growing conceptualization concerns urban climate experimentation (Evans et al., 2016; Sengers et al., 2019). It assumes that improved understanding of the emergence, dynamics, and consequences of urban climate experiments could potentially open new ways of addressing climate change (Bulkeley & Castán Broto, 2013; Bulkeley et al., 2015). Experiments represent “important seeds of change” for a society in need of transforming stagnant business-as-usual practices (Sengers et al., 2016) by exploring new pathways and practices with the goal to innovate, learn and gain experience (Bulkeley et al., 2015). Despite the positive overtones, researchers have also cautioned against uncritically adopting an experimental imperative and urged awareness of the sometimes dark history of experimentation, highlighting aspects of politics and justice (Caprotti & Cowley, 2017).

Urban experimentation can be defined as “inclusive, practice-based and challenge-led” initiatives, emphasizing learning among a broad coalition of actors engaged in co-design “with the aim of generating both proprietary and shared, public knowledge” (Sengers et al., 2016: 17). Bulkeley et al. (2015) have proposed a somewhat broader definition of urban experiments as encompassing deliberate endeavours for innovation and change, such as micro-level initiatives, policy interventions, demonstration projects and technological innovations driven by public, private or citizen actors. These experiments are characterized by being purposive or strategic, geared towards climate mitigation and/or adaptation, and delivered in the name of an urban community (Bulkeley et al., 2015). Comparative studies of urban experiments document large variations in terms of objective, leading actors, activities and temporal orientation (Boyd & Juhola, 2015; Kivimaa et al., 2017; Marvin & Silver, 2016). Looking specifically at urban climate experiments, the built environment is one of the most common sites of experimentation and there has been an overwhelming dominance of experiments related to climate mitigation, compared to adaptation (Bulkeley & Castán Broto, 2013; Marvin & Silver, 2016). There is also a dominance of experiments initiated and driven by public authorities or cities, compared to private actors or citizens (Evans et al., 2016).

Experimentation with floating housing has so far attracted action from innovative entrepreneurs rather than established construction companies (Penning-Rowsell, 2020). These entrepreneurs can mainly be conceived as regime outsiders, as in the niche experiments literature (Kivimaa et al., 2017; Sengers et al., 2016) and the experiments, thus, are primarily private-led. A niche can be seen as a space where radical innovation can develop with
the co-evolution of technology, user practices and regulatory structures (Schot & Geels, 2008; Sengers et al., 2016). Empirical studies have pointed to difficulties of niche experiments in influencing existing regimes and wider processes of change (Kivimaa et al., 2017; Sengers et al., 2016). Regarding floating housing, available research foresees bleak prospects for establishing a niche, due to uncertain legislative status and standards, weak links to ongoing spatial plans, lack of consensus regarding appropriate technology and uncertain environmental impacts (de Graaf, 2009: 92ff; Penning-Rossell, 2020). Moreover, lack of knowledge and skills among developers and municipalities, and fear of unknown risks among buyers, are also seen as limiting the implementation of floating housing (de Graaf, 2009: 92ff; Penning-Rossell, 2020).

We distinguish analytically between three aspects of urban experimentation that have been used in previous comparisons. First, we examine the goals, ambitions and conceptualizations of the experiments themselves (Boyd & Juhola, 2015; Bulkeley et al., 2015) and their links to wider urban policy agendas, to assess the place- and context-specificity of the process (Burch et al., 2014). Different motivations of experiments include creating niches for radical innovation, market creation, stimulating transitions towards sustainability, and solving societal, sustainability or climate change challenges (Bulkeley et al., 2015; Kivimaa et al., 2017; Sengers et al., 2016). For floating housing, de Graaf (2009) found that local officials lack belief in floating housing and how they contribute to sustainable urban water management (de Graaf, 2009: 92f). Second, we examine the practice of floating housing experiments by using constitutive elements as the making, maintaining, and living of experiments. This means that we explicitly examine the alignment of actors, practices, and techniques of governing (Boyd & Juhola, 2015; Bulkeley et al., 2015). It also means exploring determinants like the importance of entrepreneurs or frontrunners, coordination of involved actors, commitment, and procedures supporting the negotiation of interests and values (Sengers et al., 2016, 2019). It becomes important to pinpoint both micro-scale and contextual practices influencing experimentation (Evans et al., 2016: 10).

