Analysis on short-lived and vacant houses in Japan toward a sound material cycle

健全な物質循環に向けた日本における住宅の短寿命と空き家問題に関する研究

Wendy WUYTS
ウェンディ・ウイッツ

Doctoral student of Environmental Studies
Graduate School of Environmental Studies, Nagoya University
名古屋大学大学院環境学研究科都市環境学専攻

2021 年 08 月

Supervised by
Hiroki Tanikawa, PhD

TABLE OF CONTENT

Analysis on short-lived and vacant houses in Japan toward a sound material cycle

健全な物質循環に向けた日本における住宅の短寿命と空き家問題に関する研究

SUMMARY

The world of today faces pressure on its resources and troubling levels of waste generation, with impacts on global resource security and survival of natural ecosystems among others. Cities represent particular hotspots of resource consumption and waste generation and the problems will increase in the following decades. Inspired by a circularity approach, this dissertation zooms in on the potential of the materials embodied in short-lived and vacant houses. By applying such an approach, I aim to illustrate with cases in Japan how material stock studies can contribute to circular area development planning and policy.

Chapter 2 discusses the practical and methodological challenges and limitations. This dissertation is based on secondary data from previous research, on empirical data from interviews and observations, collected in a few neighbourhoods in Honshu, the main island of Japan in the period of 2018-2019, and on empirical data from GIS calculations.

Chapter 3 (**based on Wuyts et al. 2019**) gives a synthesis of the reasons behind a high amount of short-lived and vacant houses in Japan. These problems can be partly explained through the history of the change of housing regimes since the Second World War. Statistical data about housing, connected with historical events, like introduction of laws, new technology, building materials and knowledge after the Second World War, mainly due to American influence, illustrate the different regimes: quantity-oriented, quality-oriented and then single-oriented. The problem is wicked, because many different stakeholders with different motivations are involved. A content analysis of recent media articles, complemented with interviews, provides a list of the stakeholders. Another objective was addressing the gap for circularity strategies for the inefficient material use implied by short-lived and vacant houses. The same content analysis and interviews resulted in a retrospective list of countermeasures that could be labeled as circular, but also critiques about these actions. Based on this learnings, this chapter provides a conceptual framework for strategies for these problems.

Chapter 4 **(based on Wuyts et al. (2020)** is addressing the objective of estimating the potential of obsolete housing stock. This chapter and objective focuses only upon vacant houses, because circularity strategies for vacant houses are about end-of-life solutions, while the wicked of short-lived require beginning-of-life or middle-of-life solutions. It introduces a tool to identify, map and manage vacant housing, applied to the case of Kitakyushu. The first step is a combination of an estimation model to estimate the space of vacant houses and a material stock calculation to separate the in-use stock from the obsolete stock (vacancies). In 2018, some neighbourhoods have a higher percentage of obsolete stock than others. This qualitative data helped to understand which end-of-life strategy to apply to which obsolete material stocks: which vacant houses could be reclaimed, because their quality answers current housing needs, and which houses should be deconstructed for urban mining, as they are slums or do not satisfy the cultural and family norms and needs

I conclude this dissertation with a general discussion of the main findings and my opinions in chapter 5. It discusses, for example, how representative this study is in material stock studies and circular area development and that the findings should not be seen as representative for the whole of Japan. The estimation model is compared with the results of a local survey of 2014-2015 of vacancies in different neighbourhoods. There are divergences between the results of the tool and the local survey for some neighbourhoods, which could mean that the estimation model is not 100% representative: a missing temporal aspect or personalised estimation models for lower level (of district) might be the reason. The quality of this obsolete stock cannot be derived from GIS data; therefore a complementary study of local history in a few neighbourhoods and history of economic structures and housing needs and norms in Kitakyushu and Japan was conducted. Bottom-up material stock studies retrieving data from GIS can provide information on the material availability, but these types of data do not show which materials are available for circular actions like urban mining or adaptive reuse. These results confirm that a material stock study is not enough to develop a material sound cycle strategy for obsolete stock. Findings from other studies are needed to complement the gaps in these methods.

Keywords: Circular economy, material stock studies, obsolescence, waste of (construction) materials, service life, Japan

Chapter 1: Introduction

1. Problem statement

1.1. General: impact of inefficient resource management

The world of today faces pressure on its resources and various problems and challenges, partly due to its pursuit of economic growth and the way people, organisations and policies use and manage resources. The current dominating economic models are often called linear economy, which take a so-called 'take-make-consume-waste' (Campbell-Johnston et al. 2019) or 'extract-produce-use-dump' approach (Korhonen, Honkasalo, and Seppälä 2018). This linear economy resulted in an increasing extraction and use of finite resources and waste generations over the last four decades (Schandl et al. 2018). The global ecological footprint, material consumption (Prendeville et al., 2018; Krausmann et al., 2009) and material stock (Krausmann et al. 2017) have grown several times over this period and can be expected to grow further in the coming years.

These trends and growth-led economic models have an impact on global resource security (Prendeville, Cherim, and Bocken 2018) and survival of natural ecosystems (Ghisellini, Cialani, and Ulgiati 2016) among others. Since a few decades, researchers have been estimating the impact of human activity and studying how different materials, such as metals or fossil fuels, are used in industrialised processes which provide products and services for humans (Tanikawa et al. 2015, Kennedy et al. 2007). The physical weight of human activities can be expressed in the buildings, the infrastructure like the roads and railways, vehicles like cars and trains, furniture and other sustainable materials that provide essential services to our society (Tanikawa et al. 2015). This requires a constant supply of material, but also produces an outflow of waste. The process of supply, storage and disposal is the metabolism of a society (Fisher-Kowalski, 1998). Urban or societal metabolism views a city or a society as a system of flows of materials and waste it needs to function (Fisher-Kowalski, 1998). On the one hand, it brings the city or the society forward as a major consumer of various raw materials and as a producer of waste streams (Fisher-Kowalski, 1998). On the other hand, the metabolism system is often linked to the idea of organizing systems more circular in order to make the city, the society and the economy more sustainable (Danneels, Juwet, and Bruggeman 2018).

Using material flow and stock analysis, industrial ecology measures and quantifies the temporary sinks of these materials or their flows (see (Paul H. Brunner and Rechberger 2016) for an extensive exploration of the basis). Other methodologies calculate footprints from the level of products to the level of the economy as a whole (Erkman 1997). Industrial ecology scholars and practitioners investigate the environmental impact with the intent to make industrial systems more like ecosystems, including resource-efficient, nonexistence of waste, and in harmony with other systems (Frosch and Gallopoulos 1989). However, Industrial Ecology does not provide the tools to look into these non-quantifiable factors. Therefore, an integration of political ecology, which also studies urban metabolism, could be a complementary field, because political ecology investigates the socio-political dimensions of the circulations, organisations and transformations of materials and other resources (Danneels, Juwet, and Bruggeman 2018). A subdiscipline of geography, political ecologists consider space as both an outcome and a shaping factor of these social and political dimensions (Sultana 2020). Although political ecology seems to address social, rather than environmental, sustainability issues, it brings a necessary political and justice component to environmental studies (Swyngedouw and Heynen 2003) which often appear apolitical and are blind for the unequal distribution to resources and the benefits, and the human impacts of industries (Curran and Hamilton 2017; Wolch, Byrne, and Newell 2014). Instead,

environmental problems, or what are perceived as environmental problems, are societal problems, because the aforementioned limits are challenged by society (Kenis and Lievens 2016), to the extent that scholars talk about the era of the Anthropocene (Lewis and Maslin 2015; Crutzen, n.d.). Urban metabolism studies are therefore about the roots, the impact, the quality and quantity consumption patterns within a territory or system, with predefined boundaries.
Various studies revealed how material and other resource consumption is growing in the past decades (e.g. Krausmann et al. 2017). However, there is a small positive trend in some countries where sustainability strategies are reversing the trend, as shown for example recently for four Danish cities (Lanau, Mao, and Liu 2021).

Cities are hotspots of these resource consumption problems. Around 80% of global energy consumption (Campbell-Johnston et al., 2019; Prendeville et al., 2018), 60-80% of greenhouse gas emission and 50% of global waste generation (Chávez et al. 2018; Hoballah, Peter, and l'environnement 2012) is situated in cities. Urban areas across the globe will grow, in particular in the developing world and lead to more impact (Cohen 2006). Moreover, these growth-led material flows are not inclusive, as the world's poorest countries do not benefit (Schaffartzik, Duro, and Krausmann 2019). Therefore, it is important to zoom in on urban development and planning in sustainable resource management issues.

1.2. More specific: the wasted materials in short-lived and vacant houses in Japan

The focus of this area is Japan with its short-lived and vacant houses. Many houses in Japan remain empty: more than 8 million out of 60.6 million homes in Japan were considered to be vacant (Japanese Housing Survey 2013). For several years now, this 'waste of space and material' has been causing headaches for national and local governments. What do we do with these millions of empty houses, their very large waste stream and the expected growth of these as a result of the shrinking population and the average short lifespan of a house?
Vacancies are often overlooked in material stock studies and got only recently attention in material stock studies. The only known studies are about the housing shrinkage in Germany (Deilmann, Effenberger, and Banse 2009), and the very recent published study about the material flow and greenhouse gas impact of vacancies in the American housing stock for 2020-2060 (Berrill and Hertwich 2021) It is important to know which material stocks could be recovered for secondary use: the so-called obsolete stock. More concrete, this objective can be broken down into the following sub-questions: How do we estimate the amount and location of obsolete material stock in order to monitor the impact? How can spatial qualitative data help to determine which circular economy strategy to use for a place-specific collection of obsolete stock? (Based on Wuyts et al. 2020a).
This study looks into the results of the application of a method to quantify and map vacant houses in selected neighbourhoods of a Japanese city in order to redefine one or more further problems, necessary adaptations and refinements and ideas for future research and policy. This dissertation explores how the 4D-GIS data of housing can support this research by getting visualisations where - and when - the vacant houses are situated. In order to differentiate the data between used and vacant houses within a city that served as a case study, this thesis also introduces - and discusses - a method which is developed and implemented in the Tanikawa laboratory in order to validate the qualitative findings.

A second problem is the high amount of short-lived houses in Japan. More than 50% of buildings do not become older than 40 years (Hiroki Tanikawa and Hashimoto 2009), and in city neighbourhoods some average lifetime of a house is estimated to be 34 (ibid.).
However, are short-lived houses, or a short average lifetime of houses an actual problem? In order to answer this, I will provide some definitions of lifetime. The term 'lifetime' can be understood in different ways. Physical lifetime refers to the life between construction and demolition, but does not

necessarily mean the building is in operation. Service time refers to the time the building is used. In material stock studies, long physical lifespan reduces "raw material consumption (B. Müller 2006) and slows down demolition waste flows" (Guo et al. 2020). However, long lifespans are responsible for lock-ins of lifestyles and associated environmental and social impacts, because these buildings are often built in compliance with lower energy and other sustainability norms (Baynes and Müller, 2016, Wuyts et al. 2019). In this way, renewal also has other environmental and social benefits. A significant part of the housing stock in Europe for instance does not comply with energy norms, indoor air quality norms (e.g. (Adan et al. 2007) and other standards necessary for a transition to a low-carbon society. New housing developments can comply with modern building standards to ensure safety and eco-efficiency. However, in the case of Japan and its short lived houses, they must find solutions for their high material outflow resulting from the demolition of obsolete houses. Developing countries, which do not have as much material stock, or a fast urban metabolism as Japan, namely developing and emerging economies, are less concerned with questions of low-budget housing reclamation and restoration. such places could, theoretically, bypass the phase of low-value material accumulation and simply install long-lasting, high-quality easily-adaptable structures. Built material characterised by short lifespan, with Japan (Hiroki Tanikawa and Hashimoto 2009; Wuyts et al. 2019) and China (Guo et al. 2020; Cai et al. 2015; Jingjing Wang, Zhang, and Wang 2018), have to deal with a more intense outflow of demolition waste in a shorter time than economies with lower speed. On the other hand, some parameters can balance the impact out on a longer scale. For instance, material intensity of German apartments/houses is three times that of Japan; but German buildings 'have the reputation' to live three times as long (Schiller et al. 2019). In addition, the higher dynamic nature of material stock in such economies allows for climate change adaptation and mitigation and other strategies needed for urgent societal problems. Which lifespan or speed is right or wrong, are questions that cannot be answered easily, or maybe not at all. However, it can be noted that reducing the amount of short-lived houses can also reduce material consumption and increase material security.

2. State-of-art

A literature scope of previous research aimed to understand what was already known about the challenge of vacant houses and short-lived houses in Japan. The following four main themes were identified:

1. Studies (mostly from economic and environmental studies) that map and quantify the problem of short-lived and vacant housing
2. Studies (mostly from social studies) about the policy discourse on shrinkage in Japan
3. Studies (mostly from architecture) proposing and/or testing beginning-of-life solutions.
4. Studies (mostly from engineering) proposing evidence for end-of-life solutions

Although some studies gave a historical sensitive analysis of the high percentage of especially vacant housing in Japan (e.g. (Zhang 2020; T. Kubo and Yui 2020), these studies did not exist in the initial phase of this thesis. Chapter 5 includes a comparison of findings. Additionally, no English papers were found which offered a historical sensitive analysis to both short-lived and vacant houses. There were papers which offered evidence on one or more factors in the same field (e.g. architecture perspective; policy perspective, behavioural perspective…), but there were no papers with a systems thinking approach that synthesized the evidence and findings.

2.1. Vacant houses

2.1.1. Vacant houses, symptoms of shrinking cities

Vacant houses are visible symptoms of shrinking cities. In this paragraph, the discourse of shrinking cities will be explored. Several definitions exist about shrinkage. A shrinking city is understood as "an urban area that has experienced population loss, economic downturn, and social problems as symptoms of a structural crisis" (Cunningham-Sabot et al., 2013, p. 14) or as "a densely populated urban area with a minimum population of 10,000 residents that has faced population losses in large parts for more than two years and is undergoing economic transformations with some symptoms of a structural crisis' (Wiechmann, 2007).

In scientific literature in the field of economic geography, two main theories exist which explain the reasons behind shrinking cities.

The first theory, rooting in economic geography, sees shrinkage as a part of the 'natural' urban life cycle (cfr. Berg et al 1982). The departure point is that population change in urban core, suburban ring and Functional Urban Region (FUR) or the periphery and that "a common pattern of successive stages of urban development" Cities are often called shrinking cities, when there is migration out the cities which leads to more vacant houses in the urban core, but often there could be a population growth in the ring or the periphery. The phase of urbanization ends when congestion triggers suburbanisation and when it's more comfortable to live in less congested areas. This leads to extension of the territory of a city. When suburban areas are extended too much, this might also lead to decline of population in these areas, which will trigger policy makers to implement measures. Revival policies could contribute to population growth (especially immigration growth) in urban cores and other areas. This theory explains that it's natural that the distribution of vacancies gets 'reshuffled over time'.

The second main explanation comes from political economy, or the field which studies the influence of institutions or politics on consumption and production patterns. Vacant houses could also be seen as the result of certain policies. In the first theory, policy is mentioned as an instrument to break a phase of stagnation or shrinking, but political economy considers the policy or institutional frameworks at the base of changes in the consumption (and production) of houses and other capital. Since the end of the

20th century, economic geography knew an "institutional turn" by acknowledging social-cultural factors and the role of institutions in constructing them, but also observing how new regimes (from fordist capitalist accumulation regime after World War II to post-fordist capitalist accumulations) lead to older institutional frameworks getting obsolete and making place for new institutional frameworks (Martin 2000). This evolution of patterns of distribution of economic activity is studied in evolutionary economic geography, which "centers on historical processes that have produced these patterns" (Frenken and Boschma 2007). One big theory which can be placed in the subfield of evolutionary economic geography are the theories of long economic waves. The first theory of the long economic waves are the Kondratieff cycles. This theory studies how "economies progress through a long period of accumulation of material wealth in which productive forces move the economy to a newer and higher level of development" (Bernard et al 2013) over periods of 50 years. One reason behind these developments were technology innovations (Bernard et al 2013). A Kondratieff cycle exists of a growth and a stagnation phase. "Technological change is not, as in mainstream economic models, some exogenous disembodied proces, but an inherently socio-cultural activity dependent on the institutional setting within which it takes" (Martin 2000). Economic geographers are especially interested in why certain institutions support or hesitate about the implementation of new innovations in their territory. One basic question is "*to what extent and in what ways are the processes of geographically uneven capitalist economic development shaped and mediated by the institutional structures in and through which those processes take place?*" (Martin 2000). This requires to make differentiations of growth and stagnation on a spatial level and study the history of change for each different place. This can be done by studying the dominant institutions in that place, as they are the carriers of history (North 1990), but also the cultural processes and their role in the construction of social provisioning systems, like cultural and family norms and lifestyles and their role in "determining the path-dependent nature of institutional development (Martin 2000). To apply on the Kondratieff cycles, they are built on the logic of capitalism; growth happens through innovations with long term potentials, while stagnation happens when there is overproduction or the introduction of a new innovation. New growth phases imply changes in sectoral structures of the economy or changes in the spatial structure of the economy.

These "new incremental, major and radical 'hard' technologies require new incremental, major and radical institutional arrangements, habits, routines, values and conventions. At the paradigmatic level, major new technologies require new forms of business organization, labour relations, government policy, education systems and so on and, in turn, new institutional arrangements enhance productivity and facilitate new technologies" (Hayter 2004). Lead regions or lead nations "successfully match paradigmatic technological and institutional innovation to create models which force other nations to adapt" (Hayter 2004).

Linking with readings about obsolescence of architecture (Abramson 2016), a hypothesis emerging from combining economic geography and studies of obsolescence is that these lead regions do not invest in adaptive structures (like adaptive built environment), which generates a negative lock-in of path dependency effect, which becomes visible when a new innovation is changing the economy. Path dependency is "the probability of a particular event to occur is affected by the events that have taken place in the past" (Frenken and Boschma 2007), while a negative lock-in is "the inability to incorporate radical innovations" (Frenken and Boschma 2007). "The principle of path dependency states that '*history matters*' in that initial and existing conditions shape present and future socio-economic behaviour" (Hayter 2004). These regions where institutions are locked-in and path dependent get in a situation of decline and often become shrinking cities until the policy makers design and implement the right revival programmes.

This theory aims to explain how growth and shrinkage are 'symptoms' of the relationships between jobs, people and cities, with cities encompassing the built environment and social provisioning structures. A simple way of explaining this idea of economic geography is the following: growing

employment can be translated as growing demand and can lead to population growth, because new jobs attract people in their reproductive age. Growing population also facilitates a growing demand for consumption, which in turn can create more jobs. This relationship is a positive feedback system or lock-in. The problem is when a city gets in a negative feedback system or a negative lock-in, after for example the economy structure changes. Less jobs leads to less labor force, to less consumption, which becomes a vicious circle.
According to scholars like David Harvey, inspired by the work of Marx, capitalism leads to these changes. Capitalists must discover, design and implement "new means of production in general and natural resources in particular" if they want to expand their capital. The politics of capitalism can be described by his theory of the three circuits of capital accumulation (González et al. 2020): "The basis of the circuit of accumulation is constituted by the primary circuit of capital: the production of surplus value and its interrelation with the consumption of merchandize allowing capitalists to obtain surplus value, while consumption allows for the reproduction of the workforce. As a result of their labour, workers also accumulate savings. The financial system captures the capitalists' surpluses and savings, and then transforms these into new financial products which allow a reinvestment in different capital circuits (primary, secondary and/or tertiary)" (González et al. 2020). The financial flows dictating the built environment, like homes, (and the production of durable goods) could be considered as the secondary circuit (Harvey 1985).

2.1.2. Vacant housing, symptoms of speculation

A high percentage of vacancy does not automatically mean shrinkage. A high percentage could be a visible symptom of shrinkage, but shrinkage can also refer to a reduction of percentage of people and/or local available jobs. This could also be linked with the phenomenon of expulsions (Sassen 2014). Big corporations buy and speculate with buildings in hedge cities (like Tokyo, Vancouver and London) resulting in empty and underutilized buildings and spaces. This underutilisation also offers circularity potentials, but needs other specific policies and involves other stakeholders, because circularity activities offer low value compared with the value created by speculation (Joanna Williams 2019a). Japan knows of hedge cities where there is speculation. However, this dissertation's scope narrows down to shrinking cities and regions, where there is a clear trend of decay of jobs and (young) habitants, and the observation of structural vacant housing.

2.1.3. Defining and categorising Vacant housing

Different definitions and categorisations exist upon housing. Since 2009, Flemish government defines vacancy as following: "*A dwelling shall be considered vacant if it is not used for a period of at least twelve consecutive months in accordance with its residential function*" ("Leegstaande Woningen Opsporen, Registreren En Aanpakken" n.d.). Japanese law does not know a category based on the period of vacancy or not in us.

In Japan, they define vacant housing as "*buildings and associated structured materials that are in a state of not in use for any purpose such as residence as well as the property itself, which includes any other objects in it such as the land, or trees standing in the property*." (Japanese Ministry of Internal Affairs, 2021, English translation). They make a special mention of 'specific vacant houses', which are defined "*as the buildings that have got any risk of collapse, or may cause significant safety issues or become critically harmful to the public health if it were left for a while, remarkably spoil the scenery due to the lack of proper maintenance, or be considered to be inappropriate to be left to maintain the daily life environment of the surrounding area*." (Japanese Ministry of Internal Affairs, 2021, English

translation) Japanese national law categorizes vacancy in terms of harm to the area, hygienically, environmentally, and safety. These ideas are also present in local laws. In Kitakyushu city, for example, the observed vacant houses are ranked according to risk for the environment (f.e. (Kitakyushu City 2016a; 2016b).

In Flanders, one typology is based upon opportunities for the housing market:

1. "Frictional vacancy: frictional vacancy is necessary for the proper functioning of the real estate sector market. In other words, it is the supply that allows movement in the market. In addition, this means that only a limited percentage of the property may be vacant" (Sterkens et al, 2013 cited in (Vanderstraeten, Vastmans, and Ryckewaert 2016))
2. "Structural vacancy: structural vacancy is the (long-term) vacancy of real estate which, because of various reasons, is not or cannot be (re)filled in. The minimum vacancy period already varies between one and two years, depending on the source of the definition" (Sterkens et al 2013, cited in Vanderstraeten et al. 2016)
3. "Periodic vacancy: periodic vacancy of real estate, is vacancy during fixed periods of the year, week, month or year. A striking example of housing where this form of vacancy occurs are holiday homes or second stays" (Sterkens et al 2013, cited in Vanderstraeten et al. 2016)
4. "Temporary vacancy: temporary vacancy of a property that is awaiting a 'certain' vacancy.It concerns, for example, premises that are under renovation or premises that have been leased but are still undergoing renovation. In other words, it is almost certain that the vacancy will only continue for a short time" (Sterkens et al 2013, cited in Vanderstraeten et al. 2016)
5. "Disguised vacancy: disguised vacancy is a vacancy that is hidden behind an administrative building. One example is the improper use of the 'second residence' statute. In principle, this is a specific form of structural vacancy that is difficult to detect and/or prove" (Sterkens et al 2013, cited in Vanderstraeten et al. 2016).

In literature, one standard of frictional vacancy is 3% (Vanderstraeten et al. 2016). According to Gu and Asami (2016 as cited in Kubo and Mashati 2020), the optimal vacancy rate or frictional vacancy in Tokyo is even 1,96%. In Japan, many places have surpassed this threshold. Additionally, challenges lie in detecting disguised vacancy and separating temporary/periodic vacancy of the structural vacancy. However, these ideas are not present in Japanese national and local policies.