Third, we target “how experiments come to matter” (Bulkeley et al., 2015). Upscaling from individual examples to accelerate change is often weak, since experimental initiatives are neither applied at a larger scale nor efficiently spread (Kivimaa et al., 2017; Naber et al., 2017; van Doren et al., 2016; van Winden & van den Buuse, 2017). Upscaling can refer to situations where experiments grow or expand by adding partners, users or functionality, or by enlarging the geographical area of application, or to situations where experiments are replicated in other locations, are accumulated by being linked with other experiments, or trigger transformation by shaping wider institutional change (Naber et al., 2017; Ryghaug et al., 2019; van Doren et al., 2016; van Winden & van den Buuse, 2017). We will use the distinction by van Doren et al. of: (1) horizontal upscaling with its two subdivisions, firstly, expansion i.e. spatial growth from, e.g., street to neighborhood level, and secondly, replication i.e. transfer of the experiment to other places, and (2) vertical upscaling, referring to the mainstreaming of the experiment into format institutions (van Doren et al., 2016). In practice, pilot experiments are often driven by a “willingness to pioneer and to demonstrate that it can be done” (van Doren et al., 2016: 16), which was also found for floating housing experiments (Penning-Rossell, 2020). Since not all experiments “scale immediately but rather function as small building blocks” (van Winden & van den Buuse, 2017: 67), experiments too often become “isolated events that fade into oblivion” without having enough effect on the practices they were intended to change (Sengers et al., 2019: 161). Here the literature pinpoints explanatory factors for the upscaling or lack thereof, particularly emphasizing operational arrangements, policy context, market context, socio-cultural context, and, finally, technical compatibility (van Doren et al., 2016; van Winden & van den Buuse
For floating housing, studies agree that upscaling is still rare and far from being mainstreamed (Penning-Rowsell, 2020), due to numerous limiting factors including lack of knowledge and skills among developers and municipalities, lack of guidelines and legislation, limited trust in market development, large investment costs, lack of appropriate space, technological difficulties, uncertain water quality impacts and fear of unknown risks among buyers (de Graaf, 2009: 92ff).

3 Methodological considerations

With the aim of exploring practical experiences and challenges involved in urban floating housing experimentation in Sweden, the study builds mainly on qualitative interviews with entrepreneurs engaged in undertaking such initiatives. Capturing their perspectives allows us to analyse the practice of experimentation. Our sample of entrepreneurs includes:

- three early initiatives: Sjögången, Karlstad (Interview 1), Villa Näckros, Kalmar (Interview 2) and Aquavilla (Interview 3), representing urban experimentation with floating housing around the turn of the millennium, and
- two more recent initiatives from 2015, representing contemporary trends in experimentation: Imorgon Innovation (Interview 4) and Ocean Industries (Interview 5).

We were unsuccessful in contacting the various entrepreneurs involved in the challenging process of establishing floating houses at Marinstaden, Nacka, which started already in 1999. Considering the small number of Swedish entrepreneurs working with floating houses, the sample was deemed sufficient to capture a diversity in experimental practices. This diversity becomes clear in the five stories of experimentation and when comparing motives and upscaling strategies. However, when outlining experienced challenges in experimentation and upscaling among the entrepreneurs we found striking similarities in perspectives, suggesting that a saturation point in the data was reached in this respect. Both the diversities and the similarities thus support the reasonability of sampling. The key role of municipalities in establishing floating housing through spatial planning led us to complement the entrepreneur interviews with a small sample of interviews with municipal spatial planners where floating houses were currently being introduced: Nacka (Interview 6), Sundsvall (Interview 7) and Västervik (Interview 8). This allowed valuable insights into municipal perspectives as both enablers of and receivers in urban experimentation. We considered including planners in Kalmar and Karlstad in order to broaden the sample, but refrained for methodological reasons: too much time had passed for the municipal accounts of the specific planning details to be reliable (Kvale & Brinkmann, 2014).

Although it was a small sample, the value of including municipal perspectives for properly answering our research questions was significant. Also, among municipal planners, the similarity in perspectives was striking. The municipal interviewees were planners with an active role in planning the floating houses. The sample in this study consistently focussed on ‘following the experiment’, implying that we sought to target what was currently done in terms of floating housing in Sweden. We did not specifically select entrepreneurs or municipalities where floating houses would have been most relevant or likely as a specific climate response. That would have greatly reduced the number of relevant initiatives. Consequently, the initiatives are not presented deductively, following a joint climate adaptation frame, but rather inductively, following the specific
entrepreneurial stories. Climate adaptation thus features in the empirical presentation to the extent that it is specifically discussed by the interviewed entrepreneurs and planners. In terms of site-specific information, we target experimentation in five different municipalities; the two place-specific initiatives in Karlstad and Kalmar combined with the ongoing planning in Nacka, Sundsvall and Västervik. The municipalities are scattered across this very elongated country, and vary in size. Nacka, part of the Stockholm region, has 107,500 inhabitants, Karlstad in the west 65,800, Sundsvall in the north 58,800, and Kalmar and Västervik in the southeast have 41,400 and 21,862 respectively. They all seek waterfront expansion in order to increase their local attractiveness. Four are coastal municipalities, while Karlstad is located in a sensitive river delta area. Waterfront climate vulnerability is severe in the majority of the studied municipalities with the exception of Sundsvall, where land elevation is effectively counteracting such risks.

The interviews were conducted in Swedish and followed an interview guide targeting questions of visions, motives, who initiates and drives the process, challenges experienced and upscaling strategies in floating houses. Initially, open questions were posed, evolving into specific follow-up questions to pinpoint theoretical aspects found in the literature on urban climate experimentation. With the exception of the interview in Karlstad, functioning as a pilot interview in 2015, the interviews were conducted in the spring and autumn of 2019, and lasted approximately two hours each. All interviews were audio-recorded and transcribed verbatim.

The qualitative interview analysis was inductive and stepwise. We started by reading and rereading transcripts in order to sort out the individual stories of each entrepreneur (Sect. 4.1). We proceeded with categorization, highlighting reoccurring analytical themes related to actors, motives, characterization, and challenges of experimentation (Sect. 4.2). Here the interviews from municipal planners were added. Also, here we worked inductively. Analytical patterns were identified by relating interview responses to each other, thus exploring differences and similarities in perspectives. The validity of interpretations was strengthened by comparing statements from different entrepreneurs and municipalities (Baxter & Eyles, 1997; Silverman, 2011), where we identified a high level of agreement in many of the response patterns. This analysis was undertaken in Swedish and later, in writing this paper, translated into English. The regular use of verbatim quotes from interviewees allows substantiation of analytical conclusions. To increase transparency and validity of interpretations, we systematically note where similar statements are made by several interviewees. We also present individual perspectives, when these highlight important alternative perspectives that deepen our understanding of the research questions. To further increase the validity of the analysis, a preliminary compilation of the results was sent to the interviewees for member checking (Baxter & Eyles, 1997).

4 Visions, motives and practices of floating housing in Sweden

We start by presenting the different Swedish initiatives of envisioning and establishing floating houses in a more descriptive Sect. 4.1. Next comes the comparative and more analytically driven Sect. 4.2., illustrating patterns and trends. Here additional empirical data is introduced from interviews with both entrepreneurs and municipal planners. Also, the empirical results are related to previous literature.
4.1 Five stories of urban experimentation

Three of the five initiatives of floating houses started around the turn of the new millennium, each with different motives and background stories. When we scrutinized the five initiatives, we learned that the climate motive—however salient in international literature and in Swedish media coverage—was less pronounced in practice.

First, Sjögången was initiated by the public housing company in Karlstad (KBAB) after the flood incident in Glafsfjorden in 2000, which heavily affected the nearby city of Arvika. The incident functioned as an alarm clock to reconsider future housing options, since Karlstad is located in a vulnerable delta with a flood risk, while also heavily extending its waterfronts:

People want to live waterfront, but how this can be done without risking increased flood damage? For us, Sjögången was a serious attempt to proactively reduce risks by floating constructions, following the water level. [Interview 1]

The motives were to raise the standard of attractive rental housing, create a local landmark and strengthen the waterfront image, while at the same time proactively and innovatively reducing climate risks:

We wanted to show creativeness, that things can be done here. To use our water constructively and show playfulness, joy and innovation. [Interview 1]

When an appropriate location was secured at Orrholmen, the planning of 12 floating rental houses in Mariebergsviken started, alongside a land-based district of 127 apartments. Tengboms Architects designed the houses, which were later built by Skanska. Overall sustainability ambitions were high in terms of e.g. energy-efficiency, following LEED Gold Standard. The detailed development plan was accepted in 2007 and the Land and Environment Court gave its approval. Construction was put on hold due to economic recession and local critics argued that the floating houses would disturb and privatize the waterfront. In the upcoming election in 2010, local politicians chose to prioritize the land-based houses. In 2012 the decision to start construction of the floating houses was handed over to the board of KBAB, with the condition that the rent had to cover all costs from the start. This sent a political signal that public funds should not be spent on subsidizing attractive waterfront houses for a select few. This submission led to an administrative appeal but even with the verdict, construction continued, and the floating houses were finalized in 2013. KBAB showcases the houses to the national public housing association and hosts regular study-visits but otherwise refrains from further expansion, due to lack of appropriate locations, and the need to meet other pressing societal needs to remedy the local housing shortage. The local experiences are also accessible via the National Climate Adaptation Portal (klimatanpassningsportalen.se) (Fig. 1).

Second, the floating house of Villa Näckros in Kalmar was initiated in 2001, when Strindberg Architects AB and the construction company KG Bygg were approached by two sailing brothers who were knowledgeable about building in concrete under water, and whose ambition was to fulfil their dream of living on water. The three parties jointly developed a high-quality modern house on water:

It is about developing a new way of living that recognizes the special qualities of a life close to nature. With modern design we bring the surrounding into the house so that you feel the absolute closeness to water where you sit, dipping your toes from the lower balcony. All those small tender qualities. [Interview 2]
With explicit ambitions to test boundaries, keywords for the residence were sustainability, low maintenance, development of materials and building, care for the environment, energy-efficiency, and identity. The floating house was adapted to fit the location at Varvsholmen, where land-based houses were already planned. Gradually the initiators formed the company Modern Marine Homes in 2002. To communicate and gain support for their ambitions, a model in scale 1:5 was built and showcased to municipal politicians and officials. The land surveyor solved the Gordian knot of how to legally form property on water. The detailed development plan was approved in 2004, allowing for three floating houses. The first house was built in 2003 and was instantly nominated for the Swedish Building Industry’s Building of the Year Award. The residence received international coverage on television and in magazines, and led to numerous study visits, an interest enhanced by the photography of James Silverman. Modern Marine Homes put all their effort into design and technical development, followed in 2004, with the big hype around the house, by plans to expand:

We were contacted by people from New York, Manchester, London, Saudi Arabia, Helsinki, and last week the United Arab Emirates. They’ve all seen the photo. But we must be honest and say we have only built one house. We have been too small to upscale. [Interview 2]

In practice, upscaling was not considered an option. The first house was sold on the market in 2016 to fund the construction of the additional two houses. During that process, neighbours in the land-based houses at Varvsholmen raised critique against the further disruption of their water views. The final two floating houses were built in 2019 (Fig. 2).