2.1.4. Other research about the case of Japan

In the second half of 2019 and 2020, a lot of new research has been published about shrinkage in Japan (see table 3). Döringer and her colleagues (2020) made a comparison of literature of vacancies in Japan and Europe for the period 2005 to (30 September) 2017 and remarked that international literature has not addressed the phenomenon of Japan not so much compared with western cases and that research about vacancies in Japan tends to focus on the quantification and mapping of the vacant houses. For example, Ishikawa and his colleagues estimated the current distribution and projects of vacant housing on a regional scale (Ishikawa et al. 2016), but also on a lower spatial scale (Ishikawa et al. 2017). However, within the boundaries of a city, their method to grasp the spatial distribution was less adequate. In these studies, vacant homes are estimated using housing start statistics and the population and number of households from the census. Yamashita and Morimoto (2015) estimated the spatial distribution in a Japanese city by using data on property tax and water usage records of individual houses. However, one challenge is the sensitivity of such data; not all governments will give this data to academics. Regarding spatial and-or temporal patterns, (Peng et al. 2019) investigated the determinants of city shrinkage in terms of population using a semiparametric geographically weighted regression. Döringer et al.

remarked there was a gap in literature about Japanese vacancies about the roots. Table 2 is a summary of the causes of urban shrinkage for the regions in Europe and Japan they identified in their sample of 100 papers. This table explains how Japanese vacancy in urban areas in literature is mostly explained on the basis of the result of suburbanisation and demographic changes within cities. Noteworthy, Döringer et al (2019) focused on urban shrinkage; suburbanisation affects only abandonment of houses in urban cores. Not much research in Japan focused on deindustralisation as a cause. This dissertation includes a case to address this underrepresented cause in literature about Japan.

Table 1: Literature scope results about the cases of shrinkage in Europe and Japan

Causes	Post-socialist Europe (%)	Mediterranean Europe (%)	Western Europe (%)	Japan (%)	*n*	% of Total
Deindustrialisation	32	31	46	2	54	28
Suburbanisation	15	14	15	32	38	19
Ageing	5	3	9	34	27	14
Out-migration	14	21	22	0	26	13
Low birth rate	5	7	2	32	23	12
Post-socialist transformation	27	0	0	0	16	8
Disaster/climate change	0	17	0	0	5	3
Other	2	7	6	0	6	3
Total	100	100	100	100	195	100

93 cases (without North American cases) out of 70 articles; multiple references possible ($n=195$).

Source: Döringer et al (2020)

However, some months later, the academic book "'The rise in vacant housing in post-growth Japan: housing market, urban policy, and revitalizing aging cities', edited by Tomoko Kubo and Yoshimichi Yui (2020), addressed this gap. In his review, Bruce Judd (2020) explains well how this book gives an overview of the roots behind the problem, as well the reasons behind the uneven distribution and explanation of case studies and local or community-based measures to revitalise abandoned houses (Judd 2020), like the renovation of 'kominka' (traditional warehouses) in Kyoto (Nishiyama 2020). Table 2 gives an overview of 21 significant academic works published from 2010 until (31 October) 2020.

Table 2: Overview of identified academic literature about shrinkage of cities and vacant houses in Japan, since 2010

Year	Research	Category Objectives	Difference with this study
2020	(Usui and Perez 2020)	Spatial distribution; is it random or not?	This study starts already with the idea that there is a pattern behind the spatiality of vacant houses
	(Jian Wang, Yang, and Qian 2020)	relationship between industrial diversity and population growth	This paper did a correlation test (at national level) between economic structure (or rather the diversity) and population, but no link with housing or the historical evolution of the economic structure as this study did

	(Wuyts et al. 2020)	Explanation of problem and the spatial distribution, spatial distribution, effect, measures	This paper contributes with an economic geography study of a case like Kitakyushu linked with industrial ecology methods
	(Döringer et al. 2020)	Literature scope	They did meta analysis of cases in Europe and Japan. This study got similar findings, so this publication helps to validate some observations of missing links and gaps about Japanese vacancy
	(T. Kubo and Yui 2020) (+ book chapters by several authors, e.g. Nishiyama 2020)	Explanations of the problem and the spatial distribution; spatial distribution, discussion of ongoing measures	This book explores many ideas which I explored, but there is no exploration of circular economy/material stock type society potentials or economic geography
	(Baba et al. 2020)	Spatial distribution estimation through machine learning	This study did not engage in automatic detection through machine learning
	(Akiyama et al. 2020)	Spatial distribution estimation with big data	This study did not use big data and did not engage in machine learning.
2019	(Kawai, Suzuki, and Shimizu 2019)	Spatial distribution, explanation	This paper is more about office buildings, which this study focused on housing
	(Peng et al. 2019)	Spatial distribution	National study, while the spatial estimation model in this study is at city level
	(Wuyts et al. 2019)	Explanation, effects, measures	This paper takes more social glasses.
	(Xu and Zhou 2019)	Housing policy	"High intensity of low-rent public housing provision is associated with high housing vacancy rates in Japanese cities" (Xu and Zhou 2019). This was identified as a cause, but not explored in depth in this study.
2018	(Matsumoto, Yamamoto, and Ohya 2018)	Measure	This paper addressed a measure, but not in function of material stock type society
2017	(Hattori, Kaido, and Matsuyuki 2017)	Policy around population change and vacancies	This paper gives an overview of the discourse about vacancies and helped to understand when vacancy got considered as a 'problem'
	(Masahiro Ishikawa et al. 2017)	Spatial distribution	This paper explains an estimation method, but does not provide insights for policy.
2016	(Sakamoto and Yokohari 2016)	Spatial distribution	This paper explains the link between proximity to a core train station and vacancy, but also the historical period;

	(M. Ishikawa et al. 2016)	Spatial distribution	This paper explains an estimation method, but does not provide insights for policy.
	(Minami 2016)	Measure	This paper addressed some circular economy initiatives, but did not frame it like this study
	(Murayama 2016)	Measure	This paper looks into land use control, but this study did not engage in this.
	(Wirth et al. 2016)	Explanation	This paper helped to understand the context
2015	(Yamashita and Morimoto 2015)	Spatial distribution, explanation	This paper explains an estimation method, but does not provide insights for policy.
2014	(Woo and Son 2014)	Measure	This paper addressed bottom up initiatives.
2011	(Shimizu and Sato 2011)	Explanation	This paper looks more into demographics as a cause.
	(Morimoto 2011)	Effect	This paper explains the problems (costs) it causes to local governments.
	(Tango, Yokomatsu, and Ishikura 2011)	Measure	This paper helped to understand some non-technical factors

Although recently research is done upon the mapping and quantification of the uneven distribution of vacant houses in Japan, and the reasons behind, the questions that remain to be answered are how we can work with these realities of vacancy and short lived houses to move toward a material stock type or a circular society in Japan: which strategies should local governments use, and which decision criteria can help us. Although Kubo and Yui (2020) provided a platform to authors to discuss several measures in several chapters, none of them have engaged in ideas from industrial ecology about material stock type or circular society. Also Döringer and her colleagues (2020) identified some measures in Japan in their analysis of case studies, of which demolition is the most discussed. Demolition is not one of the measures that contribute to slowing down the urban metabolism. Less discussed measures are land-use control, urban housing renewals, bottom-up initiatives and transport management, which have potentials for slowing down housing metabolism. However, none of this research places it in the context of urban metabolism, material stock management and circularity.

Table 3: Literature review results about the measures against urban shrinkage in European regions and Japan

Responses	Post-socialist Europe (%)	Mediterranean Europe (%)	Western Europe (%)	Japan (%)	*n*	% of Total
Urban/housing renewal	19	42	26	13	31	23
Demolition/downsizing housing	17	8	8	42	23	17
Economic diversification/recovery	21	25	15	0	21	15
Cultural regeneration/tourism	9	0	13	0	11	8
Bottom-up initiatives	6	17	2	13	9	7
Innovation/entrepreneurship	9	0	6	0	7	5
Environmental improvement	2	0	9	0	6	4
Active ageing	2	8	6	0	5	4
Land-use control	0	0	0	21	5	4
Foreign direct investment	9	0	0	0	4	3
Transportation system management	0	0	0	13	3	2
Educational reorganization	2	0	4	0	3	2
Social inclusion	2	0	2	0	2	1
Other	2	0	9	0	6	4
Total	100	100	100	100	136	100

93 cases (without North American cases) out of 70 articles; multiple references possible ($n = 136$).

Source: Döringer et al (2020)

2.2. Short lived houses and short average building life time

This wicked problem is more profound and urgent in Japan than elsewhere. These patterns of using houses for a short time and then abandoning them for new ones, are not happening everywhere. Not many international academic papers have been published about the causes and solutions for the short service time of houses in Japan; the synthesis is presented in chapter 3.

2.2.1. A short lived house as underutilized potential

Lanau and her colleagues noted how building life span "is a key parameter for [modelling] stock accumulation in the [topdown] approach, [but also] a key factor in accurately predicting future flows of demolition waste" (Lanau et al. 2019). Fellow industrial Ecologists have produced empirical quantitative data about building lifetime patterns and changes for building material stocks (e.g. Tanikawa and Hashimoto 2009, Muller 2006, Cao et al. 2019, Miatto et al. 2019). Table 1 gives a non-exhaustive list of average building life times for different nations that I found in industrial ecology papers.

Table 1: Estimated or assumed average (residential) building lifespans[1] per country
Source: literature study by the author

Literature source	Country	City	Data collection method[2]	Analysed cohorte (building year)	Building type	Average lifespan (in years)

[1] In order to elucidate the idea of average building lifespan, this manuscript follows the definition by (Hiroki Tanikawa and Hashimoto 2009) of the physical lifetime of a building, i.e. the amount of years between the year of construction and the year of demolition of 50% of the buildings in a cohort. The collection of the data necessary to build such an indicator is a time-intensive exercise, where maps of different time periods are digitized in a method called 4D-GIS (H. Tanikawa, Fishman, and Okuoka 2015). The result is a physical output indicator that describes the building lifespan of an area.

[2] Data collection refers to the method of primary data collection.

Tanikawa and Hashimoto 2009	Japan	Wakayama City centre	4D-GIS	1 cohorte: Prior 1947- to 2004	Residential houses	34
Tanikawa and Hashimoto 2009	Japan	National	Other data source (statistical)	/	All buildings	40
Tanikawa and Hashimoto 2009	UK	8 km2 urban area of Salford in Manchester	4D-GIS	1 cohorte: 1830-2004	high-density residential building	96
Tanikawa and Hashimoto 2009	UK	8 km2 urban area of Salford in Manchester	4D-GIS	1 cohorte: 1830-2004	Middle/Low-density residential building	102
Tanikawa and Hashimoto 2009	UK	National	Other data source (statistical)	/	All buildings	128
Cai et al 2015	China	National	Other data source?	/	All buildings	23
Cao et al., 2019	China	National	4D-GIS	1950-1989	All buildings	Under 50
Cao et al., 2019	China	National	4D-GIS	1990- ...	All buildings	Under 50
(Guo et al. 2020)	China	Tiexi, Shenyang	4D-GIS	Priori 1911	Residential buildings	56
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1911-1932	Residential buildings	30
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1933-1947	Residential buildings	55
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1948-1968	Residential buildings	36
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1969-1978	Residential buildings	19
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1979-1986	Residential buildings	19
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1987-1997	Residential buildings	8
Guo et al 2020	China	Tiexi, Shenyang	4D-GIS	1998-2002	Residential buildings	82
(Aktas and Bilec 2012)	USA	70.000 residences in USA as sample (American Housing Survey (AHS) microdata responses)	Statistical analysis (survey)	1 cohorte: Prior 1900-2009	Single family residential housing	61 21–105 years with 90% confidence.
(Ianchenko, Simonen, and Barnes 2020)	USA	AHS microdata	Statistical analysis	1970-2013	residential housing	102-130

(Mollaei, Ibrahim, and Habib 2021)	Canada	Waterloo and Kitchener	Assumption[3] ('norm')	Early 1900s until 2018	Single family houses	70
(Miatto et al. 2019)	Italy	Padua	4D-GIS	1902-1953	Small residential buildings	188
Miatto et al. 2019	Italy	Padua	4D-GIS	1954-1968	Small residential buildings	1416
Miatto et al 2019	Italy	Padua	4D-GIS	1969-1980	Small residential buildings	3040
Miatto et al. 2019	Italy	Padua	4D-GIS	1981 and after	Small residential buildings	40
(B. Müller 2006)	Netherlands	/	Data from older study	/	dwellings	100
(Rincón, Pérez, and Cabeza 2013)	Spain	National	Statistical	2001	Dwellings	80

It shows how the average lifespan of the Japanese housing stock is short compared to houses in Europe and the United States (Table 1). Short-lived housing is a symptom of fast metabolism; regarding buildings, one important key parameter of the speed of urban metabolism would be the physical building lifespan (Lanau et al. 2019). Slowing down urban metabolism is important because this will decrease the environmental impacts (Lanau et al. 2019). However, not many studies have looked into the classification of building obsolescence as a way to identify strategies to increase the service life (Pourebrahimi, Rahman, and Ana 2020).

2.3. **Quality of Stock: In-use stock and obsolete stock of materials**

To increase the resource efficiency of these material stocks, it is important to use these material stocks as efficiently as possible (Winterstetter et al. 2016), which requires -for monitoring and understanding - a classification. It is not only important to look at the quantity of the physical presence of stock, but also at the quality of the efficient use of this stock.

Winterstetter and her colleagues outlined "an operative procedure for the classification of different kinds of anthropogenic resources under UNFC-2009, which has been encouraged at the sixth and seventh session of the UNECE expert group on resource classification" (Winterstetter et al. 2016). They made a difference between geogenic resources (i.e. resources coming directly from the natural world and have evolved over a long period of time) and anthropogenic resources (i.e. resources which have undergone a human influence and are only created recently on a geological scale). The latter is divided into three classes of deposits, depending from their (urban) mining potential:

- In-use stocks, i.e. stocks which are in use
- Obsolete stocks, i.e. stocks which are not in use anymore
- Waste flows, i.e. flows of material outside society (Winterstetter et al. 2016).

To our current knowledge, not much research is done about methods that divide between in-use stocks and obsolete stocks for especially residential housing or that explain why a house is in-use or obsolete. This study contributes to this gap by looking into obsolete housing stock: not only in the quantification, but also in the reasons behind. Therefore, we forge the grounds of material flow and stock studies with housing consumer science. As Wuyts et al. 2019 noted, "the underutilisation of a house, or the quality

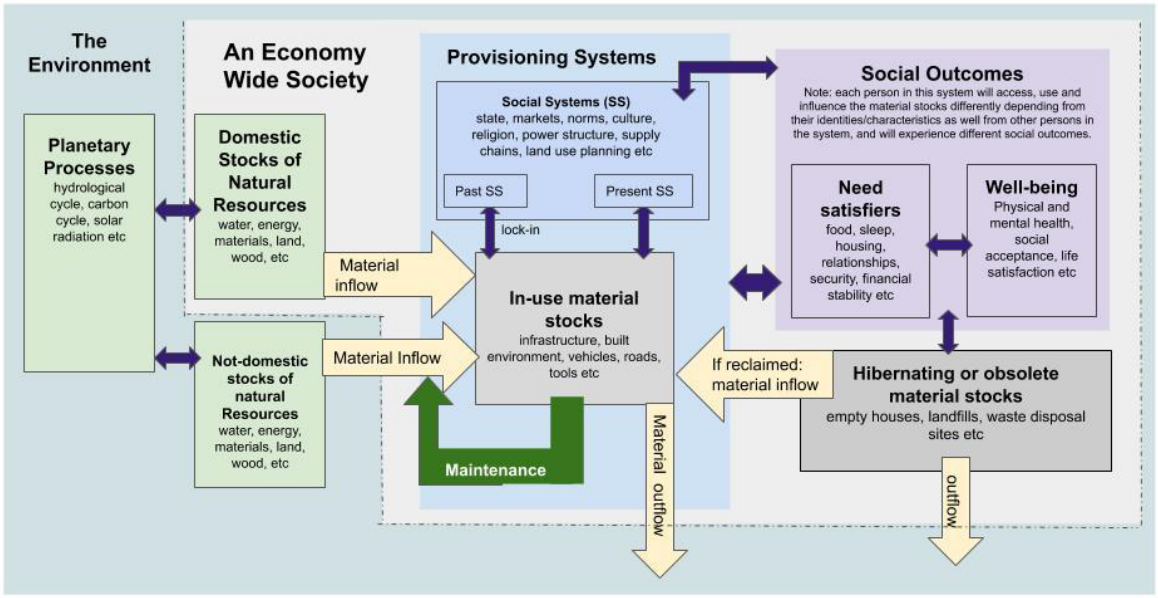
[3] Assumption refers to the fact that often the study departed from expected lifespans as recorded in building standard codes.

of material stock use, is not only a result of technical factors, but also the result of social factors, and more specific consumer/user behaviour" (Wuyts et al. 2019): the decisions of the families who "consumed" the service of housing, and the potential families who could consume/use this space or house. This knowledge of consumer behaviour can give the tools to separate the wheat from the chaff.

Figure 1 explains the importance of material and flow stock in sustainability studies. This figure is based on readings of the work by Raworth (2017), O'Neill and his colleagues (2018) and material stock and flow studies in general. Raworth proposed a safe and just space framework in her book "Doughnut Economics" (Raworth 2017a), which combines the concept of planetary boundaries with the complementary concept of human's basic needs. O'Neill and his colleagues (2018) use her ideas and of other feminist economics for their project about calculating the resource use with meting basic needs. The examine how provisioning systems, a term familiar in feminist studies, meditate the relationships between biophysical resource use and social outcomes (Fanning, O'Neill, and Büchs 2020). They define provisioning systems as physical and social systems: *"the former include networks of physical infrastructure, technologies and their efficiencies, while the latter encompass government institutions, communities and markets"* (O'Neill et al. 2018). In Figure 1, the physical provisioning system are replaced by the concept of in-use material stocks (e.g. infrastructure, built environment, tools), in compliance with the terminology of the Japanese government In-use materials stocks are the existing material embodiments that provide the current society or economy services which we need to satisfy our needs. As some of these material embodiments, like housing, are mostly private properties, a short lifespan means also a quick turnover and a high frequency of investments in the purchase of new materials, which is a high economic cost and has an impact on the wellbeing of citizens .
Other provisioning systems are social systems (e.g. markets, norms, religion, power structures), which can even have an influence on our everyday lives even if they do not exist anymore. A famous example is the Jim Crow laws, enforced in the southern USA until 1965, which racial segregation measures still have a locked-in impact on the discrimination of black people. These provisioning systems help humans to satisfy their needs and contribute to their everyday wellbeing, the so-called social outcomes.

When in-use stocks lose their service, but are not deconstructed; they end as hibernating or obsolete material stocks, which are material embodiments that do not serve the humans anymore, and could even have a negative impact on the social outcomes. For instance, empty houses could have a negative impact on the social fabric of neighbourhoods, are more keen to leakages of hazardous substances in the environment etc. Hence, reducing hibernating or obsolete stocks and/or extending the life of in-use material stocks as long as possible is not only a strategy of sustainable material management, but is also leveraged to other sustainable development goals, like social outcomes. Two forces that influence the speed or metabolism are repair and maintenance (positively) or innovation and improvement of technology, science that could change the norms and standards of living (mostly negatively; as they make current practices or material embodiments obsolete). Often these forces are not studied in material flow and stock studies, because the model works as a black box; the forces within the economy itself stay invisible.

Figure 1: An economic model to look at material stocks, other provisioning systems and social outcomes



Design by author

Models encouraging sustainable material management, like circular economy, advocate also for the investment of maintenance strategies to extend the lifespan of material embodiments (Morseletto 2020). This implies a labor pool with maintenance skills such as making and repairing. Especially as many material supplies are infinite, the pressure on the environment but also the risk of not having the materials to support our needs and well-being, it is important to reduce the extraction of new materials. As Carr and Gibson (2016) noted in their study of maintenance skills, *"t*he ability to work materials; and to make, repair or repurpose physical things, are vital skills for a future where such resources become increasingly limited". However, maintenance in the housing sector can be tricky if the value does not increase with the practice. In the case of Japan, investing in the maintenance and upgrading of a house would result in a long-term loss of capital because the value of a house quickly depreciates, reinforcing a vicious circle of poor investments and low quality housing (see Wuyts et al. 2019). Table 4 sums up the advantages and disadvantages of material stocks that have shorter or longer building 'lifespans" and displays the contradictions in extending or shortening average lifespans of residential buildings. One advantage of shorter lifespan is the ability to transfer the skills of rebuilding from one generation to the next, as a way to care for the next generation.

Table 4. Comparing advantages and disadvantages of shorter or longer average building lifespan

Lifespan	Advantages (+)	Disadvantages (-)
Shorter	● skills of rebuilding passed from one generation to the next ● new houses comply with new building standards ● building components and materials can be 'harvested' for other purpose ● The effect of job creation (in construction sector)	● embodied energy (and GHG) is much higher ● loss of wealth or economic costs for citizens/owners (normally, investment cost is higher than maintenance cost) ● more non-renewable material extraction in a same period
Longer	● capital investment (which can be inherited by next generation)	● not easy to adapt to new technologies or new lifestyles ● higher operational energy use ● safety aspects, especially if a house is of low quality

To conclude, this strategy of extending or ending lifespans could lead to a circular economy or a material stock type society, but there are trade offers which have to be considered, like safety or job creation.

3. Research objectives and questions

This dissertation aims to zoom in on short-lived and vacant houses in Japan as a symptom of wasted materials in a (local) economy. By doing so, this study wants to contribute to the literature on the underutilized potential of materials in these lost and obsolete material stocks and to the literature or circular area development. Currently, the first body of literature focuses mostly on the quantification and location of lifetimes and houses, while the second body of literature overlooks the potential of vacancies or extending lifetime of premature obsolete houses to achieve sound material cycles. Based on my critique on these bodies of literature, I formulate the following four research questions:

1. Why are short-lived and vacant houses a problem for sound material cycles?
2. Why is there a high percentage of short-lived and vacant houses in Japan?
3. What is the estimated 'potential' in obsolete housing stock in light of sound material cycles?
4. What are circular actions to cope with short-lived and vacant houses?

Both symptoms (short lifetime and vacancy) are 'waste' of materials over a long period, because the resources are not used optimally to service society. Houses are built with capital which require a lot of investment of resources (natural capital) and other capital (Meadows 1998). Houses should serve society and several generations as long as possible (Okamoto 2006), or at least when the invested resources are renewed and could replace the older investments. In addition, if houses can serve people for a longer time than in previous times and/or in other countries, a short lifespan signals a sustainability problem. As Meadows (1998) noted,

> *"sustainability on the level of built capital means investing at least as fast as capital depreciates. Across levels it means keeping the throughput needs of built capital appropriate to the sustainable yields and absorptive capacities of natural capital and keeping labor and management needs appropriate to the sustainable use of human capital" (Meadows 1998).*

This required understanding the reasons behind the current state and looking at existing studies about the material flow and stock analysis (MFSA) of houses, in particular in Japan.

The first question will be answered in subchapter 1.4, where I introduce a conceptual approach to the problem: namy the sound material cycle or circular approach[4]. In order to address the two last questions, I need a territorial approach that allows me to move away from seeing short-lived and vacant houses as a problem, but rather as an opportunity for that specific place. A territorial approach is not new, especially in contexts of buildings, which are rooted in a place and cannot move away easily. However, the combination with circularity is a rather new conceptual approach. Additionally, an approach to 'consider wastescapes as opportunities' is not new. (Amenta and Van Timmeren 2018) looked into the revalorisation of wastescapes in peri urban areas in Europe, to which obsolete buildings are a category. But they did not zoom in on the quantification of these potentials of vacant houses.