Third, the private construction company Aquavilla saw an opportunity to increase revenues for their marina in Solna by facilitating living on water:

It is awesome if we can use our shorelines more actively. Luxury Lifestyle Report asked people all over the world where they want to live and 47% say waterfront. [Interview 3]

Contacts with Solna Municipality resulted in an agreement in 1997 to allow living on water at Pampas Marina. The first floating homes were houseboats. In 1999, the concept of Aquavilla was developed. A demonstration house was built for the Annual Boat Show in 2000. Later that year, the production of eight floating villas started. A new detailed development plan from 2002 allowed for an increase to a total of 40 floating boats or villas at Pampas Marina. The ambition, however, was to expand business across Sweden. This involved investing over SEK 100 million in a new construction site in Västervik, with 12 employees, and an intense activity to spread the concept:

We have a product that we can deliver to those who find floating houses exciting. We contact municipalities to identify interest and appropriate locations. One employee works partly on provision with the sole task of finding new locations. [Interview 3]

Aquavilla experienced challenges in expanding their business, due to shoreline protection legislation and uncertainties in how to progress with municipalities who initially found the idea interesting but seldom prioritized proceeding when challenging questions needed to be solved. So far, one detailed development plan has been produced in Västervik for a district of 24 floating houses. Aquavilla has also resumed the building of floating houses at Sindersviken in Nacka, a project riddled with bankruptcies since its start in 1999, but where 12 architecturally designed Sjövillas are currently being constructed. The concept of the Aquavilla has evolved with several varieties of floating houses.
The business was recently renamed the Aqua Floating Group, since its operation today includes floating restaurants, hotels, student apartments and recycling stations (Fig. 3).

Fourth, Imorgon Innovation is an innovation-oriented business that started in 2015. Their ambition is to use contemporary innovation and design for approaching societal challenges like reintegrating dead or disused urban areas such as former port precincts by converting them into something attractive for the city and its population. In facing the waterfront, the entrepreneurs explore alternatives to land-based living for different population segments, thus embracing diversity:

We don’t aim for luxury villas. We want to make the water accessible with floating houses for different types of people and see how the floating home can fit into the wider city. For example, how can we create attractive collective housing for students, a group of people rarely prioritized. [Interview 4]

The entrepreneur started in Sundsvall since it made sense to build relationships at home. Also, a mid-sized city was deemed easier to work with in terms of bureaucracy. The entrepreneurs wanted to design and build a prototype to see if the population could get accustomed to seeing the water as an opportunity for urban development. The municipality agreed to rent out a piece of the harbour area, where a floating collective house—built in 2016—is currently placed. It functioned as a showroom, illustrating the concept and serves a process of gradual learning:

We want reactions from the population on how to develop the concept. Getting acceptance is critical. With open-house events people can fully grasp what we want to do. We have also chosen to build on the local traditions of wooden houses, which fits and gives credibility to our work. [Interview 4]

Although the actual building on water is considered to work well, developing the concept into a full-scale urban district requires endurance and patience. While the design and development can be controlled, municipal planning processes cannot. The entrepreneurs have continued in Sundsvall with a local development plan for a maritime floating district of 40 floating homes at Rosenborgskajen, intended as an attractive urban element also for commerce and recreation. This is seen as an important stepping stone for further expansion. Imorgon Innovation have also contacted other municipalities where floating districts could be relevant (Fig. 4).

Fifth, Ocean Industries was a more recent entrepreneur, starting in 2015. A former boat-builder, furniture designer and artist interested in industrial design wanted to recycle former shipping containers to allow flexibility in floating design. Containers were cut apart, relinked and stacked, to create height in an industrial urban design format, facilitating floating houses for a varied housing segment:

If you have money, you can get your house easily, but we also need houses for students, youth and seniors. My opening line when meeting politicians is that we can make sure that centrally located apartments are built, at a reasonable cost, in a flexible location. [Interview 5]

The argument is that the houses can be easily moved, pending on housing needs. Despite this, establishing the concept in practice has been challenging:

Everyone likes the idea, but it is still difficult to accomplish. I thought it would take two months and that was over three years ago. You need an enormous amount
of patience, and you must adapt to changing conditions. You also need economic persistence. [Interview 5]

Located in Gothenburg, Ocean Industries submitted proposals for establishing their products at the quayside at Röda Sten and in the waterfront district of Frihamnen, one of the largest urban development projects in the city. Initially in 2016, the plan was to build between 700 and 900 temporary residencies at Kvilepiren and Lundbyhamnen for students, newly arrived refugees, and local businesses, to test how temporary housing could become an urban quality. The latter involved floating homes for 288 residents. Ålvstranden Development, the municipal development company responsible for the plans, however contracted three other private entrepreneurs to construct temporary land-based and potentially, in the future, floating housing. Ocean Industries proceeded by producing designs for a prototype unit of housing 40 residents and thereafter sought to secure a quayside location. A showroom house was constructed in 2018. However, the plans did not work out and Ocean Industries was liquidated in 2019.

Additional technical information and illustrations of the floating houses initiatives can be accessed or requested via the following weblinks: https://www.kbab.se/hyr-av-oss/vara-omraden/orrholmen/orrholmsgatan-sjogangen/, https://www.strindberg.se/en/living/villanackros, https://aquavilla.se/, https://imorgoninnovation.com/. As Ocean Industries was liquidated in 2019, their website is no longer available.

4.2 Analytical comparison of floating housing experiments

When analytically comparing these five stories, we identify both differences and similarities in terms of housing types, initiation, motives and strategies for upscaling (Table 1).

First, the study shows that floating housing experimentation is initiated by different types of actors, stretching from the public housing company in Sjögången, to individual private architect and building entrepreneurs in Villa Näckros, and, finally, to the private innovation entrepreneur Imorgon Innovation and the two private boat-builder entrepreneurs, Aquavilla and Ocean Industries. Apart from the public housing company, these

Fig. 1 Sjögången, Karlstad. © Sofie Storbjörk
are small-scale entrepreneurs, starting up their business with floating houses as either the only or—as with Imorgon Innovation—one of its main business operations. Compared with the larger construction companies, who have so far refrained from water-based developments, the entrepreneurs are thus small-scale actors who take the risks of innovation:

The larger actors like PEAB and Skanska will most likely try and catch up with us later on, but you have to have a special interest in floating houses and a determination to take on the role as innovator. [Interview 3. Similar 2, 4 & 5]
The limited interest in floating houses from the established housing market agrees well with observations in other national contexts (Penning-Rowsell, 2020). In the theoretical literature on urban climate experimentation there is similarly an emphasis on the role of regime outsiders or frontrunner entrepreneurs in initiating and carrying out experiments (Sengers et al., 2019) rather than the established market actors.

Second, there are also large variations in the motives expressed for these floating innovations, compared with what we had expected. In the international literature on floating houses, their climate profile and ability to manage sea-level rise is a key argument (de Graf, 2009, 2012; Lin et al., 2019; Moon, 2014; Penning-Rowsell, 2020). Seeing floating houses as a strategy to facilitate climate-proof waterfront housing is also reflected in Swedish media coverage. Contrary to this, however, climate change adaptation was only explicitly emphasized as a motive in the empirical data for Sjögången, the floating rental houses in Karlstad. There the explicit goal was to think proactively in terms of rising sea levels and to build on water to avoid flood-damaged waterfront buildings. The other interviewees only acknowledge the benefits of floating houses from a climate adaptation perspective in response to direct interview questions:

It is clearly an advantage, but we have chosen not to point it out. [Interview 3. Similar 2, 4 & 5]

According to the entrepreneurs, the climate adaptation angle of the floating houses is not a key concern among municipalities (Interviews 2, 4 and 5), which is supported by the interviewed municipal planners who do not specifically mention it as a motive (Interviews 6–8). While waterfront climate risks are in fact a real threat to many of the Swedish coastal municipalities—particularly those that are not protected by the ongoing land elevation in the north—floating houses are clearly not seen as a relevant adaptation response in the interviews. Rather, some of the entrepreneurs emphasize that the climate adaptation potential of floating houses is more relevant outside Sweden:

Fig. 4 Contain Sundsvall. © Sofie Storbjörk
Table 1 Starting year, initial housing type and actor, motives, year plan approved, year construction started, and strategies for upscaling in the five floating housing initiatives

| Initiation   | Sjögången | Villa Näckros | Aquavilla | Imorgon innovation | Ocean industries |
|--------------|-----------|---------------|-----------|--------------------|------------------|
| 2000         | 2001      | 1997          | 2015      | 2015               | 2015             |
| Initial Housing type | Singular, place-specific floating rental houses | Singular, place-specific floating private houses | Concept solutions for floating private houses | Concept solutions for varied forms of floating houses | Concept solutions for varied forms of low-cost rental floating houses |
| Initiating actor | Public housing company | Private architect and building entrepreneurs | Private boat builder entrepreneur | Private innovation entrepreneur | Private boat builder entrepreneur |
| Motives | Attractive rental houses, proactively meeting climate risks | Delicate design of a contemporary high-quality floating house | Facilitate living on water. Establish a market for floating houses | Societal challenges: bringing unused city precincts to life. Establish market solutions | Facilitate living on water. Establish a market for floating houses |
| Planning and construction | Detailed development plan 2007. Construction 2013 | Detailed development plan 2004. Construction 2003 and 2019 | Construction 2000. Extended detailed development plan 2002 | Construction of display home 2016. Ongoing detailed development planning | Construction of display home 2018 |
| Up-scaling | Limited. Showcase solution that others can replicate | Small-scale expansion: fulfilling the intentions of the detailed development plan | Replication, expansion and broadening to develop varied forms of floating structures | Expansion: Learning from showcase to district-level expansion | Intention to replicate and expand |
The potential is great, particularly abroad and in low-land countries. In Sweden floating houses are more a matter of ‘taking chances’ than a necessity. [Interview 2. Similar 4]