The second question is already answered in various publications, however mostly in Japanese, and often from one perspective. I aim to synthesize the findings, check the sources by triangulating the sources, and complement them with primary data from my own research in Japan. Following smaller questions

[4] In Japan, the circular economy is not so present in the discourse of sustainable material management, compared with the European Union. More used terms are sound material cycles. However, as I am from Europe and also engage with European concepts and evidence, where circularity discourse is more profound, I use these terms interchangeably. In chapter 1.6. I will describe the context of Japan, introduce some discourse development around the conceptual approaches that I am engaging with, and explain the similarities and differences between European and Japanese discourse.

were asked: “What were the values and attitudes of Japanese people and the market conditions behind the short use of buildings in the 20th century? What are the technical factors at the base of the short building lifespan? Is this phenomenon more closely linked to technical or non-technical factors? Who are the stakeholders involved and what are their motivations?” (Wuyts et al. 2019). I am interested in outlining the context (in both 1.6 and Chapter 3), because a territorial approach begins with the belief that you must first know the context: what are the assets, what are the needs? Why does something, like vacant houses or short-lived houses, appear in such high amounts?

Lastly, there are two assumptions in this dissertation. Firstly, this study approaches these problems also as wicked problems, which are challenges with the following characteristics:

- “There is no definitive formulation of a wicked problem. The framing of a wicked problem can always be contested.
- Solutions to wicked problems are not true-or-false, but better or worse from a given point of view.
- Every attempt to intervene alters the problematic situation in significant ways.
- Wicked problems do not have an enumerable set of potential solutions.
- Every wicked problem can be considered to be a symptom of another problem.” (Vandenbroeck 2012).

One way to cope with wicked problems is the soft systems methodology (ibid.). Therefore, this study takes a systems approach to understand the roots of these wicked problems in order to explore and propose innovative ideas. Systems thinking provides a comprehensive lens to analyze consumption and production patterns by deciphering the way that a system’s essential parts, in this case housing, are interrelated across different domains (f.e. culture, technology…) and disciplines (e.g. industrial ecology, political ecology) (Acaroglu 2017). In chapter 2, this methodology and approach will also be explained further.

The second assumption departed as a hypothesis: material stock studies need to be transcended with findings from other methods, to deliver socially robust and practical ideas for the next steps in circular area development.

4. The Sound material cycles and circularity approach

Resources are needed to achieve the ultimate goals of sustainable development (Meadows 1998). In the past decades, sustainable development studies, like environmental engineering and industrial ecology, provided different tools and methods to assess and evaluate the best production and consumption choices. Industrial ecology is also at the base of one of the emerging concepts of circularity, which challenges the current linear economic model (Ghisellini, Cialani, and Ulgiati 2016). A switch from the linear model of resource consumption to more sustainable and efficient resource utilisation (Kirchherr, Reike, and Hekkert 2017; Ghisellini, Cialani, and Ulgiati 2016) is now spearheaded by governments in Europe and China, organizations and other actors as a new way forward (Geissdoerfer et al. 2017; Rodriguez-Anton et al. 2019), Kirchherr et al. 2017). The circular approach to the management of resources in cities could significantly reduce the consumption of finite resources globally, while also addressing the issues such as waste production, greenhouse gas emissions, resource security, under-utilisation of resources, and the degradation of urban ecosystem services (Joanna Williams 2019a). Noteworthy, the evidence of the impacts of this concept are not still clear, as there are still debates about the contesting discourse of circularity, which leads to different designs (Calisto Friant, Vermeulen, and Salomone 2020) and therefore different impacts. Circular economy has not (yet) a fixed definition (Kirchherr et al. 2017). In Europe, the most widely used definition is provided by the European Commission (EC), which defines the circular economy as “an economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised” (EC 2015). This dissertation follows the more recent definition by den Hollander and his colleagues, because it integrates the concept of lifespans. "In a CE, the economic and environmental value of materials is preserved for as long as possible by keeping them in the economic system, either by lengthening the life of the products formed from them or by looping them back in the system to be reused" (den Hollander et al. 2017, as cited in Wuyts et al. 2019). Moreover, in other countries, the same strategies and programs are often labeled under a name. In Japan, for example, the Basic Act for Establishing a Sound Material-Cycle Society was launched by the Ministry of Environment of the government in 2000, which is often considered as a similar concept as the circular economy in European and Chinese discourse (S. Hashimoto et al. 2006). Individual laws have been launched, like the Law for Promotion of Effective Utilization of Resources and the Construction Material Recycling Act (Japanese Ministry of Environment, 2000), which resonate with principles that are advocated by frameworks used by academics and researchers in Europe.

Businesses and researchers have explored the (mostly deterritorialized) circularity approach to economic development, with the approach and the principles of the EllenMacArthur Foundation giving cues. The research on circular economy has exponentially grown since 2015 (Reike, Vermeulen, and Witjes 2018), with a focus on sectors like construction or textile, or on materials like plastics.
Policy-makers and governments across the world have also started to embrace the concept of circularity – from local and regional to national and international levels (Fratini, Georg, and Jørgensen 2019; Prendeville, Cherim, and Bocken 2018) - and it seems these paradigms will stay here for a while, given the adoption of the recent circular economy action plan (CEAP), as one of the building blocks of Green Deal for sustainable growth, by the European Commision in March 2021 (European Commision 2021).
Since recently, planners of cities and regions design and apply a circularity approach to urban planning (Joanna Williams 2019a; Paiho et al. 2020), which takes its cues from the circular economy. They identify different strategies and pathways for this transition, mostly focused on European cities (Joanna Williams 2019a; Campbell-Johnston et al. 2019).

One of the challenges is to understand what a circularity approach means on a local level. Some planners investigate the urban economic development, focusing on the industries and businesses within the city boundaries, but the critic by spatial scholars (e.g. (Julie Marin and De Meulder 2018a; Jo Williams 2021) is that this deterriorized approach neglects the wickedness and complexities of urban systems; they are more than businesses, but embedded in a system of other systems, like infrastructure, markets, regulations etc. These streams of researchers argue that locations and geography will play a more crucial role, because there is a shift in policy from global flows and stocks to regional and local flows of resources. This trend for a more territorial approach to circularity poses an increasing challenge for spatial researchers, from analysing (what, where, when), monitoring (performance) and presenting frameworks to enable decision making and policy-making.

4.1. A territorial approach

The first known examples of circular area development are industrial symbiosis networks, although they are initially not labeled as circular economy, are the eco-efficient industry parks (EIP) in China or the Kalundborg symbiosis in Denmark as the most known examples. Their aim "to make use of the spatial proximity of industrial activities to respond to environmental concerns" (Mirata, 2005). Therefore they "work by catalysing inter-organisational collaboration among local economic actors to harvest environmental improvement potentials present at the inter-organisational interfaces" (Mirata, 2005). Mirata (2005) defined Industrial Symbiosis networks as "a collection of long-term, symbiotic relationships between and among regional activities involving physical exchanges or materials and energy carriers as well as the exchange of knowledge, human or technical resources, concurrently providing environmental and competitive benefits" (Mirata, 2005). Industrial Symbiosis is more than 'transforming trash into cash', but about sharing logistics, warehousing, sharing knowledge, material cascades, thermal cascades (Lowe 1997).

In recent years, circular area development seems to have become more than an industrial symbiosis project. Stakeholders, like Metabolic in the Netherlands, called for the integration of systems thinking. It is not enough to create 'matches' (industrial symbiosis) between economic stakeholders, or to invest in efficiency of performance of buildings (decarbonisation), but also to zoom out to the broader picture and find opportunities to also reduce environmental impact and seize opportunities for society. For example, they call for urban development to also take into account livability (e.g. the distance to work, other services of society). That is why they also started to answer calls of urban development. Metabolic developed a vision, road map and action plan to transition Buiksloterham, a 100 hectare post-industrial site in Amsterdam-North, to a fully circular neighborhood (Metabolic 2021).

Not only stakeholders, from bottom-up, start to integrate circularity in spatial development. Cities contain a considerable potential for circularity and resource recovery, because there are many unexploited reserves of materials and energy aggregated within city boundaries (Williams 2019). In addition, there is also the spatial proximity of resources, actors and technologies or agglomeration effect in urban contexts (Tapia et al. 2021; Fratini, Georg, and Jørgensen 2019), which can lead to closing resource loops (Prendeville, Cherim, and Bocken 2018), sharing and optimization of resources (Williams 2019). Kennedy and his colleagues have looked into urban metabolism at city level (Kennedy, Cuddihy, and Engel-Yan 2007), but his concept is not holistic and combined enough to be considered as a circular city conceptual framework.
Paiho et al. identified there is a gap in defining circular city and proposed the following definition:

> "Circular city is defined as '[a] city [that] is based on closing, slowing and narrowing the resource loops as far as possible after the potential for conservation, efficiency improvements, resource sharing, servitisation, and virtualisation has been exhausted, with remaining needs for fresh material and energy being covered as far as possible based on local production using renewable natural resources" (Paiho et al. 2020)

More local governments in cities like Leiden, London, and Leuven start to define circularity goals and strategies, but pathways are missing. Different cities are also engaging in documenting best practices of circular economy within their territory and design circular economy strategies, like Amsterdam and London. Often they start with pilot projects in neighbourhoods, like Buiksloterham in Amsterdam[5], but holistic circular area development is still in an embryonal phase Additionally, only recently more academics start to look into circular area development on the level of cities (e.g. (Prendeville, Cherim, and Bocken 2018; Julie Marin and De Meulder 2018b; Fratini, Georg, and Jørgensen 2019; Joanna Williams 2019a; Kębłowski, Lambert, and Bassens 2020; Paiho et al. 2020)).

In political economy and geography, it is discussed how a circular city is a social, economic, and political construction and a more just appropriate perspective would focus more on the social groups which live and work within the boundaries of a city (Kębłowski et al. 2020), rather than on the innovations. In the field of political ecology, this implies place-based study of processes, and more specifically the power relations and socio-environmental conditions that shape which social groups gain and lose (Swyngedouw and Kaika 2000). Joanna Williams (2019) presented a framework for circular cities; her seven circular actions in a city resonate with the aforementioned definition by Paiho et al. (2020): Looping, Regeneration, Adaptation, Optimisation, Sharing, Localisation and Substitution (Williams 2019). However, as this study has the ambition to integrate a social justice component, and look into the roots of symptoms, these models are missing an entrance point.
The circular area development part of this thesis is mostly inspired by the spatial driver framework by Marin & De Meulder (2018), because it integrates tools and principles of industrial and political ecology. They are inspired by territorial ecology thinking by Sabine Barles, which calls to step away from deterritorialized approaches to resource management. Their ideas will be elaborated upon later.

4.1.1. The social dimension in a territorial approach

The literature on circular economy focuses mostly upon technical and economic aspects, but research on the social (justice) component of circular economy is rather under examined (Kirchherr, Reike, and Hekkert, n.d.; Schulz, Hjaltadóttir, and Hild 2019). A social component can refer to social capital needed for the circular economy (transition). A social component is more than human resources and creating job opportunities; it can include the social justice component. A social justice component refers to the principles of participation, access to resources, security and safety.

"Some research studies the impact on communities active in the informal circular economy; mostly informal waste recyclers in the Global South, (e.g. *carteros* in Buenos Aires (Gutberlet et al. 2017)) and emerging countries (e.g. e-waste recycling in China (Tong et al. 2018) and to the authors' current knowledge, only(Kębłowski, Lambert, and Bassens 2020) started to look into the informal circular economy in the Global North. CE marketing strategies of governments and other stakeholders mostly emphasize industrial and official CE practices and processes, rendering informal practices and processes invisible(Kębłowski, Lambert, and Bassens 2020). In Brussels, for instance, CE communication and policy focus mostly upon the practices of white, highly educated entrepreneurs,

[5] https://www.metabolic.nl/projects/circular-buiksloterham/

while informal CE activities, like the second hand market of cars by a predominantly African migration community, are often 'forgotten'(Kębłowski, Lambert, and Bassens 2020). Additionally, citizens who do not have the favoured lifestyles (e.g. spending money on eco-efficient technologies) are downgraded in transition politics to 'consumers'(Kębłowski, Lambert, and Bassens 2020; Kenis, Bono, and Mathijs 2016). Besides, academics criticize that many circular services and products are not designed from a user perspective, and are often made for a certain niche market of citizens who have a certain financial security(Camacho-Otero, Boks, and Pettersen 2018)" (Wuyts and Marin, under review[6]).

Not many academic fields that engage with circular economy, like industrial ecology and supply chain management studies, integrate the social performance of circular economy activities, because of its complexity and the lack of standardized approaches and frameworks (Walker et al. 2021).

Social circular economy could be interpreted in different ways. Some actors see it as a combination of social and circular economy. Regarding circular economy, there is already contested discourse (Friant et al. 2020). In each context, social economy can also be imagined differently. In Belgium, social economy refers to activities which are for people with vulnerable positions, mostly mental and physical disabilities. Social economy's purpose is to create and protect jobs for people who would not be able to find a job as people without a disability. In Belgium, there are now actors who combine social and circular economy (e.g. HERwin) and recently financial funds and programs from the government that stimulate cooperations between industries and the social economy.

This dissertation defines social circular economy differently: the social justice component is also integrated in the creation of the framework, and especially safety and health aspects and reflections upon how some choices might often reproduce the inequalities they tried to combat in the first place, because they do not address the roots of the problem, but only the symptom.

4.1.2. Territorial ecology, instead of industrial ecology?

> **"Territory**, in **ecology**, any area defended by an organism or a group of similar organisms for such purposes as mating, nesting, roosting, or feeding" (Britannica, 2020).
>
> A territory is "the historical outcome of the processes in the long-term evolution of the human settlement and the environment, and nature and culture" (Magnaghi 2005).

A territory could be a city, but it could also be a watershed. In urban metabolism studies, often the system boundaries are the city boundaries. In economy-wide national MFAs, the boundaries are put between the national economy and the rest of the world. However, there are also studies that look into metabolic relationships between cities and hinterland (e.g. (Bahers, Tanguy, and Pincetl 2020; Krausmann 2013). All these studies acknowledge the aspect of space. However, some studies neglect the processes in space or within the boundaries. MFA methods treat the studied space as a blackbox (Iossifova, Doll, and Gasparatos 2017), with the result that it is difficult for policy makers and other stakeholders to understand which interventions would have an impact on the speed or the quality of the metabolism or the quantity, quality and timing of the outflows. Political ecology opens this box and public debates about the processes inside the 'box' or in a given area, but it stays away from design thinking processes and does not engage with the future.

---

[6] Under review with Local Environment, already accepted by the guest editors. The co-author, Julie Marin, is a postdoc researcher from KU Leuven, specialised in circular cities. The paper focuses on the circular economy in Flanders.

Hence, a territorial approach calls to take into account the historical knowledge (practices, resources, feasible linkages) of a territory, in the assessment of a current state, before imagining and designing a future for this place.

For example, Sabine Barles combined principles and tools of industrial ecology, local history and the history of technological innovations to quantity the exchanges of waters and waste between Paris (city) and the Seine (river) and to embed the evolution of these patterns in the aegis of urban strategies (S. Barles 2007). She highlighted the impact of the change of hygiene norms about and the valuation of for example excreta since 1790. The degradation of the river was not linear; some centuries ago the river's ecosystem was less degraded than before the implementation of environmental management systems in Paris and France. Sabine Barles' work illustrates that the dominating tools and methods in industrial ecology do not take into account the impact of changing worldviews and norms (which are difficult to quantify) in a territory on the perception of material and therefore its metabolism, because they might be embedded in a certain worldview.

However, the territorial aspects of a circular economy still remain unexplored (Bahers and Durand 2017). Barles pointed out the need for investigating " the relational logic of geographical norms and scales as factors for adequate management of resources" (Sabine Barles 2009). Barles' research influenced the work of Marin and De Meulder, who proposed as one of the first scholars a framework to understand the multiplicity of pathways in circular area development.

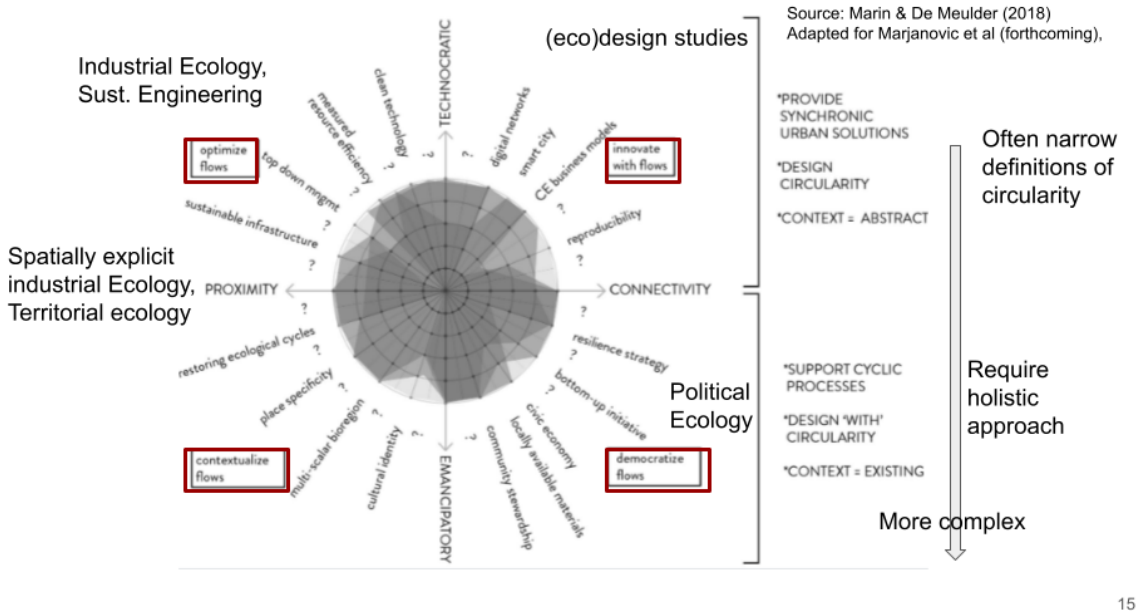
4.1.3. A framework for spatiality drivers of circular designs

Marin & De Meulder differentiated between four sort of imaginations of circular economy in a city, based on urban landscape theories (Figure 2) and conclude "with an agenda for multi-perspective and multi-dimensional circular city design, which is anchored in place specific and multi-scalar transition relations" (Marin & De Meulder 2018). According to this compass, there are four views in circularity strategies:

1. Optimize flows, i.e. taking care that the costs equal the benefits
2. Innovate with flows, i.e. investing in technology, mostly the newest innovations and from Industry 4.0. (digital industry)
3. Contextualize flows, i.e. understanding the interactions with other ecosystems of higher, lower levels and neighbouring zones
4. Democratize flows, i.e. taking care that everyone can benefit from the material stocks and the provisioning systems and the associated social benefits

A compass is not a map and does not tell what to do, but what to consider in the identification and design of circular economy strategies, and to have an eye for processes and priority zones. Concepts which can be identified in policy and practice and academic work can be classified according to these flows on the base of previous typologies and dichotomies. Marin & De Meulder call to consider all flows in a new design of circularity in a space; so not only focus on optimizing flows through for example top management decisions and infrastructure efficiency and/or innovating by installing for example smart city programs, but also in democratizing flows, by for example investing in universal social welfare programs and small-scale projects. In addition, these strategies still have an anthropocentric view, so it's important to view the context and other ecosystems in which the priority zones are embedded and how they influence each other.

Figure 2. A compass to design circular landscapes and cities



Source: Marin & De Meulder (2018), adapted by the author

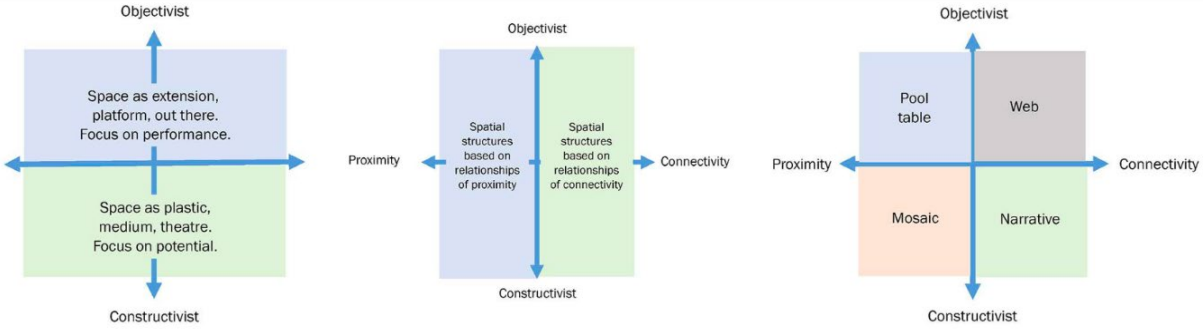
These four imaginations were based on their turn by Vandenbroeck (2017), which organised

> "*urban metabolism spatial practices according to their dominant sustainability framings, bringing clarity in how different disciplines have diverging approaches to urban metabolism questions. The framework articulates that a metabolism driven governance and design practice can result in very different futures, depending on this practice's conception of space. According to Vandenbroeck, a fundamental difference in urban metabolism spatial practices lies in an objectivist versus a constructivist worldview (...). For Vandenbroeck, the objectivist worldview focuses on performance and efficiency, and it intervenes in space 'from the outside', considering people as objects of control, human resources, or rational utility maximizers. Contrarily, the constructivist worldview focuses on potential, acting from within the intervention space with situational materials and resources, such as people (...) Another dichotomy that Vandenbroeck reveals in urban metabolism spatial practice is spatial structures that are based on relationships of proximity versus spatial structures that are based on relationships of connectivity*" (Marin & De Meulder 2018).

These two dichotomies combined lead to four typologies of metabolism approaches (figure 3):

1. **Pool table metabolism**: investing in engineering and management resulting in efficient resource flows leading to environmental and economic gains
2. **Web metabolism**: investing in the optimal use of the local assets to increase 'convenience' and safety as well gain environmental and economic advantages.
3. **Mosaic metabolism**: rethinks the "*historical link between city and hinterland*" (Marin & De Meulder 2018) to regenerate ecological balances and to strengthen cultural identity
4. **Narrative metabolism**: the most abstract approach, which invests in creating and maintaining the conditions of a sufficient living together, focuses on the creation of conditions for an always precarious way of living together (Marin & De Meulder 2018).

Figure 3. The combination of two dichotomies about spatiality in metabolism (a and b) into an organisation of four metabolism typologies (c)



Source: Marin & De Meulder 2018

Each typology of metabolism approaches envelops also a certain metabolic agenda that prioritizes specific circularity drivers (Marin & De Meulder 2018):

1. A **technocratic agenda** improving flows to an optimal level and using industrial ecology principles and tools, mostly linked with the pool table metabolism, but not taking contextual factors into account
2. A **business-driven agenda**, focusing on digital economy, flows and innovations
3. A **holistic agenda**, which contextualises flows and is connected with mosaic metabolism approach
4. An **activist agenda**, which aims to democratize flows and has a lot of attention for social and environmental justice (Marin & De Meulder, 2018):

The main observed strategies in Flanders exist mostly upon repurposing brown fields so green fields do not have to be exploited, and avoiding biodiversity loss; mobility re-organisation and the preservation of cultural heritage (VVSG, 2020). This reveals a business driven agenda.