Considering the perspectives from the interviews, it is thus fair to conclude that the climate adaptation motive—the potential of floating houses to climate-proof waterfront cities—is with one exception currently invisible among the Swedish floating houses initiatives. As for mitigation, high ambitions with respect to energy efficiency are explicitly mentioned regarding Sjögången and Villa Näckros. For the others, the floating houses follow the same energy-efficiency requirements as land-based houses. Of the other motives found in international literature, the ideas of space-replacing lack of land or creating innovative touristic destinations (de Graf, 2009, 2012; Lin et al., 2019; Moon, 2014; Penning-Rosswell, 2020) do not feature at all in the Swedish context. Sweden is, by international comparison, sparsely populated, except for the expanding city centres. This means that in the Swedish context, planning on unclaimed urban sites can become an important motive among the entrepreneurs (Interviews 1–5). However, the main argument is not urban greening but rather extending coastal city centres, by turning unused city surfaces like abandoned harbours to attractive waterfront developments. Among the interviewed planners, these perspectives vary depending on geographical location. In Sundsvall, located in the northern parts of Sweden, the respondent sees no lack in availability of land-based surfaces for urban development (Interview 7). In Västervik, located in the south-east, the planner suggests that exploitation on water does mean an addition in exploitable surface “particularly in 20 years when we have used up our land” (Interview 8). Further, in addition to the motives expressed in the international literature, the interviews suggest that a key motive for floating houses in Sweden is rather the element of innovation and the ability to offer something unique and attractive, making the water accessible as alternative to traditional land-based living. This is a reoccurring motive amongst all entrepreneurs and all municipal planners. For Västervik, the floating houses is intended to strengthen local identity building:

The proposal fits our conscious strategy of turning into a waterfront city. Our interests merge. Floating houses are an exciting new contribution that triggers imagination. [Interview 8]

Among the motives we also encounter inherent contradictions in framing the floating initiatives as enabling living with nature while at the same time allowing residents all modern comforts of life. This means that the floating houses have both nature-based and modern urban qualities. Another contradiction is that of making the waterfronts more publicly accessible at the same time as they allow space for private housing. All three municipal planners claim that for them to be considered cutting-edge, supporting entrepreneurs and their willingness to innovate becomes an important feature (Interviews 6–8). For the entrepreneurs, the element of designing attractive modern floating homes, is also a reoccurring motive. To summarize, the empirical observations support the Swedish framing of floating houses as an example of urban experimentation and place-marketing rather than climate-proofing.

Third, the five initiatives differ in their characteristics and upscaling intentions. Sjögången and Villa Näckros can be described as place-specific initiatives, exploring opportunities of singular floating houses, thus innovation characterized as “willingness to pioneer” (van Doren et al., 2016:16) with prime emphasis on showing what can be done. While there was clearly an ambition for upscaling also in these initiatives, it did not come about due to limitations in the manouevrability of the entrepreneurs. The
public housing company did not have the necessary political mandate to attempt upscaling, due to the housing shortage crisis. The private entrepreneurs of Villa Näckros lacked the muscle and energy to upscale their business beyond the small-scale on-site expansion from one to three houses regulated in the detailed development plan, enlarging the geographical area of application (van Winden & van den Buuse, 2017). Contrary to this, the three latter entrepreneurs have sought to establish a market for floating houses as an alternative to land-based living, in line with the market-creation experiments identified by Kivimaa et al. (2017). Although they began by testing the innovation in a specific location, the explicit aim was to upscale by establishing concept solutions that would allow replication in other locations. Different forms of horizontal upscaling were sought, and no attempts to upscale vertically were found. For Imorgon Innovation an initial upscaling from singular house to floating district represents an expansion of the experiment as it “brings the pilot to scale” (van Winden & van den Buuse, 2017). Thereafter the idea is replication where possible, by modifying the concept to fit the needs of specific locations. Aquavilla is upscaling by expanding the design to different types of floating houses and by developing their business from Aquavilla to Aqua Floating Group, to capture the ongoing innovations of varied forms of floating structures. Further, they allow replication in different municipalities. For both, the ongoing development of floating districts in Sundsvall and Västervik becomes important steppingstones for product expansion and replication, as it illustrates possibilities to expand from single houses to floating districts. Ocean Industries is a story of an entrepreneur fighting for enacting an idea but not making it all the way.

Fourth, we find several reoccurring challenges along the way from initiation to enacting the experiments in practice. From the five stories we learn that initiating experimentation requires building and engaging necessary expertise, sharpening argumentation for the advantages of innovation as well as funding display/pilot houses to showcase outcomes. Interest in innovation and the carving out of a niche/profile that is well-fitted to municipalities, potential homeowners and citizens enables progress. To thereafter enact experiments requires a continuous and constructive dialogue between entrepreneurs and municipal officials. The study found that municipal planners have enabled floating housing experiments despite considerable complexity. Their initial interest and willingness to support innovation needs to be maintained despite the implementation challenges that arise, including finding appropriate location, settling judicial matters such as floating property formation and obtaining permits from the Land and Environment Court to ensure environmental consequences. These challenges correspond well with determinants identified in previous literature on urban experimentation (Evans et al., 2016; Sengers et al., 2016, 2019) and on floating housing in particular (de Graaf, 2009; Penning-Rowsell, 2020). In the Swedish context, the current lack of agreed-upon technological solutions and standards does not appear problematic for implementation as suggested in the previous studies on floating houses (de Graaf, 2009; Penning-Rowsell, 2020). Compared with the international literature, planners in the Swedish context emphasize that the floating solutions need to be designed in a way that benefits larger societal interests, thus avoiding “building for the rich” or “privatizing the water” (Interviews 1, 2 & 4). Newer entrepreneurs like Imorgon Innovation already have the flexibility to match different population segments as their niche, but also Aquavilla have broadened their concept to “better fit into society” (Interview 3). The longstanding tradition of the Swedish shoreline protection legislation explicitly requires such accessibility. It is also a critical aspect for the municipalities currently developing floating districts. The piers and floating constructions must be publicly accessible:
It is not enough that people are allowed to walk there. It has to be perceived like added value for the public rather than for the houseowners. Rosenborgskajen will have a lighthouse as landmark and there will be restaurants, commerce, sun decks, and possibly floating parks. [Interview 7. Similar 6, 8]

Municipal representatives are firm in their attempt to overcome the contradiction of accessibility vs. privatization of the waterfronts. To meet requirements of accessibility, the experience is that floating structures are best integrated in urban development from the start rather than serving as “add-on” components (Interviews 2, 4). This is something that becomes even more important when upscaling is considered.