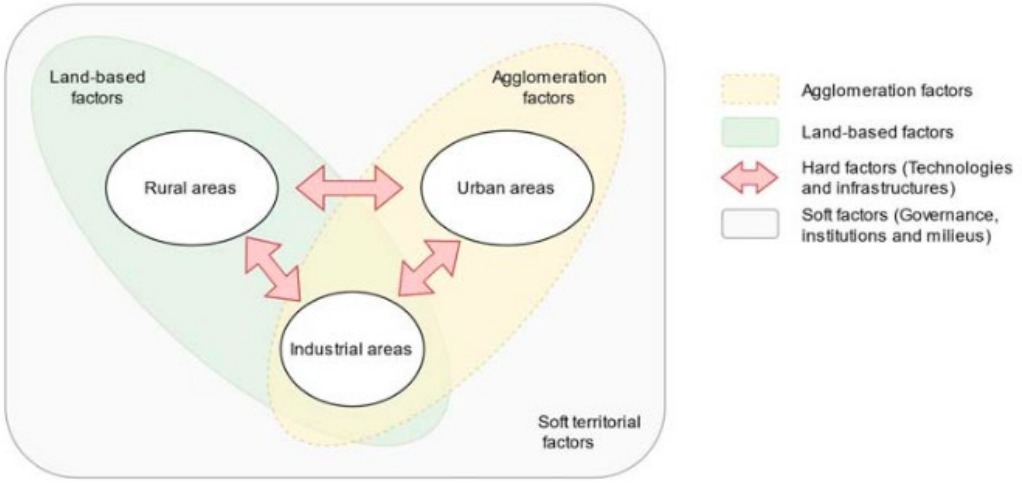
4.1.5. Factors in a territorial approach

Tapia and his colleagues did a literature study which aimed to "explore the role that territorial factors play in shaping circular economic transformations at lower spatial scales, as potential drivers of economic competitiveness and resilience" (Tapia et al. 2021). They considered six categories:

1. "**Land-based factors** emphasize the significance of physical endowment to satisfy the growing demand of secondary and biotic materials in a circular economy;
2. **Agglomeration factors** are important determinants for a circular economy, as these provide circular businesses with the necessary access to resources, knowledge and collaboration, as well as viable markets; some of these functions are enabled by
3. **Hard territorial factors**, in particular by accessibility and connectivity infrastructures
4. (Hard territorial factors, in particular) access to state-of-the-art technologies;
5. **Softer territorial factors**, including knowledge-related factors
6. (Softer territorial factors), (including) governance and institutional arrangements, support collaboration among companies and between them, as well as among consumers and public institutions" (Tapia et al. 2021).

They hypothesized that land-based factors play a more important role in (strategies for) rural areas, while agglomeration factors are more important in an urban context (Figure 4). The hard and soft factors are important for both contexts. They also make an exception for a special landzone, namely industrial areas, which could be in rural or urban areas. For example, agglomeration factors could contribute to the reclamation of low-value materials, because the urban context implies a higher density in the same territory and therefore a higher (likelihood) of quantity and the effect of the economics of scale. Although not limited to urban contexts, agglomeration factors also include the higher concentration of community-led initiatives that "operationalize circular economy strategies on a non-for-profit level" (Ibáñez 2019). These communities have the skills and values, including the norms, that a circular economy needs.

Figure 4: Territorial factors and their interactions in different types of territories.



Source: Tapia et al. 2021

The third category consists of proximity and accessibility factors. As this thesis works in the Japanese context, where proximity and accessibility are valued in urban planning and individual decision making about housing use, these factors should not be underestimated. But even then, for urban mining initiatives, "areas located close to transportation hubs, like airports, ports, railway stations, and/or having in place effective intermodal transportation systems and logistic hubs can be significantly advantaged when it comes to triggering the economies of scale related to for example the processing of secondary raw materials, for example low- value waste collection-recycling" (Tapia et al. 2021).

4.2. A behavioral approach

Although it seems that only businesses can apply circular economy strategies, momentum is created in several countries (like the Netherlands and Belgium) that circular economy is not only the sum of circular businesses, but envelops a whole rewiring of the current socio-technical systems of society (Marin and De Meulder 2018). Hence, circular economy potentials do not translate only into material circular economy practices, like recycling or repurposing materials or buildings, as observed in most academic research and policy (Kirchher et al. 2017), but also into looking at behavioral psychology and campaigning strategies to mobilize consumers of houses to preserve their houses as long as possible (Pomponi and Moncaster 2017).

Pomponi and Moncaster (2017) provided a literature study on the circular built environment and highlighted the need for especially psychological/behavioral and societal/cultural dimensions. This

omission is also visible in other domains of circular economy practice. This explains why despite gaining momentum in companies and government, consumers seem to be less engaged in circular economy practices (Kirchherr, Reike, and Hekkert, n.d.).

Most research on consumption has looked into the (lack of) intention of consumers to engage with the innovative technologies and business models, the barriers and drivers (e.g.(Planing 2015)), but lacking in understanding the context and meso level aspects that influence the perceptions which have an impact on individual behaviour (Camacho-Otero et al. 2018; 2019; Planing 2015).

This means understanding the user dimension of the product; in this case: the user of the house. Camacho-Otero., et al. (2019) also noted that not much studies are done on circular economy from the consumer/user side.

One idea is to forge ideas of material stock studies with consumer and family theories, and more specific housing adjustment theory. The housing adjustment theory, as explained by Morris and Winter (1975), theorizes the link between changing housing conditions according to norms and housing adjustment, which could be remodelling (or demolishing and rebuilding from zero) or moving out so the perceived housing need deficit is satisfied (Morris and Winter 1975). Later research provided empirical evidence for the effect of housing need deficit (e.g.(Mohit, Ibrahim, and Rashid 2010)). This research is building on even older theories about family life-cycle events by Rossi, which theorized how new events generate new housing needs (Lantz and Rossi 1957).

Understanding the norms and set of values that drive the consumption patterns can lead to the identification of the required circular economy strategies. However, this is a very ambitious goal which will require years of research (of interventions and scenarios) or more manpower and is out of the scope of this dissertation. However, chapter 4 will touch this aspect lightly.

4.3. Applying the circularity approach to short-lived and vacant houses

Circular economy is a concept which is connected with urban metabolism, as circular economy is an answer to the way societies, cities, cultures consume materials. As short-lived and vacant houses embody material resources, as aforementioned, the solutions and creative strategies to cope with these two challenges might lie in the circular economy. However, circular economy principles are not investigated in the context of area development, and even less to almost none for shrinking regions.
Finding solutions for short-lived and vacant houses is under researched, in science and practice. The only study that is an exception is the study of revalorisation of wastescapes in Europe, where a circularity approach is applied (Amenta and Van Timmeren 2018).

Although research is done upon the mapping and quantification of the uneven distribution of vacant houses in Japan, and the reasons behind, the questions that remain to be answered are how we can work with these realities of vacancy and short lived houses to move toward a material stock type or a circular society in Japan: which strategies should local governments use, and which decision criteria can help us. Although Kubo and Yui (2020) provided a platform to authors to discuss several measures in several chapters, none of them have engaged in exploring ideas of material stock type or circular society as an answer/solution to the obsolete (construction) materials embodied in these vacant houses. Also Döringer and her colleagues (2020) identified some measures in Japan in their analysis of case studies, of which demolition is the most discussed. Demolition is not one of the measures that contribute to slowing down the urban metabolism. Less discussed measures are land-use control, urban housing renewals, bottom-up initiatives and transport management, which have potentials for slowing down housing metabolism. However, none of this research places it in the context of urban metabolism (or material stock management) or links it with circularity as a pathway. During the study, I found that Japanese policy and practitioners have not focused much on circularity as a solution to existing

structures, or obsolete existing structures in general[7].

Noteworthy, even less examples exist of circular area development in shrinking regions. The Dutch IBA Parkstad Limburg departed from precisely that circumstance: a shrinking region. By 2030, this region has ca. 7500 houses too much, 130.000 sqm retail too much, 20.000 sqm offices too much, but a need for 1500 new dwellings[8] Therefore, experiments with architects have been conducted, with a European fund of Urban Innovative Actions, to reuse building components of these obsolete buildings to design new buildings, under the project Superlocal[9]. Some main conclusions are that savings in environmental impact are achieved, but the economic costs are 2,5 times than in conventional way, mostly because these obsolete buildings were not designed for disassembly[10].

A structured programme with a long term vision and large area coalitions and resources as in an IBA are (too) few, mainly because these projects need additional financing (from governments) to come breakeven. No other studies are known about circular area development in shrinking regions.

To the current author's knowledge, no research has been conducted on the circular actions for short-lived and vacant houses in Japan, or in other countries. However, there are studies which talk about obsolete stocks (e.g. (Daigo et al. 2009) for the case of in-use and obsolete copper stocks in Japan), no frameworks with strategic solutions and indicators were developed around housing stocks.
This study looks into the path forward to investigate the circular economy potentials of this so-called disposable house culture and presents a novel framework with circularity strategies to cope with vacant houses and short-lived houses, or the material stocks they embody.

Noteworthy, short-lived and vacant houses require different strategies and plans, as the first requires prevention of short life (and more beginning-of-life and end-of-life solutions) and the latter requires end-of-life solutions.

---

[7] This is also agreed by variou other urban planners that look into discourse and planning in Japanese cities with whom I communicated in the past years. See subchapter 6 to learn more about the context.

[8] Information is given by Paul Consten during one of the concluding workshop of Superlocal project, 24 March 2021, Parkstad Limburg

[9] https://www.superlocal.eu/

[10] Information is given by Elma Durmisev during one of the concluding workshop of Superlocal project, 24 March 2021, Parkstad Limburg

5. Structure of the dissertation

Inspired by a circularity approach, this dissertation zooms in on the potential of the materials embodied in short-lived and vacant houses. By applying such an approach, I aim to illustrate with cases in Japan how material stock studies can contribute to circular area development planning and policy.

This dissertation is based on secondary data from previous research, on empirical data from interviews and observations, collected in a few neighbourhoods in Honshu, the main island of Japan in the period of 2018-2019, and on empirical data from GIS calculations. Chapter 2 discusses the practical and methodological challenges and limitations I was confronted with during my study. I reflect on how I dealt with those challenges and what the implications were for conducting scientific sound research and my research trajectory.

Chapter 3 gives a synthesis of the reasons behind a high amount of short-lived and vacant houses in Japan. I argue that the reasons can be explained by firstly, looking into the history of the change of housing regimes since the Second World war. My ambition is to not give a detailed overview, but rather a synthesis to inform the further arguments in this dissertation. This chapter zooms in on the stakeholders "who are in favour of these short lifespans, their own motivations, and the rationale behind recent countermeasures initiated at the local to governmental levels" (Wuyts et al. 2019), as well the 'activists' who resist this mainstream housing and family cultural norms by reclaiming abandoned houses. It is also important to know what has been done in the past and presence in order to identify the challenges and opportunities and learn from that. This chapter includes a historical analysis of lifestyle changes in postwar Japan that have an impact on the fast metabolism of houses. It unearths how the introduction of new technology and knowledge after the Second World War, mainly due to American influence, altered the culture and the lifestyle, including the standards, regulations, norms and practices, of many Japanese citizens during the second half of the 20th century. The recorded low average building lifespan during the second half of the 20th century by previous scholars is the result of path dependencies and historical processes. This study identified housing regimes in post-war Japan where we look at the most important norms and divide the period in 3 phases: quantity-oriented, quality-oriented and then single-oriented. Especially in the end of the 20th century we observe the rise of a new market in housing: the single households who require a new type of homes. As postwar Japan in the 20th century was very oriented to nuclear family norms, many houses are not adapted to this new change. Another objective was addressing the gap for strategies. This chapter provides also a conceptual framework for strategies for these problems. However, this framework is still vague.

Chapter 4 is addressing the third question or the objective on estimating the potential of obsolete housing stock. This chapter and objective focuses only upon vacant houses, because circularity strategies for vacant houses are about end-of-life solutions, while the wicked of short-lived require beginning-of-life or middle-of-life solutions. Vacant houses are still physically present there and are potential 'mines' for resource recovery. In Japan and beyond, several spatial analysis proposing and testing estimation models to estimate the current and/or future location of vacancies. However, they are not integrated in material stock studies by Industrial Ecologists and do not present insights about the weight and resource recovery potentials of these underutilized resources. The specific questions were: Which circularity strategies can be applied to obsolete housing stock? Which obsolete stock has potential for repurpose (hibernating stock) and which has not any goal but demolition (dead stock)? Which criteria should we take, empathizing with the stakeholders? The objective is to provide a new set of strategies and decision guiding tools by combining methods and findings from industrial ecology with local history, history of change and economic geography. This chapter presents "a framework for

the identification of delayed, justified, or premature obsolescence (...) [which] can be used to decide whether the life of a residential building should be extended or ended" (Wuyts et al. 2019).

I conclude this dissertation with a general discussion of the main findings and my opinions in chapter 5. It discusses, for example, how representative this study is in material stock studies and circular area development.These results confirm that a material stock study is not enough to develop a material sound cycle strategy for obsolete stock. Findings from other studies are needed to complement the gaps in these methods. I present ideas for future directions in practice and research.

The chapters of this dissertation include two manuscripts that were prepared as articles and have been peer-reviewed and published (chapter 3 and 4). Therefore, they include an additional literature review and discussion. The other chapters (2, 5) have been prepared specifically for this dissertation and therefore have a slightly different format. Finally, for a better understanding of the historical context in which I carried out the study, I provide first a brief overview of the development of circularity and sound material cycle discourse in Japan.

6. Some context on spatial circularity and sound material cycle discourse in Japan[11]

This subchapter explains the development of spatial circularity in general, and more in particular in Europe, and shows how spatial circularity concepts and ideas can be (or not) connected with concepts in recent Japanese policy and research discourse.

6.1. Discourse on spatial circularity in general

Circular economy is an emerging concept in urban planning (figure 5). Although the body of research on circular economy started to grow exponentially in 2015 (Reike et al. 2018), the spatial dimension of circular economy is still a frontier. Only recently, researchers have looked into the spatial requirements for circular economy and started to identify different pathways, strategies and actions for different places, for different levels (from neighbourhood via the city level to regional level). As buildings are rooted in a place, the building level should also be integrated in a spatiality analysis of circularity, because their environment (physical environment), but also social systems in which it is embedded), has also an impact on the performance (durability) of the building.

Figure 5: Visualisations of Scopus search with inquiry 'circular cities', filtered on relevance, in June 2021, a) number of publications per year (in blue), and forecasted publications (by doubling the number, in brown), b) journals of publications

Journals

Journal	Count
Sustainability	20
Building and environment	3
Regional Science	3
Waste management	1
Urban studies	1
Journal Cleaner Production	1
EIST	1
others	7

Source: author

In 2018, the first pioneering papers on the level of city appeared ((Prendeville, Cherim, and Bocken 2018; Julie Marin and De Meulder 2018b; Jonker et al. 2018) as well on the level of landscapes and regions (Amenta and Van Timmeren 2018). They address the governance challenges and levers. In 2019, more descriptive accounts of mostly European cities were presented to illustrate the different pathways, levers, barriers of the transition (Cavaleiro de Ferreira and Fuso-Nerini 2019; Girard, Nocca, and Gravagnuolo 2019; Joanna Williams 2019c, [b] 2019; Gravagnuolo, Angrisano, and Fusco Girard 2019; Joanna Williams 2019a; Campbell-Johnston et al. 2019; Girard and Nocca 2019; Savini 2019)), but also the different imaginations of this concept (Fratini, Georg, and Jørgensen 2019). In the last two years, a dozen more papers have been published to contribute to the field of circular area development, but mostly focused on European context, with some exception in North-America (Petoskey et al. 2021)), Marjanovic et al., (forthcoming)) and a research with a prescriptive approach for a Japanese city (Wuyts et al. 2020).

[11] This is a new subchapter written especially for this PhD thesis. I want to acknowledge Marjan Marjanovic and Dr. Tomoko Kubo for their comments and ideas about the differences in discourse.

Like the definitions for circular economy (Kirchherr, Reike, and Hekkert 2017), the definitions of circular city are various. One of the most known is provided by Paiho and her colleagues: '[a] city [that] is based on closing, slowing and narrowing the resource loops as far as possible after the potential for conservation, efficiency improvements, resource sharing, servitisation, and virtualisation has been exhausted, with remaining needs for fresh material and energy being covered as far as possible based on local production using renewable natural resources' (Paiho et al. 2020), p. 6-7).
A circular city could also be defined as a social, economic, and political construction and a more just appropriate perspective would focus more on the social groups which live and work within the boundaries of a city (Kębłowski et al. 2020), rather than on the innovations. This implies place-based study of processes, and more specifically the power relations and socio-environmental conditions that shape which social groups gain and lose (Swyngedouw and Kaika 2000).[12]

Concerning policy response, since a few years, local and regional governments are also embarking on a transition and often look to (best practices in) other countries to draw inspiration. In 2015, Amsterdam published a Vision and Circular Roadmap, and also Paris and London declared their intention to adopt a circularity approach, soon followed by Rotterdam, Brussels Capital Region, Rome, Porto and many other European cities (Jo Williams 2021). Often, these cities decide upon their own definitions of circularity, tools, boundaries… which are mostly steered by their political agendas and values (Julie Marin and De Meulder 2018b; Calisto Friant, Vermeulen, and Salomone 2020) Often other countries relabel their local concepts and existing practices as circular. Or some cities, like Stockholm, embarked on a circular development pathway, but did not label it officially as such (Jo Williams 2021).

Summarised, not much research engaged with circularity in urban and regional planning, and the geographical focus was mostly on western countries, with research clusters in Italy (e.g. (Girard and Nocca 2019), the Netherlands (Amenta and Van Timmeren 2018; Van den Berghe and Vos 2019) , Belgium (e.g. (Julie Marin and De Meulder 2018b), Finland (Paiho et al. 2020) and the United Kingdom (e.g. (Joanna Williams 2019a).

Although (Ogunmakinde 2019) did a comparative study on CE development in Japan, the scope was mostly on national level and policies, and not on the complexity of what CE means on 'the ground'. The following subchapter will outline the discourse development and differences.

6.2. Circularity in Japan

In Japan, a territorial approach to circularity or metabolism of materials has existed for many centuries and is not new. The ideas behind the concept were all present in Japan before circularity became popular and adopted by many European cities. While the main focus is on contemporary developments, I provide a brief historical overview of concepts, ideas and practices and zoom only briefly in previous eras. For contemporary development, I focus on Yokohama - one of Japan's biggest cities which is considered to be one of the pioneering sustainable development cities in Japan- in order to illustrate different circularity pathways, inspired by the ones identified in European cases by Williams (2021).

Japanese Edo-period (1603-1847)

[12] For other definitions and different interpretations of circularity on spatiality (cfr Marin & De Meulder), I refer to the subchapter above that explains spatial circular economy.

In his Gaia Atlas for sustainable cities, Girardet (1996) divided cities into biocidic and biogenic cities. Biocidic cities have a linear economy, where they take resources from nature, but do not invest in the regeneration of these resources, resulting in the collapse of these cities (Girardet 1996). In contrast, biogenic cities are in balance with the rest of the environment, taking care of the maintenance of the land, returning human and animal waste to the ecosystem (ibid.). The towns, villages, and cities in Japanese Edo-period (1603-1847), when the borders were closed for the rest of the world, could be considered as biogenic cities. Circular metabolism was spatially present, linking 'night soil' to the agricultural system and repurposing the bathing water (Brown 2013). Waste did not exist in Edo-Japan (Brown 2013)[13]. Outflows were appreciated. As the material cycles were also very localised, the management was easy on an everyday level. At the start of early industrial revolutions, by-products were valued. It was only with the introduction of artificial fertilizer, petroleum and other technical innovations that some biobased by-products such as 'night soil' became waste or obsolete, and a burden to society (Sabine Barles 2014).

Rapid industrialisation, technological evolution and introduction of public hygiene approach (1847-1945)

On the other hand, more infectious diseases plagued Japan (as in other parts of the world) and the link with unsanitary water channels and disease-bearing animals lead to the initiation of laws like the Dirt Removal Law in 1900 and improvement measures in night soil management (Tanaka 1999). Public hygiene became an important standpoint in management and policy responses (ibid.). In the Meji era (1847-1912), Japan changed from an isolated feudal society to a modern industrialised nation state, characterised by rapid industrialization and technology advancements (Macpherson 1995).

Public health in Postwar environmental policies (1945-1999)

In the years, the link between different health impacts and industrial activities became more evidenced, as in the case of for example the itai itai disease, a cause of cadmium pollution of water through mining activities in Toyama prefecture (Yoshida, Hata, and Tonegawa 1999), or the air and water pollution in heavily industrial areas and cities as Kitakyushu in Fukuoka prefecture (Irvine and Bai 2019). Different waste acts and public cleaning acts were established in the second half of the 20th century, like the Public Cleansing Act of 1954 and Waste Management and Public Cleansing Act of 1970 (Japan 1970), as policy responses to the environmental pollution problems resulting from post-war rapid reindustrialisation. There was also growing awareness for the waste production which resulted in laws and policies to stimulate sorting and recycling, starting with the First Recycling Act in 199((Tanaka 1999)

Toward a Sound Material-Cycle Society in 21st century

In the beginning of this century, the Japanese government launched the Basic Act for Establishing a Sound Material-Cycle Society (Moe 2000), which can be considered as the call to transition toward a circular economy. Article 2 defines it as following: "a society in which the consumption of natural resources will be conserved and the environmental load will be reduced to the greatest extent possible, by preventing or reducing the generation of wastes, etc. from products, etc. , by promoting proper cyclical use of products, etc. when these products, etc. have become circulative resources, and by ensuring proper disposal of circulative resources not put into cyclical use (i.e., disposal as wastes)" (Moe 2000). In 2003, the Fundamental Plan for a Sound Material-Cycle Society (FPSMCS) was adopted by the Japanese government and a set of three economy-wide material flow indicators and

[13] This was the case for other places. See for example medieval Flanders, Belgium (J. Marin and De Meulder 2016).

numerical targets were introduced into the FPSMCS, and numerical targets were set for each indicator (Moriguchi 2007).
In 2018, the Fifth Basic Environment Plan of the Government of Japan was published which, forwarding the Circulating and Ecological Economy (CEE) and circulating and ecological sphere (CES) concepts, "to localize the flow of resources between urban and rural areas". Noteworthy, this concept existed already and builds further upon Japanese concepts and ideas like satoyama (and satoumi) (Takeuchi 2010). Some cities have been adopting (or at least, planning to adopt) the concept of circularity in their policies (e.g. Kitakyushu, Toyama, Shimokawa, etc.). It is a particular idea of circularity which puts a great emphasis on the integration of urban ecosystems with their rural hinterlands (to promote regional revitalisation), the shift to a renewable energy and natural resource based economy (agriculture and forestry), and the emphasis on local/regional scape (Ortiz-Moya et al. 2021), (Takeuchi et al. 2019; Hotta et al., n.d.). They are also exporting these concepts to other cities and towns regions in Asia, like Nagpur in India (Thapa et al. 2020). The initial difference between Europe and Japan might lie on the fact that European researchers and practitioners initially focus more on manufacturing industries (e.g. construction, industries in ports), and focus on circularity in urban economy rather than to interactions between urban and rural components.
However, these differences are blurring out, as European researchers integrate bigger scale, urban greening and other regenerative economy strategies (Jo Williams 2021) and investigate also city-hinterland interactions regarding nature based resources (Julie Marin and De Meulder 2018a). In practice, there are also initiatives in Europe to establish rural circularity, like Zero Scotland's project in Circular Highlands and Islands since 2020[14].

Additionally, since 2019, the national government promotes the concept of SDG FutureCities, "which aims to create urban areas and regions that realize a sustainable economic and social system with recognition of continuing global urbanization. Eco-Model Cities and FutureCities are selected from municipalities nationwide to implement specific initiatives. Eco-Model Cities uphold the FutureCity concept through pioneering efforts with the ambitious goal of creating a sustainable, low-carbon society. FutureCities respond to challenges common to humankind like aging and environmental issues" (City Yokohama, 2021). Yokohama and Kitakyushu are both examples of FutureCities and Eco-Model Cities.

Different approaches exist in the circular economy discourse, also in research and policies related to Japan. As this thesis focuses on the built environment and especially obsolescence, it is interesting to look at policies and practices looking into the potential of existing structures. Japan has built up a lot of material stock in its buildings and infrastructure, and this material stock accumulation seems to be saturated mid-way through the 21st century (Fishman, Schandl, and Tanikawa 2015). By adopting a circularity policy that focuses on existing structures, Japan would find the means to reduce their independence and reduce their global impact. "In circular urbanism, as much is adapted as possible and as little is built as possible. At best, it is dismantled, rearranged and adapted, repaired and, at best, overgrown." (Marin & De Meulder 2021).
However, Japanese discourse is oriented towards 'new' technology, designs, cities, materials and land, and less focused on the potential of existing flows and stocks. The pathway of 'planned eco-town' is present in Japanese cities, which embodies the 'innovation discourse'.
On the other hand, Japan also kows bottom-up projects, where local players experiment with for example finding new purposes for materials and abandoned houses, other infrastructure and places (e.g. Nagano Rebuilding Center, Onomichi Empty House Reclaiming Project), but these projects are tactile and temporary, leading that these experiments and living circularity labs are not scaled up. These places

[14] https://www.zerowastescotland.org.uk/content/circular-highlands-and-islands

have space availability for low value activities, which is also a precondition found in European cases on tactile urbanism (Jo Williams 2021)**.** In Japanese cities and towns which cope with shrinkage and vacancies, like Onomichi, this precondition is more present than in European big cities where space for low-value activities is a rare resource.

Different pathways, illustrated by Yokohama

Some have adopted an official circularity strategy, like Yokohama, which is the second-largest city by population and the most populous municipality in Japan. It lies on Tokyo bay and has experienced rapid development since the mid-19th century (following the end of Japan's relative isolation), because of its port infrastructure. Yokohama was also part of the scene of the 1923 earthquake in the Kanto region, which destroyed much of its buildings, a memory that is still present in the way the city copes with disasters and emergencies and an awareness that we find in social business (e.g. Solarcrew business) to strategic developments in the area (FutureCities).

The first clear pathway is that of the planned eco-town. The Ministry of Economy, Trade and Industry (METI) and Yokohama City strongly engage in circular economy as policy practices. Yokohama City has launched several smart-city projects (e.g., introducing home energy management systems encouraging sharing economy such as sharing-mobility services called baybike, electric vehicles) (Yokohama City 2021). As part of being an EcoTown and FutureCity, the city selected 4 model districts. These ideas focus on 'optimising', i.e. building "new" systems, technology, or city by utilizing new materials or unoccupied land.

In Japan, demolition is often the answer to vacant constructions, which are often seen as a problem rather than an opportunity (Döringer et al. 2020). Less attention is paid to utilizing existing materials, resulting in a fragile existing-stock market in Japan (especially, generational transactions dominate the existing housing market). To my current knowledge, there are not large-scale 'circulate (utilizing existing ones to make a sustainable economy)' developments or related policies in Yokohama, for example, but only on a smaller scale.

In Yokohama, there is also a pathway of bottom-up and grassroot projects that promotes sound material cycles or circulation. Another stakeholder, which works on connectivity, and networking, is the online platform Circular Yokohama that maps the projects and does community building in order to generate knowledge about circular economy (Circular Yokohama 2021a). They promote bottom-up projects, like social businesses, charity and educational projects. For instance, Solarcrew aims to reclaim vacant houses as spaces for connections in times of peace, and as shelters in times of emergency (Solarcrew website, 2021).

Then there is this Japanese CES approach, which focuses on the renewable economy, builds on local assets and combines several sustainability goals. For example, the "SDGs Yokohama Kanazawa Living Lab, where local businesses, citizens, and teachers work together based in Kanazawa ward, Yokohama, makes use of the eelgrass (seaweed that grows in the sea) as fertilizer, grows vegetables such as chili at local farms and creates a unique seasoning called 'Kanazawa Hachimi' with elementary school students (...). This project builds on a unique strength that Kanazawa has both the only beach in Yokohama and has farmland inland. This is a good example which shows that a sustainable circular economy requires consistency with regional characteristics" (Circular Yokohama 2021b).

Different labels, different drivers for local-regional circularity

In Japan, there are different initiatives, strategies and plans that could be labeled as circular, from Zero Waste bottom up towns initiatives (with Kamikatsu as a famous example for 20 years experience[15]) to top down and national concepts like the sound material cycle society of these more recent CEE and CES concepts. Additionally, some stakeholders use the label 'circular', as in bottom up initiatives like Circular Yokohama, to bring together often isolated smaller practices. Not much English publication of research is published about the contested discourse in Japan, that provides a synthesis on the trajectory of circularity discourse in Japan -and/or which outlines tensions between the different stakeholders. These aforementioned 'circularity' practices, concepts, and policy responses could be driven by different concerns by these different stakeholders: material security, hygiene, public health, biodiversity loss.... but it is not clear yet to which extent and how they create tensions and barriers in the transition. It is only clear that circularity and sound material cycle concepts are contested definitions in Japan, leading to different pathways.

[15] https://www.theguardian.com/world/2020/mar/20/no-waste-japanese-village-is-a-peek-into-carbon-neutral-future

Chapter 2: Methodology

Opportunities in terms of sustainable material management for the problem of vacant and short-lived houses in Japan remain largely underexplored in English scholarly literature. In case of vacant houses, for Döringer et al. (2019), this is due to the focus on demolition of construction in Japan. In the case of short-lived houses, this is due to only a recent interest in long-living houses and orientation on quality (Noguchi 2003). Although not explicitly evidenced, this can be argued by the fact that Japan is very efficient in recycling (and in particular downcycling), with for example almost perfect recycling rates of asphalt concrete (K. Kubo and Leader 2014). Research in other countries have demonstrated that optimisation of existing regimes, like recycling, or incineration, can stand in the way of more desirable circular or sound material cycle practices (e.g. (Van den Berghe, Bucci Ancapi, and van Bueren 2020). An initial hypothesis, which is not in the scope of the objectives, is that Japan is a victim of its own (recycling) success. Demolition, and downcycling materials at the end of their life is not the most desirable strategy. This research focuses on other pathways, namely in working with existing structures (reclaiming vacant houses) and avoiding too early demolition (extending service time).

In this section, I give an introduction to my main departure and approach. I consider the aforementioned problems as wicked problems, in line with other researchers who also see environmental sustainability issues as wicked (Schad and Bansal 2018; De Angelis 2020). From the 1970s onwards, this term indicates that many problems cannot be seen in isolation, that there are no clear solutions and even a risk that problems get worse if certain policies or actions are implemented (Vandenbroeck 2012). There are different rich research traditions that invite ‘dancing with uncertainties’ (Meadows 2001), embrace complexity and investigate relationships between actors and the systems. This approach can be called systems thinking. There are different methodologies under this approach: ‘Soft Systems Methodology, Transition Management, Future Scenarios, Design Thinking, and Appreciative Enquiry’ (Vandenbroeck 2012) and others. The main methods that I use are soft systems methodology. In the chapters of the case studies, I will explain further the details. In this section I will highlight the main basics of wicked problems, systems thinking and soft systems methodology, as well discuss concerns about limitations and my capabilities.

1. Wicked Problems

The 1960s were turbulent times for the United States (nuclear threat, urban planning problems, raising awareness of environmental issues) which initiated debates about how to solve these problems and led to the introduction of the idea that these ideas are wicked or messy (Vandenbroeck 2012).
Wicked problems are characterized by high levels of complexity and the involvement of multiple stakeholder or actor groups (with often strongly divergent values and perspectives) (Rittel and Webber 1973; Vandenbroeck 2012). Therefore these wicked problems cannot be solved by traditional problem solving approaches (ibid.). In their highly cited paper ‘"Dilemmas in General Theory of Planning" Rittel and Webber give a description of wicked problems (Rittel and Webber 1973) . The following characteristics are as follows (Rittel and Webber 1973; Ritchey 2013)

1. “Wicked Problems have no definitive formulation.
2. Wicked Problems have no stopping rule.
3. The solutions can only be good or bad, not true or false.
4. There is no immediate or ultimate test of a solution.
5. Attempts to solve wicked problems are "one shot" deals. No trial and error. Planners have to bear the consequence of every intervention!
6. Wicked Problems are highly resistant to clear and agreed upon solutions.

7. Every wicked problem is unique.
8. Every wicked problem is a symptom of other societal problems.
9. Discrepancies between explanations of a wicked problem can be explained in multiple ways.
10. There is no public tolerance for failure in solving wicked problems".

In particular, characteristic 9 indicates that, although one of my objectives is to provide an explanation for the two problems of short-lived and vacant houses, that these explanations can be discrepant with other explanations provided by other researchers. My aim is to not also solve these problems, but one of my aims is to shed light on the wickedness of these problems.

In some domains, like climate change problems, they talk even about super wicked problems (Levin et al. 2012) and add additional characteristics, like the urgency ('time is running out'), the lack of a central authority that could direct the needed solutions, that often those seeking the solutions are also at the cause of it, and the problem that policies discount the future too much. As material consumption related strategies can be linked to climate change impacts (Hertwich et al. 2020), one could argue that these wicked problems of the wasted materials due to short-lived and vacant houses are also super wicked.

Observing the world, and in this study Japan, through a (super) wicked problem lens may deliver more realistic expectations and make stakeholders, especially planners, more conscious of human sensitivities, like different values and priorities in their agendas, the tensions that can arise, so urban planning in name of material sound cycles or circularity can be socially robust and feasible (Vandenbroeck 2012).

2. Systems thinking

Real world problems cannot be solved solely behind a desk, but generating, reflecting on and composting ideas is an inherent part of the process. System thinking is an interdisciplinary field that can be useful in coping with wicked problems (Vandenbroeck 2012).

Systems thinking is a qualitative approach to understand the complexity of a phenomenon, in this case the challenge of short-lived and vacant houses in Japan, and the systems in which this phenomenon occurs. This approach does not always predict the outcome of this investigation. This Japanese proverb might illustrate the complexity of systems: 'When the wind blows, the barrel-maker prosper'[16] explains how one condition or activity can have an apparently unrelated effect. The social and environmental problems resulting from the economic system can often seem independent from one another.
This approach in the solution-oriented field of circular economy is not new. Metabolic, one of the pioneering stakeholders in the Netherlands, takes a systems thinking approach "acknowledging that many of these challenges are inextricably linked, and stem from a few key root causes" (Metabolic 2021) (figure 6). "Rather than trying to understand the world by reducing it to its individual elements and looking at them in isolation, systems thinking focuses on the relationships between elements and how these result in emergent outcomes over time" (Metabolic 2021).

Figure 6: Metabolic's methodology combines systems thinking and data-driven analysis to arrive at actionable solutions.

[16] This proverb is introduced by Tanikawa sensei in the introduction of his class about environmental systems thinking and planning: "When the wind blows, dust will be blown into people's eyes. If dust is blown into people's eyes, some people will go blind. The traditional employment for blind people in Japan was itinerant shamisen-playing story-tellers. The blind people would therefore be predicted to purchase shamisen. The skin of the shamisen is made of dog or more often cat. So if the number of blind people increases, then cats will be killed for their skin. If cats are killed then there will be more mice. And if there are more mice, people will need to make sure that their rice is kept in barrels. So they will order barrels. And barrel makers will get rich."

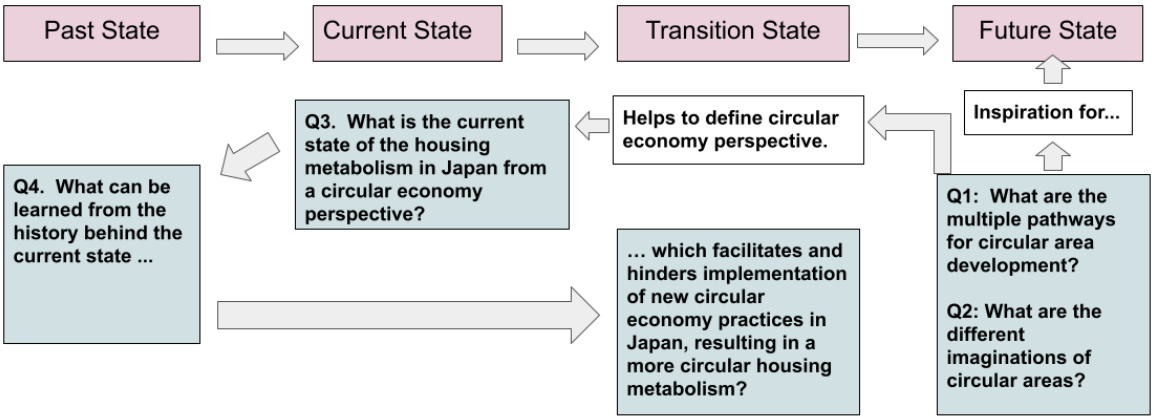
Source: Metabolic 2021

Metabolic identified four core principles behind their systems thinking approach:

1. Changing one element in a system will always lead to ripple effects somewhere else.
2. To change a system for the better, we must first understand what causes it to function the way it does.
3. When not considering problems in the context of a broader system, attempts to fix them can often result in unintended consequences or 'burden shifting'
4. Understanding the holistic effects of changes to a system can help us achieve the best possible outcome.

More concretely, this doctoral thesis follows the framework that the researcher developed in 2017 for her Master thesis on the introduction and implementation of new circular economy practices in a higher education institute (the curriculum and the campus area), under the guidance of sustainability transitions and innovation academic and practitioner experts (Wuyts 2019). The basic framework of Nadler and Tushman illustrates how organisations can transition from a current state to a desired future state and the different problems that can occur in the transition state (Nadler and Tushman 1997). Wuyts added "the importance of the state before the current state: the past. To be able to identify the drivers and to address root causes of the current state, the researcher dived into the history of the system of (the organisation) and learned from the successes and failures in the past" (Wuyts 2019).
Combining and applying aforementioned ideas to the challenge of vacant and short-lived houses in Japan, with a material stock type society or a circular economy as the desired future state, the systems thinking approach of this dissertation could be explained as follows (figure 7):

Figure 7: framework of circular economy transition management and the associated research questions , inspired by Wuyts (2019), Nadler and Tushman (1997)



After outlining the multiple pathways for and interpretations of circular areas, one part of this study will dig into the past state to understand what can be learned from the past (through analysis and synthesis of the documentation of events in the past, previous research) that can hinder or facilitate the transition and the design thinking part.

In some way, by adding 'local' history, this research design is aligned with Sabine Barles' call to combine "industrial ecology, local history and the history of technology" (S. Barles 2007), but while she focused on watersheds as territory, this study focused on the problem of short lifespan of houses in the territory of Japan. Looking into history is not a new advice or idea in systems thinking. In her essay "*Dancing with systems*", Donatella Meadows (2001) calls to start always with a historical analysis of the system that we need to study (Meadows 2001). This study followed this call by paying special attention to the historical trajectories of norms and practices around housing in Japan.

Few Industrial ecologists add a temporal dimension (e.g. Tanikawa, Miatto), but often limit themselves to the quantification of material stocks and flows, and not in the deeper roots (Pirgmaier and Steinberger 2019). Only when they engage with political ecology (like (Cousins and Newell 2015)), or recently in a study about the case of Tiexi's morphological change over a timespan of 100 years (Guo et al. 2020), industrial ecology studies integrated (qualitative data from) local history. Not only did local history contextualize the consumption patterns, but on the other way do industrial ecology findings provide new evidence for or verify the current views of (recent) history about a place. History is always subject to change if new sources or evidence comes. So this marriage of industrial ecology with a history of evolutionary economic geography, as in this thesis, has benefits for both fields. The challenges of exploring common grounds of different fields are similar to many transdisciplinary research, but in the name of sustainability, researchers should cope with the uncomfort abilities of exploring new frontiers. Sharing common values and ideologies about sustainability could be one catalyst for this kind of needed research.

Based on the concepts, previous experiences in research and design thinking, and during the PhD study itself, the following steps can be proposed for a systems thinking journey:

1. Start from a place or a territory and decide upon the boundaries of the territory you will study (e.g. Japan, a series of islands with the sea as boundary and a quite shared cultural history, or more zoomed in: a city, like Kitakyushu or Onomichi)
2. Study the ecology, culture and history in this territory and the lessons it can provide about the people and other beings and resources who live there,
3. Identify (new) priority zones, because we work with super wicked problems and there is a sense of urgency.

4. Study the needs and assets of the people in these priority zones
5. Study the impact of interventions
6. Share the findings of step 4 and 5 with stakeholders and reflect together,
7. Implement slowly new interventions in cooperation with stakeholders
8. Evaluate these interventions, monitor evolutions in other areas,
9. Reflect and start from step 3

These steps are also present in several research process models, like the one from (Mauser et al. 2013). Noteworthy, due to limitations of the dissertation, this dissertation has no ambition to complete the whole process or 'solve' the wicked problem (see also subsection 4 about limitations).

Lastly, it is important to note the conceptual difference between 'hard' and 'soft' approaches. A 'hard' systems thinking (ST) approach aims at developing ((quantitative or qualitative) models of a problematic part of the world, which are often considered to be objective and accurate in order to identify where and how to intervene (Vandenbroeck 2012). In a soft systems approach, which is more constructivist, the ST thinkers focus on finding a consensus between the different perspectives of the stakeholders (ibid.). As Vandenbroeck summarises it well: "in hard systems thinking we construct models 'of' the world, whilst in the soft approach we construct models 'for' the world" (Vandenbroeck 2012). This study applies a hard ST approach[17], because it aims to develop a qualitative conceptual framework of the problems as will proposing which interventions would be most interesting and 'right'[18].

3. Soft systems methodology

One of main goals was to provide a conceptual framework of circularity actions to the problematic situation of a high amount of short-lived and vacant houses. The method that I mostly followed was the Soft Systems Methodology (as outlined by (Checkland and Poulter 2006), because it focuses on activities rather than on the organisational rules and frameworks of the state, municipality or other administrative unit. I started with the ideal reality of a 100% circular economy or sound material cycle society and stepped away from the wickedness, the complexity around the high amount of short-lived and vacant houses in Japan. I built my own activity model that would serve this purpose, and challenged it through asking questions to other people in Japan, concerned with short-lived or vacant houses (including experts in architecture) and who act in real-world complexity. For example, I got challenged to consider safety and justice aspects, when I witnessed and heard about the risks of reclaiming abandoned houses on steep hills in landslide-prone areas (Onomichi, August 2018), after heavy rainfall and landslides in July 2018 unearthed this risk.
Soft systems methodology is summarised: "the discovery and articulation of a problematic situation in the real world ('finding out') leads to a phase of conceptual modelling in an idealised realm ('systems thinking')" (Vandenbroeck 2012). The main result is the conceptual framework, presented in chapter 3. This methodology also has its weaknesses: the logic is difficult to follow, as well there is a chance that I am still blind to other views and especially counter-arguments for my own ideal reality and try to fit ideas and activity models in my own normative stance and worldview because of cognitive dissonance

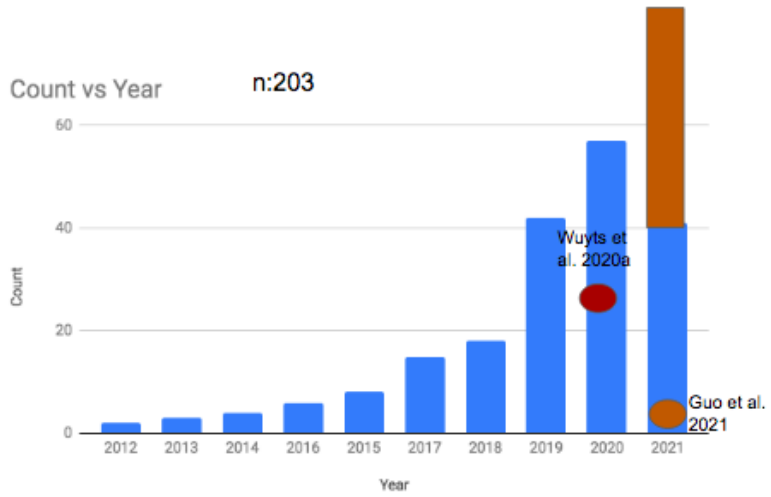
[17] However, at the time of writing this dissertation, I have worked on studies, as co-author, that take a more soft ST approach on circularity in planning and look into the different perspectives and stakeholders. These studies are about cases in Belgium and Canada, and the articles are currently under review. I am familiar with both approaches and am also an advocate of combining both approaches. A soft approach can give insights about possible frictions why transition is happening and in why in which direction.
[18] But not necessarily right. The proposals are just ideas for first directions. For the 'exact' interventions, it is important to study the context of the problem.

(ibid.)

4. Spatially explicit material stock studies[19]

Concurrently to the popularization of the theory of circular cities by urban planners, industrial ecologists have been designing and refining methodologies to quantify and/or locate the material flows and stocks within system boundaries (Graedel 2019). Recent review studies on material stocks and flows in the urban environment (Lanau et al. 2019); (Augiseau and Barles 2017) show a well-established methodology that applies to various cities/regions. Yet these reviews fail to mention how material stock studies can contribute to adopting a circular approach to urban development. However, material stock studies can contribute in monitoring the performance of policies and inform decisions about circularity. Recently, the 'marriage' of circular cities by urban planners and material stock studies is on the rise (figure 8), but it is still in its infancy and has to be explored more in order to understand how the material stock methods can inform an contribute in the best way possible spatial designers with planning space in a way it can enable sound material cycles.

Figure 8: Bibliometric results of a literature study about studies that combine circular area development and material stock studies



Journals

Journals	Count
Building and Environment	1
BRI	3
Ecological Economics	3
EST	8
Journal Cleaner Production	24
Journal Industrial Ecology	19
RCR	33
Sustainability	14
Other	98

Source: by author, Scopus Search, with query: "circular AND (cit* OR urban OR built environment OR region*) AND (material stock*)". Selection: published in January 2015 to June 2021. a) The evolution of papers over time, b) the journals where these articles are published. I doubled the number of the papers published in 2021, to give an estimation of how many papers will be published in 2021 in total, and added two papers I authored.

The preliminary results of a literature study on the intersection of material stock studies and circular urban development displays that material stock studies tend to serve the action of looping and urban mining, as they create data repositories that are potential cadasters for secondary resource recovery. Most of the bottom-up studies provide detailed data for future urban mining efforts (Ajayebi et al. 2020; Augiseau and Barles 2017). When bottom-up studies are conducted in a spatially explicit fashion, they provide information that better suits the local context. Some empirical studies explain the limitations of

[19] This subsection is an adapted version of an extended conference abstract that I wrote together with Alessio Miatto for the The 2nd international conference on Circularity in the Built Environment (CiBEn), November 2021. It includes the preliminary findings of a systematic literature review on the contribution of material stock studies in circular area development.

material stock studies that disregard the spatial distribution of the stock.