The interviews illustrate the difference between showing that floating housing is possible and further developing the concept by expanding business beyond the singular experiment (van Doren et al., 2016; Naber et al., 2017; van Winden & van den Buuse, 2017). With the focus on innovation and willingness to pioneer in terms of technology and design, some of the initiatives, like Villa Näckros and Ocean Industries, proved to be too small to manage upscaling. For Sjögången this was not even an option. Those whose ambition is to upscale, such as Aquavilla and Imorgon Innovation, proactively engaged with municipality representatives to explore mutual possibilities. Such interactions were described as challenging, because the initial enthusiasm of the municipal planners tended to fade as critical questions start to surface. Also, the responses from the different County Administrative Boards, supervising local spatial planning, regarding the necessary permits for floating houses created uncertainties for upscaling.

Municipal planners receiving proposals from the private entrepreneurs raise several concerns regarding the potential of upscaling. They find it uncertain how well this innovation—floating housing—would function beyond the single application and be more widely replicated within the cities. It becomes a question of fit:

It is a matter of moving the Swedish people’s home on the water. It would need to blend in better with the rest of society, the cityscape and its larger operations. [Interview 8. Similar 6-7].

For floating houses to function on a larger scale, they would also need to be adapted to fit the various local contexts of implementation. Site-specific differences in terms of biogeophysical, social and political factors will have an influence on local outcomes, which also means that not every location would be appropriate for floating houses (Interviews 3–8). Currently, floating houses do not fit with the larger urban development plans, rather they feature as an innovative side project that offers something unique:

They are not linked to our wider urban development plans. It is more a project on the side where we support local innovation. It also fits with our willingness to support diversity in housing by way of attractive alternatives. [Interview 7. Similar 6]

This application implies that floating houses function more as an isolated event (Sengers et al., 2019) or even a curiosity (Bulkeley et al., 2015) than a replicable form of housing. An explanation for this, according to the municipal planners, is the lack of practical evidence regarding the large-scale potential of floating architecture. The ongoing projects of floating districts in Västervik and Sundsvall become important thresholds for gaining experience, thus serving as testbeds for practical applications (Interviews 6–8). Interviewees also raise doubts regarding the real market interest:

With the weather we have in Sweden, marine living becomes a limited market. Those living there are real enthusiasts. The houses are costly. [Interview 6]
This indicates that floating houses does not necessarily fit the population at large:

It is a very exposed way of living that might not suit everyone. It has to do with our folk soul. There are no hedges to hind behind, which limits the interest. [Interview 8]

The market responses and to what extent the houses are “appreciated, sought after, and considered attractive” will determine if any additional steps are taken, according to municipal planners (Interviews 6–8). Here, the response of the established housing market actors could have an important impact on enhancing future upscaling, if they see the market potential of floating housing (Interviews 2–5). An additional challenge here is however the small-scale nature of the districts compared with de facto municipal housing needs:

Floating houses are no real solution to our housing shortage. They are too small-scale. [Interview 7. Similar 8]

Upscaling would also risk reanimating conflicting interests, since a large-scale application would necessitate developments not only in abandoned port precincts but also in unexploited waterfront areas falling under the shoreline protection legislation. Preserving the Swedish shorelines is a longstanding national concern. This brings us to the final complication of establishing floating houses found in the data: the national context. In Sweden, floating houses is a fairly recent concept. This is emphasized by both entrepreneurs and municipal planners:

For us it’s a new phenomenon. In Europe, particularly the Netherlands, this has been a longstanding tradition. [Interview 5. Similar 3, 4, 6 & 7]

The older versions of living on water in Sweden, going back to the 1960s where some people lived on houseboats at Norr Mälarstrand in Stockholm, where a number of illegal night-clubs were also located, was considered a rather shady and doubtful business, quite the opposite of the current connotations of luxury and attractiveness (Interview 3). Here experiences differ greatly from the studies in the Netherlands (de Graaf, ). In a national context like the Swedish, lacking traditions for living on water, a process of normalization is required for expansion beyond the current singular experiments.

5 Concluding discussion

The Swedish case allows us to critically problematize the use of floating housing to climate-proof waterfront urban development. The experiences presented here challenge the expectations from policy (UN-Habitat, 2019) and previous research literature on floating housing that assumes their potential to contribute to enhanced climate-proofing (de Graf, 2009; de Graf, 2012; Moon, 2014; Lin et al., 2019; Penning-Rowsell, 2020). The Swedish initiatives are also at odds with several of the theoretical assumptions from the literature on urban climate experimentation.