Few studies highlight how strategies should be differentiated according to the different districts within a city with their specificities (Wuyts et al. 2020; Augiseau and Kim 2021), but this specification is not present in most of the articles we analyzed so far[20]. The lack of specification is a common critique from an urban design perspective. Urban designers typically start by mapping territorial specificities, such as stakeholder analysis, the history of the place, and other facts about the local context. We found a stakeholder analysis only in one of the articles we analyzed (Volk et al. 2019), but few more studies include local histories. The impression we got from several studies is that the goal of the researchers is the quantification of the material stocks per se, whereas the application of this information is only a tepid afterthought or someone else's problem.

Material stock studies offer both qualitative and quantitative data to support the transition to a circular urban environment, but their effectiveness varies greatly. Top-down material studies can offer insights for macro-policies and monitoring the environmental performances but are rarely useful to local planners and designers who face specific needs and assets. In particular, dynamic bottom-up spatially explicit material stock studies act as an effective planning and monitoring instrument.
However, we also identify gaps concerning the feasibility (i.e., spatial requirements, economic viability, recycling potential) and the impacts of circular practices in that context (e.g. impact of transport to the closest recycling plant).
To effectively implement a circular built environment we need innovative studies that combine material stock analysis of different scopes (i.e. materials, components) to help discern which material is best for specific locations/applications, keeping into consideration local characteristics (e.g., transportation requirements to recycling facilities). Further, prospective studies that take into account the existence of vacant and abandoned buildings will support the creation of a dynamic repository of materials that can be potentially harvested for reuse.

Chapter 4 attempts to show how a combination of GIS and material stock studies offers insights on the "the identification, mapping and management of resources embedded in building stocks for future reuse or recycling" (Çetin, De Wolf, and Bocken 2021). It illustrates how "to identify vacant houses and their material stock in the city of Kitakyushu in Japan in order to make informed decisions on the future use of resources" (ibid). The details of this method will be explained further in chapter 4. The limitations and flaws will be discussed in chapter 5.

5. Research limitations related to researcher's capabilities

Chapter 3 and 4 include a method section and a discussion of the methods[21], which will be elaborated upon in chapter 5, but this subsection gives more details on the limitations related to my capabilities and the case area, in order to make clear to be alert for the flaws and biases in this research. The scope of this research is defined by the period of study, the limitations of the researchers in the studied context, the country and the case studies. Postwar Japan is a great case to study this problem, because previous studies provided quantitative data, on which this study could build, and highlighted the quick turnover of houses, compared with western countries.

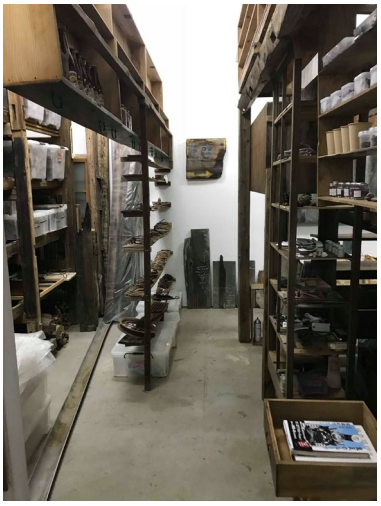
[20] The preliminary findings are based on a sample of 45 articles.
[21] Because chapter 3 and 4 are originally published as peer-reviewed international journal articles.

When I started this dissertation, I had set high ambitions to use Japan as a case study[22]. This created many limitations in my research design, because first of all, I did not speak any Japanese at the start of this study. The results are limited, because I was dependent on English research, or voluntary translations by peers in the research group or friends of documents and other data that was merely in Japanese. The main findings are discussed with international literature, but I might have missed findings from research in the Japanese language. I am aware that there is a whole body of Japanese literature, which I cannot access. On the other hand, not many Japanese people speak fluently and understand comprehensive English which also limited my sample of participants in key expert interviews. There might be a big bias in this sample, because I only got the views, opinions and knowledge of people who already have the capacity to talk two languages. I might have also missed a lot of information and knowledge that is only available in English. Another problem lies in the risk of getting 'lost in translation' (Nikulina et al. 2019); some ideas and concepts are difficult to translate from Japanese to English, not only because of language, but also because of epistemology and culture. There have been occasions that Japanese people, who are fluent in English, had trouble explaining abstract ideas from Japanese official documents into English to me. Some concepts and ideas are embedded in different epistemologies, culture and even normative stances that I am used to.
Moreover, the linguistic boundaries hindered participation in stakeholder and innovation processes. Although I outlined different steps in the section on systems thinking, it was difficult to induce or facilitate events where I can share findings with all relevant stakeholders and even contribute to the implementation of new interventions[23].

Especially in chapter 3, I used an inductive approach and methods like critical news media review and semi-structured interviews, where there are risks that I directed the content too much, by selecting questions that rather reproduce my initial thoughts. However, when I did interviews in Onomichi (figure 9), I stayed for a longer period, walked in different places as much as possible and tried to be open, have conversations with shopkeepers and waiters to learn more, be a passive observer, open to receive new insights. Walking as a method, often in combination with a stakeholder analysis, is often not reported in academic publications, but getting recently more acknowledged by urban geographers as an inductive method that might be less subjective and, especially if combined with other methods, add rigor to findings collected by other methods (Pierce and Lawhon 2015).
However, given my own capabilities and the selected case study, there will be flaws in the main findings and the impact of this dissertation on the real world problems is and will be rather limited.

Figure 9. Photo collage of attending community meeting and a community stock of materials they retrieved from abandoned housing in Onomichi

[22] Looking back, I would have lowered my ambition and chosen different case studies, for example Flanders, Belgium, to conduct my PhD study, or areas where I could speak and understand the language at a certain level.
[23] Looking back, I could have also worked 'retrospective', identified pathways and actions that could be considered as sound material cycle or circularity actions and calculated the impacts, costs and benefits. This is an idea for future research.




Source: author (February 09, 2018)

Chapter 3. Understanding the high number of short-lived and vacant houses in Japan in order to propose sound material cycle strategies [24] [25] [26]

1. Introduction

This chapter engages with the ongoing discourse on circular vs. linear consumption and the management of product lifespan (Camacho-Otero, Boks, and Pettersen 2018; Cooper 2008) by investigating the reasons for disposable house consumption (i.e., the linearity of the built environment in post-war Japan). Moreover, this chapter contributes to the global and local material stock management research (Krausmann et al., 2017; Tanikawa et al., 2015). Additionally, by shedding light on the role of building lifespan and the socio-cultural dimension, this study tried to understand how path dependencies created by dynamic material stock and decisions have and will continue to influence material flows.

Specifically, this article aims to answer the following research questions. 1) What were the values and attitudes of Japanese people and the market conditions behind the short use of buildings in the 20th century? 2) Were there technical factors at the base of the short building lifespan? 3) Is this phenomenon more closely linked to technical or non-technical factors? 4) Who are the involved stakeholders and what are their motivations? 5) Are the proposed and undertaken actions in the current political discourse effectively contributing to this process?

Here we present a framework to understand the stakeholders' point of view on the obsolescence and ending service of residential buildings, and provide social circular solutions for different stakeholders in Japan.

2. Material and methods[27]

In this study, the problem of short-lived buildings was analysed through a qualitative approach, which includes four tools: a literature review, a media analysis, expert interviews, and participatory observations. These tools are applied in a coordinated way and complement each other.

First, the authors conducted a review of the recent scientific literature, in order to frame the current state of the discourse on short-lived buildings, the associated problems, and the counter- measures that have already been adopted.

Additionally, the authors performed an extensive media analysis, based on articles from online newspapers and expert blogs published between 1 January 2013 and 31 August 2018. A total of 47 media articles (see Appendix) concerning Japan were selected by combining the following keywords: "vacant house", "abandoned house", "empty house", and "short lifespan house". The identified

[24] This chapter has been published as: Wuyts, Wendy, Alessio Miatto, Raphael Sedlitzky, and Hiroki Tanikawa. "Extending or ending the life of residential buildings in Japan: A social circular economy approach to the problem of short-lived constructions." *Journal of cleaner production* 231 (2019): 660-670. I designed the research, collected and analyzed the research data, conducted the literature review and drafted the manuscript. The other authors made substantial contributions to the interpretation of the research data, came up with the structure of the article and substantially critically revised its content.

[25] As noted in chapter 2, the findings are based on a small sample of interviews and observations in selected smaller case studies in Japan, namely mostly in Onomichi, complemented by findings from a thematic analysis of English news media. Therefore, the findings are not representative of the whole of Japan. Chapter 6 will discuss how relevant these findings are for Japan or globally.

[26] The footnotes in this subchapter are not previously published in the journal article which had a world limit. These footnotes provide clarifications and further evidence for certain statements in this article. I want to thank Shirakawa Hiroaki sensei for helping me to identify where I had to provide these footnotes.

[27] Chapter 2 provides more detailed information about the methods and materials.

narratives were then categorized into different groups (i.e. actors, root issues, ongoing and proposed solutions, and barriers for solutions or problems) and further processed to portray the media discourse on short-lived buildings in Japan[28].

Second, the authors designed the guidelines for the expert interviews, based on the findings collected during the literature re- view and the media analysis. A total of 20 interviews with experts were conducted, most of them in Onomichi (a town in Hiroshima Prefecture); this location was chosen for its strong local community, which is actively reclaiming abandoned houses. During the visits to Onomichi (in January, February, and August 2018), interviews with 13 experts were conducted: 2 non-profit organisa- tion (NPO) representatives (including 1 community architect), 1 guesthouse manager, 1 ex-urban planner, 2 art professors in the role of community leaders, and 7 do-it-yourself (DIY) abandoned house reclaimers.

On separate occasions, 1 company chief executive officer (CEO) of an international wooden house construction com- pany, 1 architect employed in a firm specialised in wooden con- structions, and 4 academics (from the fields of building, engineering, and architecture) were interviewed.

The transcripts of the interviews were analysed through a qualitative content analysis (Mayring, 2010). The main narratives contained in the transcripts were identified, categorised, and abstracted, in order to detect the central rationales of the actors involved.

Moreover, the authors realized participatory observations at community meetings and workshops in Onomichi, Nagoya, and Gifu, in order to better capture the point of view of local communities on the issue of abandoned houses and short-lived buildings.

Lastly, the authors cross-checked the results: the findings of the qualitative analysis were compared with historic statistical data on the lifespan and construction of houses in Japan since the Second World War.

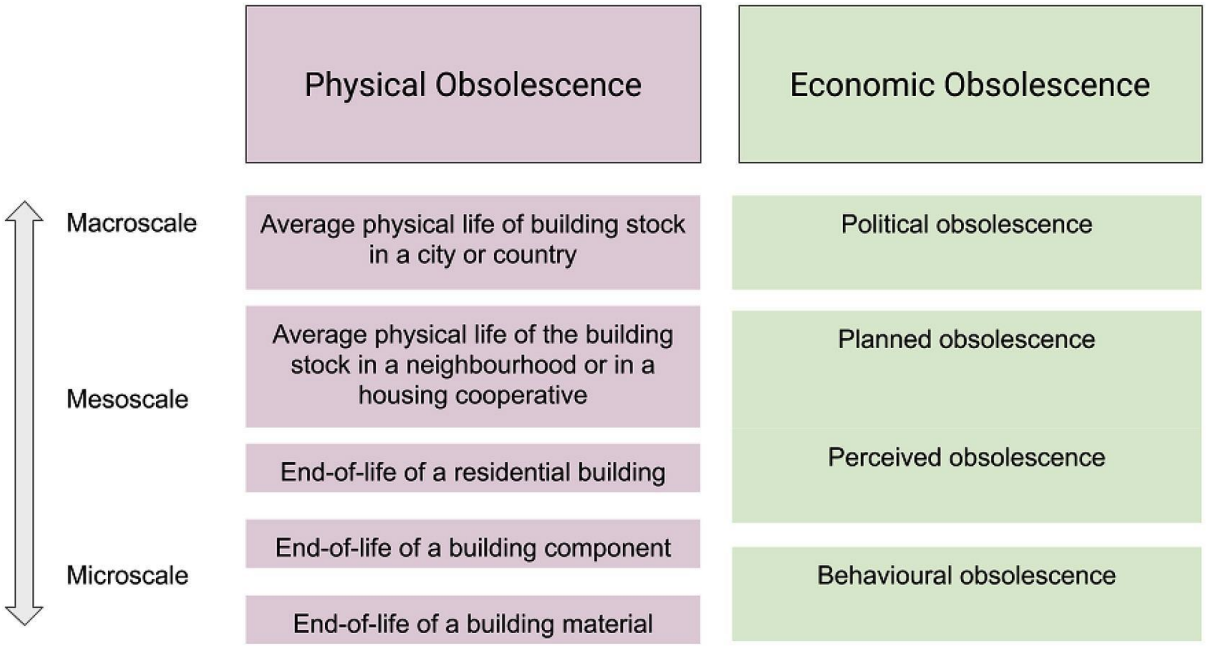
3. The concept of (residential) building obsolescence

A concept often encountered when discussing the lifespan of products is ‘obsolescence’. Obsolescence can be defined as a decline or loss of utility or structure of an object, building or product and different mechanisms can lead to the decrease of the building’s utility or structure (Thomsen et al. 2011; Pourebrahimi et al. 2010). Abramson (2016) defines it “as a situation in which the design lifespan of a product (i.e., in this case a building) is not met”. Thomsen and van der Flier (2011) defined building obsolescence as “a process of declining performance resulting in the end of the service life. They identified different causes of obsolescence and categorised them along two axes: the first axis accounted for physical and behavioural obsolescence, while the second accounted for endogenous and exogenous obsolescence. Overall, they described four types of obsolescence: endogenous-physical (e.g., poor initial quality of the building or physical decay), exogenous-physical (e.g., pollution, natural disasters), endogenous-behavioural (e.g., mismanagement of the building, poor design), and exogenous-

[28] I used a Google Spreadsheet (See Appendix 1). I would read the articles several times, in order to refine the choice of codes and identify four themes. Besides bibliometric facts (year publication, cities, places they mentioned, the name of the newspaper or blog), I used final codes/columns that I used, based on four themes: 1) root problems, 2) which (proposed) solutions are mentioned? 3) Which stakeholders are mentioned and/or interviewed in the article? 4) Which problems and barriers do stakeholders face in finding solutions or plans? Additionally I collected interesting quotes and noted if they referred to scientific papers and policies. I verified the source, if that was available digitally and (if in Japanese) could be translated with a translation machine. That helped me to find ‘new evidence’, which is more scientifically grounded. I also noted if it was about the problem of short-lived, empty or both houses. I counted how often a code was mentioned. However, I noticed that some articles copied the content of other blogs and did not give too much weight to the amount of times that a code is mentioned, but rather to the quality of the article (based on the fact if they refer to scientific reports, policy documents, the stakeholders that they might have interviewed…).

behavioural (e.g., changing land value or government regulations, like construction standards) obsolescence (Thomsen, van der Flier, and Nieboer 2015; Thomsen and van der Flier 2011). These authors, like Akyurek and Ciravoglu (2017), pointed out that almost no research has been done on planned obsolescence from an architectural point of view. Building obsolescence might be properly understood only by focusing more on emotional, cultural, political, and economic factors (Abramson 2016; Akyurek and Ciravoğlu 2017). Several studies focused on Western developed countries indicate that buildings are rarely demolished following the degradation of the main structure (Ramage et al. 2017; Buchanan et al. 2011) or technical failures (Seiders et al. 2007). Moreover, Liu et al. (2014) argued that in East Asian countries authorities play a more influential role on the urban renewal processes than in Western countries (Liu et al. 2014), so one could argue that political obsolescence could be more common in East-Asian countries with a strong developmental policy.
The obsolescence of residential buildings, as derived from the literature, was categorized according to their scale and to causal factors (Fig. 10). The causal factors were divided in two main cate- gories: physical and economic obsolescence. Economic obsolescence is divided into political, planned, perceived, or behavioural obsolescence on the basis of driving factors at different scales. Physical obsolescence refers to technical factors and material dimension. Scale refers to the complexity of the assessment and will be discussed in sections 4 and 5. The following paragraphs discuss the literature on physical and economic obsolescence and conclude with a summary of previous studies on Japanese post-war houses.

Fig. 10. Relationships between different types of obsolescence in a multiscale built environment.



Source: Wuyts et al. 2019

3.1 Physical obsolescence

The term physical obsolescence refers to shortcomings in the physical attributes of a building (e.g., unstable foundations, leaking roof, unsafe structure in relation to expected seismic events). Shortcomings can be caused by endogenous (e.g., aging materials, weathering, construction failures, poor design) or exogenous (e.g., natural or man-made disasters, air pollution, acoustic discomfort) factors (Thomsen, van der Flier, and Nieboer 2015; Kintrea 2007). The term “exogenous factors”

referred to environmental forces in the context of a Dutch housing stock assessment for several housing cooperatives (Thomsen, van der Flier, and Nieboer 2015). Dutch houses are particularly affected by endogenous obsolescence, while Japanese houses are much more likely to be affected by exogenous factors. In fact, Japan is exposed to a large number of natural disasters (e.g. strong earthquakes, typhoons, tsunami, landslides, floods, volcanic eruptions) that lead to material stock loss (Hiroki Tanikawa, Managi, and Lwin 2014).

The available literature on buildings' physical obsolescence indicates that this aspect has been assessed at different spatial scales by several authors: at the district scale (Thomsen, van der Flier, and Nieboer 2015; Hiroki Tanikawa and Hashimoto 2009), on a single type of building (Bastos, Batterman, and Freire 2014), on building components and structural building materials (Seiders et al., 2007). Winistorfer et al. (2007) reviewed not only buildings' obsolescence, but also noted how houses can be disassembled and building components or materials be reused through recycling (Winistorfer et al. 2007).

This study can infer that the lifespan of the built environment, at the building or local scale, depends on the lifespan of its structural components. The dominant structural materials in Japanese buildings are reinforced concrete and timber (Tanikawa and Hashimoto, 2009). Concrete is susceptible to chemical (e.g., carbonation, reactions with chlorides) and thermal (e.g., freeze- thawing cycles, high temperatures effects) degradation; meanwhile, timber is generally perceived as a more perishable material. Nonetheless, in a properly designed and maintained building these structural materials could easily outlive a 30-year lifespan.

The design of Japanese houses has improved significantly since the 70's, due to the needs of the modern working lifestyle (introduced during Japan's economic miracle), and to the introduction of stringent building regulations. Major changes in Japan's building codes were brought by the introduction of the Building Standard Law (BSL) in 1981; this law required buildings to withstand medium-scale earthquakes without suffering structural damages, nor collapse as a consequence of large-scale earthquakes (Hasegawa, 2013). The Century Housing System, a voluntary certification system initiated in 1986 by the Japanese Ministry of Construction, stipulated guidelines in terms of building durability, appliances, and ease of maintenance; this system was not suc- cessful, since many consumers could not assess the quality of the buildings (Minami 2016). The Housing Performance Indication Standard, enacted in 2000, extended the minimum standards of the BSL to non-structural performances, such as thermal conductivity and soundproofing (Hasegawa, 2013). Unfortunately, it is still optional to apply this norm; hence, houses designed after 2000 might not meet the correspondent standards. Despite the existence of all of these norms that aim to promote quality housing, the average lifespan of Japanese buildings is still equal to 1/3 of that in Western countries. Overall, these observations suggest that the short life of Japanese houses is not related to their structural characteristics.[29]

[29] Note after publication of the article: In case of physical obsolescence, it means that it is 'too late' for circular economy strategies, if I do not include recycling, and in particular downcycling, as a circular economy strategy (Bocken et al. 2016). However, urban mining and recycling should not be omitted in urban planning, because they can still have some value for society. The problem is that the built environment is heterogenous; not all components of the inside and outside deteriorate at the same pace (Lanau et al. 2019). Previous studies elucidate that physical obsolescence can be studied at different spatial scales: "at the district scale (Thomsen et al. 2015; Tanikawa and Hashimoto, 2009), on a single type of building " (Wuyts et al. 2019). Another level to study obsolescence and identify circular economy strategies is on the level of building components and structural building materials (Seiders et al. 2007, Arora et al. 2020, Winistorfer et al.20). For instance, Arora and his colleagues (2020) studied CE potential of building components which are retrieved from buildings in Singapore and could serve nearby emerging housing markets.

3.2. Economic obsolescence

The economic obsolescence of a residential building is defined as the end of its economic or service life, which can lead to demolition, deconstruction, or vacancy. The economic life of a building is defined as the assumed or expected period of time during which the costs and benefits of a building are assessed, with the aim of deciding its design and management (Bradley and Kohler, 2007); in particular, it can refer to decisions made by both consumers and producers.

Economic obsolescence can be considered at three different spatial scales: while the lifespan of a house is ultimately decided by the owners (i.e., microscale), they are influenced by construction marketing strategies and by real-estate companies (i.e., mesoscale), as well as by power structures, ideologies, and legislations (i.e., macroscale).

Microscale economic obsolescence can occur when the owner or tenants of a house do not occupy it. This can happen at any moment during the life of a building. In fact, owners can decide to demolish the house (ending its physical life), or alternatively continue to live there, rent, sell, transform, refurbish, or abandon it (extending its physical life). Thomsen et al. (2011, 2015) differentiated between endogenous and exogenous behavioural obsolescence; however, this article sees exogenous behavioural obsolescence mainly dependent on the political sphere, and considered only endogenous behavioural obsolescence. It is fundamental to understand the influence of personal decisions on buildings' demolition, since the ultimate decision on this matter will be that of the owner. This is especially relevant for Japan, where the majority of people own the place they live in, mainly following the rapid economic growth and diffusion of wealth that the country experienced during the second half of the 20th century (Waswo 2013).

Planned obsolescence is the practice of planning or designing a product with an artificially limited useful life, in order to hasten its replacement and increase revenue (Hollander et al. 2017). When planned obsolescence is applied to architecture, it translates into this article's concept of mesoscale economic obsolescence: functional buildings are replaced with new ones, in order to maximise land value and revenue (either by selling or renting the building). This practice started at the beginning of the 20th century, at the spread of the industrial revolution, and escalated in the second half of the same century (Abramson, 2016). Goetz (2012) noted the importance and influence of economic dynamics (e.g., land value) on this phenomenon, which have led to changes in the built environment, renovations, and large building activities (Goetz 2012). These authors also pointed out that there is no evidence of a deliberate planned obsolescence for buildings, contrary to what happens for other consumer goods (e.g. electronic products). However, construction, demolition, and real estate companies are stakeholders who benefit from a large number of (de)construction activities and are interested in maintaining the status quo. Nowadays, although solutions for long-lived buildings are available in Japan and building standards oblige designers and builders to comply with certain minimum quality requirements (Hasewaga, 2013), construction companies heavily promote new designs and technologies through their marketing campaigns, encouraging customers to replace old buildings with new ones. This theory was explored by Winistorfer et al. (2007), who pointed out how desirability constitutes a more important decision criterion than durability in the design of a house. Information asymmetry in the available literature concerning Japanese housing (Table 5) can lead to uninformed or negative judgments: consumers do not possess enough knowledge to make the most rational decisions concerning their house (e.g., about moving, remaining, buying another house). Noguchi (2003) stated how most housing manufacturers are now establishing their own standards for structural resistance, inducing confusion in the customers (Noguchi 2003). Additionally, Hasewaga (2013) noted that the introduction of the housing performance index in the 20th century resulted from the customers' incapability in assessing the quality of their houses.

Macroscale housing obsolescence, on the other hand, tends to be caused by political and ideological factors (Akyurek and Ciravoğlu 2017; Kintrea 2007). These factors resonate with the current social systems and local physical properties (e.g., local resources, climate, topographical features), influencing the way humans organise themselves, as well as the speed and area of diffusion of new technologies, architectural styles, and lifestyles (Diamond 2002, 2013)(Diamond, 2013, 2002). Meen (2016) highlighted that urban forms and land use can be explained by land price[30], a theory that can be reconducted to the works of Ricardo (1817) and Von Thünen (1826). Furthermore, Meen (2016) observed that demolition is often triggered when the prospected value of a redevelopment exceeds the current value plus the demolition cost (Meen 2016). Several scholars exemplified how urban economy can drive the shape of cities, but also how the terms of this development were defined by the political-ideological discourse (Akkerman 2009; Attwood 2012) (Akkerman, 2009; Attwood, 2012). Abramson (2016) further analysed the phenomenon, concluding that political obsolescence always[31] serves the interests and ideologies of the elite, causing premature obsolescence[32].

3.3. Previous studies on the obsolescence of Japan's post-war houses

The obsolescence of a building can be caused by a combination of different factors. Reade (1985) investigated the phenomenon of premature housing obsolescence (i.e., the demolition of a building well before the end of its expected lifespan) in Great Britain and Sweden, identifying four possible causes: technical, economic, behavioural, and political (e.g., poor design, excess of supply, inappropriate management practices, spatial class segregation) (Reade 1985). In the case of Japan, this study noticed a set of additional causes that are leading to the demolition and/or abandonment of residential buildings (Table 5). Among the main causes, we found the preference of Japanese consumers for new houses and their aversion for preowned buildings, as well as the impact of political decisions. According to a white paper by the Ministry of Land, Infrastructure and Transport (MLIT), in 2008 the percentage of second-

[30] If the land price is high, this might result in the preference for development that generates high value to pay back the costs that are made. Joanna Williams (2021) illustrates also how low-value activities, that could be seen as circular activities, or activities that enable circular economy, would not make a chance with high-value activities as real estate development. Tsui argued how urban manufacturing is important for circular activities like repair, but that only high-value industrial activities such as the diamond industry can survive in cities, like New York City, Antwerp, where land has too high a land price (Tsui et al. 2020). Also Van den Berghe and Vos (2019) give evidence, with cases in the Netherlands, that new construction might be compatible with circularity indicators, but that there is a risk that they 'chase away' area functions that are as important for livability and circularity of the area (Van den Berghe and Vos 2019).

[31] Abramson (2016) wrote a book about the phenomenon of obsolescence in architecture. The word 'always' makes this sentence a too strong statement, but in his book he gave examples (mostly of North-American architecture) of buildings that have to make place for new constructions, often higher buildings, as a result of political decisions. Abramson mentions that bigger buildings are often seen as a visible evidence of the investments the policymakers do for their city.

[32] A third type - behavioural obsolescence- was not well explained in this article, but got elaborated more upon in my second article (Wuyts et al. 2020b), which integrated the housing adjustment theory by Morris and Winter. According to Morris and Winter (1975), homeowners or other stakeholders evaluate the conditions of the house with the help of norms. These norms could be family norms or cultural norms. Family norms represent how the family thinks about domains like cleanliness, comfort, convenience and safety, while cultural norms represent the perceptions of the culture about what is clean, convenient and right. "If the current housing conditions do not comply with these norms, a housing need deficit will occur and can lead to an adjustment, like renovation, expansion, or moving out, unless the constraints (e.g., income and time) are too high" (Wuyts et al. 2020a). These constraints depend on the socio economic and psychological background of the involved stakeholders. For instance, if the family expands because of a birth, but the income of the family is too low to move to a bigger house, the family might decide to stay in the house, although their comfort needs are not met.

hand housing transactions in Japan was only 13%, while in the United States, UK, and France it was 78%, 89%, and 66%, respectively (Tango, Yokomatsu, and Ishikura 2011).

Table 5: Causes leading to the short economic lifespan of houses in Japan

Scale	Cause	Explanation	Academic research
Macro	Monetary policy favouring home ownership and new constructions	• Tax system (high inheritance tax, deduction of income tax for real estate investments, mortgage tax cuts for new constructions). • Housing subsidy (higher chance of obtaining it by applying for new houses). • Laws to protect ownership, since the early 20th century (in response to social uprisings related to housing shortage). • Leasehold system, which limited the lease term until year 1992.	Kanemoto (1997), Yoshida (2008), Tango et al., (2011), Koo and Sasaki (2008), Waswo (2013), Matsumoto (2018)
Macro	Inelastic land supply	• Scarce land availability. • High land cost and a burdensome search process (the process for selling land is slow, due to the decision making system; moreover, land use zoning is not detailed and regulations are strict). • Limitation of floor space in buildings.	Yoshida (2008), Koo and Sasaki (2008), Hasegawa (2013), Kanemoto (1997)
Macro	Change of the living standards and lifestyle during the 20th century	• Shift from heavy manufacturing to a service-oriented economy.	Tango et al., (2011), Waswo (2013)
Meso	Influence of the construction sector	• The construction sector invests in marketing strategies that portray the purchase of new houses as safer and cleaner. • Lobbying at political level promotes the construction of new buildings.	Yoshida (2008), Noguchi (2003), Minami (2016)
Micro	Changes in the household cycle	• The housing market is not adapted to changes in the household cycle (marriage, divorce, retirement, job change).	Tango et al., (2011), Minami (2016), Waswo (2013)
Micro	Customer preferences	• Preference for new houses. • Fear that older houses are not earthquake-proofed and dirty; fear for hidden malfunctions, since potential owners do not know the history of the house, etc. • Sense of a new beginning.	Tango et al. (2011)
Micro	High maintenance or renovation costs	• Periodical maintenance (disinfestation, mould removal). • Scarcity of subsidies for house maintenance or renovation. Houses represent illiquid assets. • The value of houses tends to decrease over time.	Koo and Sasaki (2008), Yoshida (2008), Tanaka (2008)

Source:(Wuyts et al. 2019)

4. Results

The theoretical framework of short-lived buildings, presented in section 3, is important for the understanding of our empirical results. This section describes and explains in detail the central rationales and narratives in the context of the current scientific discourse. This presentation of the results will be the base of a critical discussion and assessment in the subsequent section of the chapter.

4.1. Impact of lifestyle changes on built environment renewal

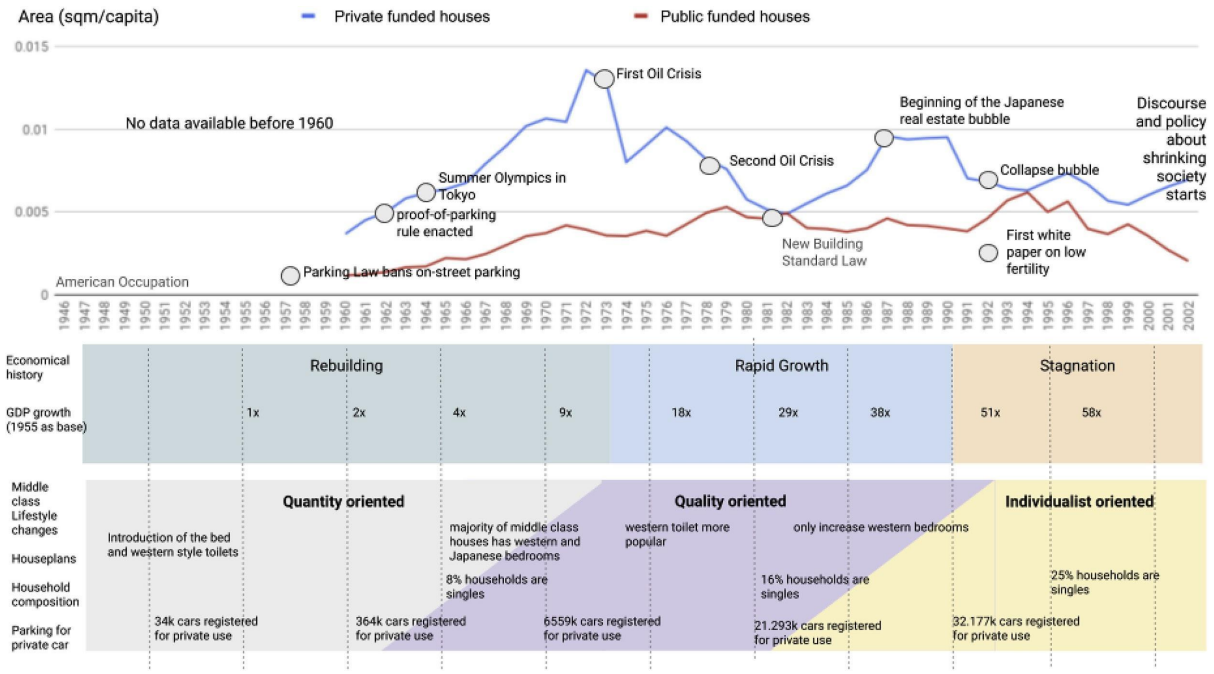
Post-war Japan experienced three waves of socioeconomic changes (a rebuilding stage between 1945 and 1973, a rapid growth between the 1970s-1980s, and an economic stagnation since 1992), which have led to changes in consumer behaviour and consumption (Gordon 1993; Krausmann, Gingrich, and Nourbakhch-Sabet 2011; Waswo 2013). These socioeconomic changes drove the creation of new lifestyles, affecting the built environment every 20-30 years. As pointed out by Krausmann et al. (2011), Japan accumulated large stocks of infrastructure in only 20 years since the end of World War II, and renewed them during a subsequent wave. However, most houses were not ready for the drastic lifestyle changes that the Japanese middle class experienced after the war (Minami, 2017). In fact, new constructions were required to adapt to the new Japanese corporate culture. Fig. 11 summarises several indicators of lifestyle changes; moreover, it includes data on the area of new construction of privately and publicly funded houses in Japan (period: 1960-2002). The trend of public funded houses was added as a reference: they are less bound to idiosyncrasies and more dependent on macroeconomic events (Ozaki and Lewis 2006).

This study identified three stages that marked the style of construction activities in Japan. During the first stage (after World War II), the most important thing was to ensure the construction of enough houses for the whole Japanese population. This necessity led to the production of a large mass of building stock over a period of 20 years, until 1973, when the production halted due to the first oil crisis

(Krausmann et al., 2011; Waswo, 2013). This first stage was characterized by a marked quantity-oriented approach (i.e., construction of housing with short service time): the government aimed at (re)building material stocks as quickly as possible, especially in cities, in order to satisfy the high need for housing. Consequently, many cohorts of houses and buildings from those times ended serving or got demolished. Others even collapsed due to technical factors, like poor initial quality (i.e., endogenous physical obsolescence), and/or the choice of inappropriate structural materials due to lack of knowledge, technologies, and building standards (e.g., use of concrete instead of reinforced concrete). These factors make surviving houses from those times very vulnerable to exogenous physical obsolescence (e.g., earthquakes) if not retrofitted.
The second stage was more quality-oriented and perhaps con- nected to the economic bursting phase during the 70s and 80s (Krausmann et al., 2011). In that period many people could afford to buy new houses, structurally more stable and of overall better quality than those built in haste just after World War II. The in- fluence of Western values and ideas (e.g., individualism), combined with the marked labour division between men and women (which assigns women to the domestic sphere (Ozaki and Lewis 2006; Bullock, Kano, and Welker 2017; Frost and Gordon 1995; Nish 2008), brought several changes in Japanese homes: for instance, futons and tatami rooms were pro- gressively replaced by beds and hard floors (Ozaki et al., 2006). Additionally, the introduction of new household appliances called for larger rooms, and caused an increase in the overall household energy consumption. House plans changed gradually: in the 80s, western style bedrooms started to be built in almost all new con-structions (Ozaki et al., 2006). The introduction of new building laws and quality assurance systems reflected the readiness of Japanese citizens to afford more expensive homes in favour of quality; this situation eventually led to urban renewal. Another interesting aspect is the large diffusion of personal automobiles in the Japanese middle class since the 1970s, which was partially responsible for the wave of constructions: a proof of parking became necessary in order to purchase a car in Japan and many houses from previous waves did not include a parking lot or garage.

The wealth gained during the quality-oriented stage induced changes in lifestyle, including an increase in the number of single households, delays in the birth of the first child, and the diffusion of higher education (causing people to enter the workforce later in their lives); moreover, the corporate lifestyle became wildly spread and accepted. The combination of all these factors exacerbated the low fertility rate and population shrinkage that Japan is currently experiencing (Hattori, Kaido, and Matsuyuki 2017). At the burst of the Japanese economic bubble, more than 25% of all households were composed of a single person (Fig. 2). Upward social mobility and the associated geographic movements from rural to urban areas, which had started in the previous century, strengthened at the end of the 20th century, following a sharp decline in many domestic agricultural goods (e.g., wood, tea), and political changes in the early 1990s: financial resources were increasingly concentrated in urban areas. All of these socio-economic changes resulted in a further renewal of the built environment: the demand for small apartments in popular cities (e.g., Tokyo, Nagoya) reshaped the geographical distribution of in-use stocks.

Figure. 11. “Area of new construction of privately and publicly funded houses, stages of economic history, macroeconomic events, and lifestyle changes in post-war Japan during the 20th century.



Source: Wuyts et al. 2019, Data source: "GDP baseline year: 1990. Source of data: Information Policy Division, Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Statistical Survey Department, Statistics Bureau, Ministry of Internal Affairs and Communications, Economic and Social Research Institute, Cabinet Office, Government of Japan, Registration and Information Division, Road Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Hattori et al. (2017), Ozaki et al. (2006), Krausmann et al. (2011)" (Wuyts et al. 2019).

4.2. Stakeholders and their motivations

Obvious stakeholders are the local and national governments, interested in providing affordable houses for the whole population, but also lobbied by construction companies that promote the cre- ation of new buildings. Local governments are primarily affected by the consequences of short-lived buildings, since they have to handle the needs of the local population and mitigate the environmental impacts associated with the consumption of resources (during constructions) and the generation of waste (during demolitions)[33]. On the other hand, the central government limits its actions to the prescription of constructions, the imposition of environmental laws, and the design of taxation systems[34]. Universities and other research institutes work as analysts and consultants, but on rare occasions they are involved in pilot projects (e.g., the Kitakyushu Renovation School) well received by the media. Amongst the stakeholders interested in boosting new constructions, construction companies are on the forefront. These businesses push for the creation of wealth through the creation of new buildings; moreover, they minimise their capital risk by favouring the construction of condominiums, discriminating against potential renters, and avoiding non-profitable second-hand houses[35]. Many construction companies include architects. Interestingly, Japan is one of the countries with the highest number of architects per capita; many of them have been working exclusively on new constructions, perhaps due to the existence of a profitable and large market base in the country.

[33] Results of media analysis, see Appendix 1.
[34] Results of media analysis, see Appendix 1.
[35] Results of media analysis, see Appendix 1.

On the opposite end of the spectrum, there are small or medium scale social initiatives battling against the vacant house syndrome. These non-profit organisations (NPOs) act as intermediaries between the local governments and low-income people looking for accommodation, championing projects involving the refurbishment of abandoned homes and their donation to underprivileged people. Surprisingly, these NPOs include Japanese artists and tourism agencies, which increasingly aim to transform empty houses into commercially attractive tourist spots. The houses chosen for the NPOs' projects are usually traditional, with a high historic or aesthetic significance, and are often converted into community centres, shops, or preserved as cultural heritage (Ono 2018). Religious institutes are also actively preserving old buildings, either in the role of landlords leasing land, or as benefactors: they tend to not engage in economic speculation, contrary to corporate landowners.

Hence, the short service time syndrome that Japan is facing cannot be ascribed to deliberate consumers' actions; rather, it represents one of the unintended consequences of the changes in legislative framework, power structures, and lifestyle that occurred after the Second World War. In post-war Japan, citizens were encouraged to organise their lives according to a standardized life path, which involved geographical and social mobility. This included: moving from the country to the city, competing to gain admission to (top) universities in cities, getting a stable job in a big company, marrying and buying an apartment, having children and educating them to enter the same life path, retiring, and finally living on a pension.

The arguments of insufficient design, harsh climate and natural disasters, or economic benefits are commonly used by stakeholders to justify the demolition and reconstruction of houses. However, a deep analysis of the citizens who resisted the aforementioned standardized life path reveals a different logic: the action of building a new house represents an acknowledgement for citizens experiencing upward social mobility. Citizens who achieve the construction of a new house tend to identify themselves as successful and well-doing in a conform country like Japan. The short lifespan of housing in Japan mainly derives from cultural mental models, rather than from technical or economic circumstances[36]. Therefore, institutional and social programs should be continuous and systematic, focusing not only on the built environment, but also on citizens' behaviours, the work- life balance, and social welfare. These kinds of programs will increase the lifespan of housing more effectively than approaches favouring technical fixes. At the moment, the implementation of innovative programs is impeded by several governmental institutions and the lack of institutional cooperation; overall, this situation is leading to a slow adaptation to pressing societal concerns. Citizens that practice circular economy and want to extend the lifespan of houses can be guided by psychological and/or economic motivations, and not necessarily by environmental concerns. Although circular economy promotes resource efficiency and promises environmental benefits, this notion is hardly ever mentioned outside of the academic debate. When NPOs and their do-it-yourself (DIY) renovation activists were interviewed about their motivations, environmental motives were rarely mentioned. Rather, among the primary reasons this study found the low investment costs and the need for a 'slower and more meaningful life'. Their responses resonate with the content of a recent research concerning internal migrations in Japan (J. Y. Lee, Sugiura, and Others 2018): social, psychological, and micro-economic concerns appeared as the main factors motivating people to move (back) to the countryside. Furthermore, the reclaiming and

[36] This study built on previous research, by combining the quantification of short lived buildings with insights from local com- munities and citizens, and with a cultural historical analysis of the post-war disposable house culture. Analysing the values, attitudes, and motivations of stakeholders in Japan during the second half of the 20th century, this study could disentangle the non-technical factors behind the short use and disposal culture of housing in both the previous quality-oriented and the current individualist- oriented stage. The observed situation in Japan reflects the unin- tended consequences of regulatory frameworks, socioeconomic changes, geographic-upward social mobility, and induced lifestyle changes in the middle class, which led to a linear economy for the built environment.

preservation of old houses can be understood as a symbol of conscious lifestyle- choice, through which these citizens reject the ideal of upward social mobility.

4.3. Proposed and undertaken actions in Japan regarding short-lived houses

The Japanese national government is already focusing on extending the economic life of buildings. The Act for Promotion of Long-Life Quality Housing, implemented in June 2009, granted tax reductions and subsidies to households, as well as to small and medium building landlords, for building renovation. This act partly represented a countermeasure to the forecast labour shortage and promoted the construction of houses that could be more adaptable to changes in the household cycle (Minami, 2016). However, as previously mentioned, many Japanese people want to live in newly built homes and aspire to rebuild their house every few decades. Some media articles have acknowledged this situation and advocated for the assignment of more power to local governments, in order to balance ownership rights and public benefits, promote the renovation of old houses, and revert the capitalistic concept of monozukuri ('making things') that characterised the rapid Japanese economic growth after the Second World War (Jones, 2015).

A second action, which has been discussed but has yet to be implemented on a large scale, is the reclamation and reuse of empty houses (e.g., as guesthouses, art galleries, coffee bars). The media praise this kind of action (e.g., 'Nowadays young people don't have much money, so they won't hesitate to buy older buildings'; Berg, 2017). Yet, these kinds of actions are sporadic and isolated, perhaps because most of the empty houses are located in areas with low land value, are exposed to pollution, do not have attractive views, and/or possess low construction standards (Kintrea 2007; Goetz 2012). For these reasons, generally such constructions are reclaimed by the least affluent citizens: blue-collar workers, ethnic minorities, and immigrants.

The reclamation of abandoned buildings has some regulatory barriers. First, there is a lack of a regulatory framework, such as a centralised system for the organisation and update of land records. Presently, Japanese landowners are not legally required to update their ownership information in case they change their residency: land ownership information is loosely organized across an array of different stakeholders, hindering local governments from tracking owners. Second, before the implementation of 'The Act on Special Measures Concerning Vacant Houses', local governments did not have the power to claim, demolish, or insert abandoned houses in an 'empty house register' accessible to interested buyers; in that case, they could be sued by the owners. Nowadays, each local government has its own array of policies, financial instruments, and projects to attract buyers. The safety net law was revised in order to allow the renovation and rental of these houses to low-income individuals and families, who were previously unable to access public housing. Two journalists stressed the importance of this revision: 'According to a 2014 survey by the Japan Rental Housing Management Association, 68% of Japanese landlords do not rent to disabled people, 61% do not rent to foreign nationals and 60% do not rent to seniors' (Brasor and Tsubaku, 2017). The journalists remarked that one of the main problems was represented by the lack of coordination between the ministries of housing and welfare[37]. These observations highlight again the need for a reform that would improve institutional capacity and coordination at the national level.

During conversations with more than a dozen of Japanese citizens (between 20 and 50 years old) involved in the reclamation of empty houses, we observed an homogeneous set of aspirations, opinions,

[37] More correct naming: Ministry of Land, Infrastructure, Transport and Tourism and Ministry of Health, Labor and Welfare

and lifestyles: they were represented by DIYers, which had decided to abandon their hectic and lonely lifestyle in the big city and search for a new community. The ideal lifestyle and values of these citizens resonated with those of a typical circular economy consumer (Camacho-Otero, Boks, and Pettersen 2018). As mentioned in the previous subparagraph, these young people do not only renovate old houses because it is cheaper than buying new ones, but also because the associated frugality and sense of community give more meaning to their lives. Some of them even stated to be living resisting mainstream consumption.

However, reclaiming abandoned houses might be a poisoned chalice. On multiple occasions during the interviews it was remarked that a significant part of the reclaimed houses was in areas characterized by high environmental risk (e.g., landslides, floods). During our last visit to Onomichi (August 2018) the local NPO even informed us about the recent death of two people living in a reclaimed house (July 2018). Moreover, a local architect explained how retrofitting (e.g., the installation of X-shaped beams) could mitigate but not completely eliminate the risk. Renovation subsidies from the local government are not sufficient to cover the cost of an optimal retrofit; hence, people usually choose to take the risk of living in subpar safety.

Although in Japan most demolition waste is downcycled into road beddings (Seiji Hashimoto, Tanikawa, and Moriguchi 2007), that does not close the loop of resources within the residential built sector. An alternative would be the selective deconstruction of old buildings, so as to recover their components or materials. During one visit to Onomichi[38], deconstruction was found to be practiced as part of a personal project by a professor and DIY activist: one empty house had been dissected to the level of building materials, which were employed for arts and crafts by a local group of artists with the final objective of selling them. Unfortunately, this project seems an almost completely isolated case: our research of the academic literature and Japanese media did not provide other examples of commercial initiatives involving the deconstruction of empty houses and the reuse of building components, except for Nagano's Rebuilding Center, where physical obsolescence is discussed at a small scale level and not limited to a single building (Wuyts et al. 2019)".

Lastly, a fundamental precondition to a successful circular economy is the involvement of more stakeholders (Witjes and Lozano 2016). A great example in Japan is the NPO in Onomichi, which organises a series of workshops to increase awareness and spark the debate on repurposing specific empty houses and/or land, assisted by experts in cultural heritage protection. Local multi-stakeholder governance seems to play a very important role in the transition towards a circular built environment; hence, its impact deserves further investigation.