Starting with the latter, the literature defines urban climate experimentation as “inclusive, practice-based and challenge-led” (Sengers et al., 2016) and purposive/strategic, geared towards mitigation/adaptation and delivered in the name of an urban community (Bulkeley et al., 2015). Except for Sjögången, orchestrated by a public housing company, the Swedish initiatives are neither inclusive nor driven in the name of an urban community. Also, compared with the situation in the Netherlands, there is no longstanding tradition of living on water, nor any national agenda or support mechanisms legitimizing such
initiatives (de Graaf, ). Rather, the contemporary initiatives of floating housing are the product of private small-scale entrepreneurs, often with limited economic muscle, seeking to establish living on water as innovation project and/or with an ambition to create a new housing market. Privatizing the innovation process limits the on-site integration and local ownership. It also raises criticism and opposition from citizens, for whom floating housing is already an odd component in the cityscape that—despite recent attempts to overcome the contradiction between accessibility and privatization—risks restricting public views of and access to the treasured waterfront. The Swedish tradition of shoreline accessibility runs deep in the public mindset. This means that the necessary link to the wider urban policy agendas (Bulkeley et al., 2015) remains weak. The more recent developments in constructing accessible floating districts, like those by Imorgon Innovation, aim to improve this, not by engaging in co-design (as suggested by Sengers et al., 2016) but by capturing local views and taking measures to increase public accessibility at the piers.

While the ongoing experimentation can clearly be defined as purposive/strategic (Bulkeley et al., 2015) or practice-based and challenge-led (Sengers et al., 2016), it is not so in terms of climate adaptation as a societal challenge. Therefore, the initiatives do not meet the requirements for urban climate experimentation, except for Sjögången in Karlstad and its principal aim to benefit climate robustness. Otherwise, the Swedish entrepreneurs innovate to fulfil dreams of providing unique living on water. For some the revitalization of unclaimed urban sites is also a key motive. This serves an urban development agenda supporting densification while also, in the case of Västervik, strengthening the local identity building as waterfront city or, for all three municipalities, their local innovation agenda. Such initiatives could still provide benefits for the ongoing climate adaptation if they transformed the current waterfront interactions to reduce their vulnerabilities (Dyckman et al., 2014; Granberg et al., 2016; Storbjörk & Uggla, 2015). However, the findings do not show any great promise in this respect since they today are little more than singular experimental endeavours with their main function to place-market innovations and illustrate that a modern, attractive and comfortable living on water is indeed possible.

The literature on floating housing suggests them to be a promising solution to the climate crisis. In Sweden, the expectations that floating housing holds the potential to enhance climate-proofing of waterfront urban development are not met by practice. Hitherto, floating architecture tends to feature more as scattered singular experiments motivated by a desire to innovate (van Doren et al., 2016) than as a coordinated future solution that would allow improved resilience. First, the initiatives are considered to be small-scale side projects for a limited market that do not match the Swedish housing traditions. Contrary to the Netherlands, there is no tradition of living on water to fall back on, nor any national agenda with policy instruments supporting their establishment (de Graaf, 2009, 2012; Huang-Lachmann & Lovett, 2016). Varied forms of upscaling (van Winden & van den Buuse, 2017) such as on-site expansion, turning display homes to district scale and developing concept-solutions for replication. However, their potential for upscaling is still highly uncertain and ridden with implementation challenges related to acute housing shortage, shoreline protection, privatization/accessibility, market interest and urban development fit. While upscaling is by no means unproblematic in the Netherlands (de Graaf, 2009, 2012), shoreline-protection and accessibility concern as well as poor urban development fit appears specific for Sweden. Here floating housing is stuck in an experimental mode of testing by taking the chances that appear, rather than being driven by strategy, relevance or necessity.

Second and more importantly, while the floating houses may themselves prove resilient to the consequences of rising sea levels, thus protecting their individual owners, they do not
automatically provide any additional urban coastal protection. Adaptive measures are still needed for the current land-based city with its vulnerable waterfront development patterns. This identified complexity suggests the limitation of floating housing to present any “real alternative” and to proactively shift current development pathways (Evans et al., 2016; Juul Madsen & Hansen, 2019; Sengers et al., 2016) for the vulnerable waterfront areas in a way that would contribute to enhanced urban climate-proofing. They simply do not trigger any broader transformations (Naber et al., 2017; van Winden & van den Buuse, 2017) in perspectives or practices that support the much-needed climate adaptation. Even with the ongoing floating experiments, larger transformational approaches (Kates et al., 2012) and innovations in urban waterfront design and development are needed in order to overcome dysfunctional path dependencies and to protect Swedish coastal communities from the consequences of climate change. Unfortunately, current municipal operations are unsuitable to meet this challenge due to opposing waterfront concerns and interests as well as a longstanding institutional separation between waterfront development planning and risk management/coastal protection. Integrated efforts and joint problem-solving would potentially facilitate a more transformative mindset and innovative practices where new waterfront interactions that help reduce vulnerability in a changing climate are explored. The conclusion is thus quite the opposite than that of abandoning urban climate experimentation. Rather, we argue for enhanced urban experimentation that is specifically geared towards responding proactively to the climate crisis, as the literature on urban climate experimentation cited above calls for. We believe, based on the conclusions in this paper, that such important experimentation cannot be left in the hands of small entrepreneurs as regime outsiders with varied agendas and motives. Rather, there is a need for public innovation programmes that specifically support cross-sectoral, future-oriented co-design endeavours where key public and private waterfront actors join forces for a more robust and reliable urban climate-proofing.

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Declarations

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