The following table summarizes the interview results: the stakeholders participating in the application of countermeasures to the short- lived housing issue in Japan, their motivations, the root problems, the proposed or undertaken countermeasures, and the barriers faced by the stakeholders).

[38] February 2018

Table 6: Summary of the interview results. The * symbol indicates the interviewed stakeholders.

Stakeholder groups	Motivations for participating in the application of countermeasures
National government (ministries)	Protection of societal investments and environmental resources
Local government *	Protection of societal investments and elimination of risks for the local population
Civil society (e.g., NPOs) *	Enhancement of social networks, conservation of local skills and knowledge
Universities and research institutes *	Sustainable development
Real estate companies	Economic reasons
(Community) architects *	Sustainable development, service to society, cultural heritage conservation
Local activists, artists, and other citizens *	Post-materialist values, anti-industrial values, emotional attachment
Religious institutions	Cultural heritage conservation, post-materialist values

Root problems	Countermeasures	Barriers for countermeasures
Law and regulation side effects	Local reforms: more power to local governments and communities	Lack of flexibility and innovation in regulations and laws
Mega trends (e.g., shrinking society, lifestyle changes)	Changes in national laws and regulations	Financial barriers at different scales (from national to citizen)
Lack of adaptability to new life changes	Investment in behavioural campaigns, to change the values and attitudes of citizens	Legal barriers
Preference for new things and consumerism	Fostering of the housing second-hand market	Cooperation with stakeholders who have materialist values
Fear for natural disasters and belief in technical progress	Investments in more green and renewable construction materials, renaissance of wooden constructions	New customer preferences cannot be integrated easily in the existing housing stock
High maintenance costs of structures or materials	Investments in skills and knowledge concerning the preservation and maintenance of housing	The scattered location of abandoned houses does not comply with compact city planning, housing situated in high-risk zones (e.g., prone to landslides) or far away from many formal work opportunities
High living costs in certain areas in terms of work time	Finding new purposes for the constructions or construction materials	Lack of a registration system for the ownership of houses and/or land
	Reclaim of abandoned constructions for less privileged people (e.g., single mothers)	Spiritual or cultural norms

Source: (Wuyts et al. 2019)

5. Social circular economy strategies for premature, justified and delayed obsolescence

Previous studies demonstrating the abundance of short-lived buildings in Japan and other East Asian countries were mostly based on descriptive aggregate evidence, derived from material flow and stock analysis. However, these accounts did not analyse in detail the underlying causes (mostly social and psychological), nor the power structures behind the disposable housing culture.

This study investigated the causes behind the behaviours of consumers and stakeholders, providing an inclusive cultural and historical reading of house consumption in Japan. Obsolescence in Japan appeared mainly triggered by non-technical reasons. Interviews with architects and engineers validated this theory: the high building standards and advanced construction technologies available in Japan guarantee the construction of quality buildings. Houses are demolished primarily due to economic reasons, or end up abandoned due to the death of the previous owner if the building does not appeal to the real estate market. These observations hint at the very wicked nature of the short-lived house problem (Rittel and Webber, 1973): this is a complex issue, rooted across multiple scales and different stakeholders. The proposed solutions have several legislative barriers that prevent them from being adopted on a large scale. Circular economy identifies different strategies, the majority of which facilitate the flow of materials in value circles (i.e., the same resources keep flowing in the economy, creating value in the market sectors they pass through).

A flow-based CE would consist of value circles like recycling, refurbishing, and remanufacturing. A stock-based society is char- acterized by an economy in which constructions, infrastructures, and other durable products are used for a long period of time. Through the promotion of a stock-based society, stock economic lifespan would be optimized, providing services for citizens for an extended period of time, reducing the need to extract new natural resources, and limiting material flows. In particular, the lifespan of buildings would be extended as long as possible, by incentivising their renovation and reuse. Nevertheless, in some cases the demolition of an old building is preferable to its preservation. This

article provides a framework of obsolescence for residential buildings (Table 7), focusing in particular on the different types of stakeholders and dividing obsolescence in premature, justified, and delayed; additionally, some social CE strategies are proposed. Obsolescence is not something that stakeholders should shun, since it is a part of the natural cycle of a building life and, hence, an unavoidable dimension (Thomsen and van der Flier, 2011). The replacement of a building can be desirable when new and more sustainable constructions can be realised. Buildings that have reached a certain point in their life and whose replacement is encouraged are referred to with the term "justified obsolescence". Such buildings are usually located in exposed areas (e.g., those in Onomichi case), or damaged to that point that the necessary investments for their renovation would be greater than the benefits[39].
'Premature obsolescence' reflects mostly the interests of an elite at the expense of less privileged people (Abramson, 2016). Small residential buildings are replaced in favour of more profitable buildings, following urban economic logistics. This kind of renovation, known as gentrification, has the tendency of pushing previous owners to more peripheral areas, since new buildings are costlier (Abramson, 2016; Akyurek and Ciravog;lu 2017). The phenomenon of gentrification in Japan consists mainly in the removal of old buildings, rather than in the removal of people as observed in Western contexts (where well-maintained old houses and buildings can become a highly-appreciated asset). Nevertheless, the premature obsolescence of buildings in Japan still causes great economic instability to owners, since they become unable to accumulate wealth for themselves and their next generations through home investments[40].

On the other hand, a considerable number of houses in Japan still do not comply with the BSL of 1981: although technically unsafe in case of a major seismic event, they are still occupied, either because of emotional or financial reasons. The term "delayed obsolescence" defines buildings that should have been demolished, or at least retrofitted, but are not. Similar situations are clearly linked to people's lack of economic resources: they cannot buy a new house suited to their needs, renovate, or even maintain their present house. This is often the case for older people or other citizens at the edge of society[41].
Many houses in Japan, built during the quantity-oriented stage, suffer from delayed obsolescence. Policy makers in countries dealing with the aftermath of wars or other severe crises can learn from Japan's history. After World War II, the Japanese government encouraged mass ownership by providing financial incentives (e.g., house loans) to citizens, rather than social housing programs, although many people had lost their capital. This likely nudged high-risk loan borrowers into purchasing low-quality houses; alternatively, citizens were nudged in buying normal houses, but without much capital left for their maintenance and improvement in the following decades. Different socio-economic or psychological characteristics in the population influence their maintenance and house improvement behaviours, which in turn affect house appreciation (Hayunga, Pace, and Zhu 2019).

---

[39] Justified obsolete buildings do not exist anymore; but their non-existence should not be a source of environmental or social concern for policy makers and other stakeholders. However, it is still interesting to know why these houses were built in the first place, in order to learn some lessons for future design.

[40] In the case of postwar Japanese short-lived and vacant housing, one could say that a significant proportion is prematurely obsolete. These houses can still exist, but can also be demolished in the studied historical periods.

[41] The latter is motivated by the acknowledgment of a social justice dimension, and the social impacts I observed on field visits or recorded in formal and non-formal conversations with stakeholders in Japan and challenged my first activity model (see subsection about soft system methodology). Circular economy, in the narrow meaning, does not imply it will lead to the fulfillment of all Sustainable development goals. Therefore, I added 'social' to the circular economy in the title of my first paper (Wuyts et al. 2019) to elucidate that circular economy misses a social justice and equity component. These three types in which non-existing-anymore and existing houses for a given historical time period could be connected with certain social circular economy strategies.

Table 7. "Conceptual framework of obsolescence in residential buildings; PL: physical lifespan, EL: economic lifespan" [42]

Timing	Stages of obsolescence	Lifespan	Typical profile of stakeholders	CE strategies
Before time	**Premature physical** (i.e., demolished too early)	Low PL	Citizens with relatively high and stable income	Cooperation and multi-stakeholder assessment, monetary policies, continuous behavioural campaigns
	Premature economic (i.e., unoccupied)	Low EL, relatively high PL	Various	Local government involvement, restriction of new constructions in shrinking regions, reclaim of abandoned houses
On time	**Justified**	Medium EL and PL	Various	Deconstruction and sale of reusable building components and materials
Overtime	**Delayed**	High PL	Citizens with lower income (e.g., elderly, single mothers, divorced women, low-income young adults)	Government support, reclaim of abandoned houses in safe areas

Source: Wuyts et al. 2019

The study indicates that a people-centred approach (i.e., on a case-to-case basis) is the most effective method to tackle premature obsolescence. Demolition is encouraged for older, unsafe, and unsanitary buildings, at the condition of retrieving all valuable components (e.g., metals). The will to demolish an old building (i.e., justified obsolescence) should not be confused with its perceived obsolescence, which is used by stakeholders to justify its demolition (on the basis of a subjective opinion, rather than on a rigorous objective judgement). Identifying the moment in which obsolescence is justified is particularly challenging and requires a case-by- case assessment, preferably through the input of different stakeholders; moreover, it requires investigations on the costs, benefits, and a cradle-to-grave environmental assessment of the benefits linked to the construction of a new building versus those linked to the lifespan extension of the existing one.
In order to divert people from living in delayed obsolete buildings, the government should put in place renovation or relocation incentives, and inform stakeholders about the necessity of improving the quality of living. Policy makers have a major role in addressing the issue of empty houses.

The design of better strategies in a material stock-based CE requires specific measures to counteract the psychological causes of the current situation. The already established 'Act for Promotion of Long-Life Quality Housing' can contribute to the change. This study highly recommends larger investments in continuous behavioural economics, more cooperation between ministries (e.g., construction and welfare ministries) addressing the influence of the marketing strategies of housing manufacturers, and changes in the current property-tax system. Even more so than technical solutions and innovations, the problem of short-lived houses in Japan requires the creation of local and national governmental programs that address certain social norms, encouraging a longer use, the improvement, and/or the maintenance of houses.

[42] Inspiration from Europe: A strategy could be governmental interventions, like taxes or subsidies. The results of the experiments of the pioneering Superlocal project in the Netherlands indicated that the costs for reusing building components is 2,5 higher than if virgin building components were used especially if the old buildings were not designed for disassembly[#]. The labor costs were too high; therefore the practitioners proposed tax reductions for labor costs, higher tax for the use of virgin building components, and higher disposal fees for projects with low reversibility score were recommended[#]. The buildings in Japan are also not designed for deconstruction, and therefore it is expected that labor costs will also be high, but this is not evidenced yet.

Chapter 4: Identifying and locating the circularity potential of vacant houses in selected neighbourhoods in Kitakyushu[43] [44]

1. Introduction

'Empty houses' do not occur in helpful clusters. Rather than an urban cancer, to be cut out by abandoning the declining neighbourhood, they are a kind of urban measles. Individual houses fall empty in every neighbourhood when their owners grow old. For Japan's mayors, measles is the most painful disease. They are left with the same costs—the same lengths of road and number of primary schools are required—but an ever-falling population of taxpayers who can pay for it all (Harding 2015).

Japan is a country with a rapidly ageing population (Hattori, Kaido, and Matsuyuki 2017)and many vacant houses. According to the latest survey, the national residential vacancy rate reached a new record of 13.6% (Japanese Ministry of Internal Affairs and Communications 2019).

Harding's metaphor draws attention to two crucial aspects that Japan is called to face: the difficulty of understanding the spatial–temporal development of vacant houses within urban areas, and the management of the social costs related to this phenomenon. Although Harding claims a lack of specific spatial patterns behind the vacant houses, recent Japanese studies in geography have revealed different dynamics for different areas within cities, especially when they added in a temporal component (T. Kubo and Yui 2019).

According to the studies of the spatial distribution of vacant houses within city boundaries, Nishiyama (2019) identified that vacant houses in megacities like Tokyo are mostly situated in suburban areas, while smaller cities tend to experience vacancies mostly in the city centres (Nishiyama 2019). This article verifies these findings and uses this understanding to propose and discuss solutions.

To examine the second aspect, this article assesses the societal, economic, and historical context in which the phenomenon occurs and proposes measures to prevent and reduce the social (e.g., weakened social fabric) and environmental costs (e.g., leakage to the environment, avoided material extraction) of vacant houses. There are a large number of vacant houses scattered around Japan. In addition, the average lifespan of Japanese houses is only 20–30 years (see chapter 1), which leads to a high demand for construction materials. Considering the push towards urban sustainability, academic experts are advocating that societies move from the continuous construction of new buildings to a circular built environment (Pomponi and Moncaster 2017). While the first term conveys the practice of constructing and demolishing without efforts to reduce the environmental and other impacts, the latter term encompasses practices in design, construction, maintenance, and deconstruction that are in line with circular economy (CE) principles.

As part of this shift, the study of vacant houses in shrinking cities will be increasingly important going forward. First, although age-related vacancy is mainly found in Japan, many rapidly growing cities are dealing with underused material stocks, and regions of Europe and the USA are already coping

[43] This chapter has been published as: Wuyts, W., Sedlitzky, R., Morita, M. and Tanikawa, H., 2020. Understanding and Managing Vacant Houses in Support of a Material Stock-Type Society—The Case of Kitakyushu, Japan. *Sustainability*, *12*(13), p.5363. I designed the conceptual framework, collected and analyzed the secondary research data, conducted the literature review and drafted the manuscript. Sedlitzky substantially critically revised its content and conducted literature review. Morita collected primary data on the field and made the calculations. Tanikawa designed the quantitative estimation method. I made substantial contributions to the interpretation of the quantitative research data. Morita designed the map with my requirements.

[44] Only the challenge of vacant housing is addressed in this paper/chapter; as the method is only applicable to this challenge. It measures what is physically present in that moment, and cannot locate short-lived houses.

with the social costs (Haase et al. 2014; Döringer et al. 2020). In addition, temporary vacant housing should not be considered a social problem because old temporary residential areas may attract future investment (T. Kubo and Mashita 2020). However, when vacant housing is a symptom of permanent stagnation, as in the case of many Japanese cities, this social problem, when not managed in the right way, can lead to social disorder and the expansion of slum-like areas (T. Kubo and Mashita 2020).

Mobilising vacant houses can also be considered as a strategy in the transition toward circular cities. In this regard, it might seem surprising that the spatial dimension of the circular economy has not been explored well in the existing research. One reason could be that in industrial ecology, which is one of the fields at the foundation of the circular economy (Ghisellini, Cialani, and Ulgiati 2016), space is a rather neglected dimension and the circular economy is often seen solely as the sum of businesses (Julie Marin and De Meulder 2018b). This study aims to address this gap in the research on the urban circular economy by including space as a resource in the model. In other words, buildings are not only stocks of materials, but also stocks of space and should therefore be included in any local sustainable development strategy. Hence, in circular cities, buildings should serve societies for as long as possible; when their service time ends, the buildings should function as a reservoir of secondary materials and urban mining (the practice of recovering secondary resources from obsolete sinks of materials in cities), which could help reduce the embodied environmental impacts (Lanau et al. 2019).

In Japan, the vision of a "material stock"-type society was put forth by the Japanese Ministry of the Environment in 1999: "a society in which construction, infrastructure, and products are used for a long period of time" (Okamoto 2006). In this type of society, the quality of material stocks is improved, and low-value stocks are replaced to serve society in the most efficient way. This implies a longer and more intense service use, which results in extracting fewer primary resources and slower material flows. Policymakers need to understand and manage the resource accumulation embedded in buildings and infrastructure to prevent a shortage of services like housing and mobility. Transforming the linear metabolism of materials into a circular one could guarantee the continued use of older materials and thereby contribute to sustainable urban development. For cities, this means that such an approach can also help to reduce urban sprawl, which is not just ecologically but also economically unsustainable (Humer, Sedlitzky, and Brunner 2019). While the energy, materials, money, time, and other resources embodied in these vacant houses are fixed and not serving society, their presence hinders compact city planning and stimulates urban sprawl. Therefore, this study aims to contribute to the understanding and managing of this obsolete housing stock to support a material stock-type society.

Recent developments in the theory of the circular economy have embraced this concept. In fact, as in the concept of a material stock society, the circular economy theory advocates a model of the economy where the material loops are narrowed and slowed down, and quality of life is improved. This article focuses on the potential of urban mining (Arora et al. 2020) and other circular economy practices for dealing with these obsolete material stocks (P. H. Brunner 1999).

First, some stakeholders might perceive the obsolescence of a house differently depending on their know-how and prioritised criteria, and might have different opinions about when the (social) costs of a vacant house are too high, and hence, which circular economy strategy is best for reducing these costs. To guarantee the success of the implementation, it is essential to understand the perspectives of local stakeholders on vacant houses and the current norms and standards for a home, which influence their adjustment behaviour (Morris and Winter 1975). Potential and previous homeowners have housing needs that can be derived from "cultural standards against which actual housing conditions are judged" (Morris and Winter 1975). Few scholars researching building material stock have engaged with homeowner and consumer sciences to understand the changes in norms and standards for the built

environment over time, so more research is required on housing adjustment theories, urban planning, and material stock in order to identify feasible circular economy options.

The majority of material stock research discusses delaying building obsolescence (Wuyts et al. 2019; Thomsen and van der Flier 2011), increasing the average building lifetime (Hiroki Tanikawa and Hashimoto 2009), or investigating durability (Pomponi and Moncaster 2017) as essential strategies for the transition toward a circular and therefore more sustainable built environment. A common finding of these scholars is the need for research that can account for and communicate, at the right moment, which materials in what quantities and where in the city become available for urban mining, and other circular economy strategies (Heisel and Rau-Oberhuber 2020). Whereas industrial actors are more interested in detailed accounts, more economy-wide insights can help policymakers develop place-specific circular economy strategies for different materials (Julie Marin and De Meulder 2018b).

Hence, this study applies a model of a circular economy approach for obsolete housing proposed by Wuyts et al. (2019) to assess the problem of permanent vacant houses in a city.

The study behind this model integrated the idea of cultural norms that influence the evaluation of houses by residing families. This model resulted from observations in Onomichi, a model town in Japan coping with vacancies. Some vacant houses in this model town were demolished and replaced by green areas and playgrounds for children. Other vacant houses could be restored and repurposed. The limit of this model is that it has not been tested in other cities. Hence, the novelty of this study is that it applies this model for the first time and evaluates this.

As this article intends to understand the roots of the problem and identify opportunities for reducing or reactivating this stock of embodied materials, we propose additional tools to be integrated to map the spatial and temporal patterns of vacant houses within the boundaries of a city as a heuristic amendment to the existing model.

As a case study we analysed Kitakyushu, a city in southern Japan, which is a frontrunner city in urban sustainability with much know-how regarding cleaner production and waste management (Irvine and Bai 2019). Since the establishment of Yahata Steel Works in 1901, the heavy and chemical industries of this city in northern Kyushu have led the economic growth of the city (Japanese Ministry of the Environment 2018). In the decades following World War II, the city of Kitakyushu in southern Japan gained an international reputation for its steel production (Shiroyama and Kajiki 2016). The city was built for, and around, its industrial structure; the housing accommodated the labour force of the new industry (Kazuhiko 2010). However, as these industries lead to higher income, and house ownership was culturally and institutionally idealised in Japan (Waswo 2013), the city expanded horizontally; people started to build new houses in the hillsides and suburbs of Kitakyushu. In the 1980s, the steel industry was past its heyday of the 1960s, and the local government took a more central role in the transition to environmental industries and cleaner areas (Irvine and Bai 2019), introducing policies and programs in the early 1990s to change the city's industrial structure into that of an eco-town (Kazuhiko 2010). This was the beginning of an urban sustainability transition with experiments and initiatives balancing and reinforcing it, which makes Kitakyushu a frontier city in urban sustainability, hailed by international and national institutions (Irvine and Bai 2019). The city's architecture dates from the heyday of Kitakyushu's steel industry, as most buildings are midrise tenant buildings, but the passage of time has given these buildings a worn look, i.e., these buildings have corrugated iron roofs and walls and do not show signs of exterior maintenance (Holden 2015). As the standardisation of safety, comfort, convenience, and cleanliness embedded in codes and standards is reproduced in the built environment and in people's expectations of what an "ideal home" should be (Shove 2003), especially given Japan's

postwar economic quality-oriented growth, many of these houses are considered to be obsolete. Kitakyushu has a renovation culture whereby communities reclaim abandoned houses in the city centre, some of which are over 100 years old (Holden 2015). At the same time, new residential development is still taking place in suburban areas, which is observed in other cities in Japan. In general, for Japan, the mechanisms behind vacancies and urban shrinkage are more related to demographic changes and urban sprawl (Döringer et al. 2020), neoliberal urban housing policies, and changes in people's lifestyle (T. Kubo and Mashita 2020). In other Western countries, urban shrinkage is commonly interpreted as a consequence of a decline in local industries (for example, the rustbelts in the USA and Northern England) (Pallagst, Wiechmann, and Martinez-Fernandez 2013) or as the result of a political regime change, as in postsocialist Europe (Radzimski 2016). The city of Kitakyushu seems to be a hybrid result of both of these "historical trajectories," where the spatial distribution of vacancies in one district can be attributed to a local industry decline, whereas another district seems to reflect changes in lifestyles and cultural housing norms, and standards of cleanliness and safety, comfort, and convenience in particular. For policymakers and industry, it is pivotal to understand the consequences of an Industry 2.0 model (mass production on assembly lines), which was the backbone of Kitakyushu's economy for almost the whole of the 20th century, to an industry 4.0 model (digitalisation, artificial intelligence), which implies a demand for a new type of labour pool. The industrial labour force became more "obsolete" in this local industry decline. By applying housing adjustment theories, this manuscript will explain the impact of economic structural change on the housing norms, which in turn have an impact on the demographic and built environment patterns. As the current housing conditions of some districts are more characterised by this change, each district has a different housing metabolism and requires a different circular economy strategy. This makes Kitakyushu an excellent case study not only to analyse the complexities of the urban housing metabolism, but also to prove the importance of designing a place-sensitive, social, circular built environment.

1.1. Political–Industrial Ecology: From Problem to Solution, and from Theory to Practice

To fully understand the metabolism of housing, we believe a pragmatic combination of industrial and political ecology-based approaches is needed. At first sight, the approaches, methods, and perspectives of political and industrial ecology might appear incompatible, but Newell and Cousins (2015) introduced a political–industrial ecology approach, which has proven to be a viable basis to assess the sustainability of urban systems (Newell and Cousins 2015).

While political and industrial ecology share urban metabolism as a common research interest, their approach to it is different. Some scholars, mainly from the field of geography, describe political ecology as a subfield examining the sociopolitical dimensions of the flows, exchanges, and transformations within an economy, while industrial ecology attempts to measure and visualise the incoming and outgoing flows or accumulation of stocks as precisely as possible (Danneels, Juwet, and Bruggeman 2018). This could lead to the interpretation that industrial ecology describes the patterns, and political ecology deciphers why these patterns happen; furthermore, the former applies quantitative assessments while the latter is also open to qualitative approaches. However, industrial ecology, like political ecology, has no stand-alone definition and draws principles, tools, and methods from other disciplines like engineering and economics. The boundary between political and industrial ecology, especially for the study of urban metabolism, is very vague (Newell and Cousins 2015; Danneels, Juwet, and Bruggeman 2018; Breetz 2017; Cousins and Newell 2015), which calls for a more integrated approach and perhaps even a refusal to label those tools related to industrial ecology and those related to political ecology. Industrial ecology also utilises qualitative data and examines social dimensions, for instance, to understand the stakeholder processes in industrial symbiosis (Chertow 2000). The Vienna School of

socioeconomic metabolism especially looked beyond quantitative accounts to understand how historical processes have shaped stock-flow trajectories (Fischer-Kowalski and Haberl 1998). In addition, Newell and Cousins (2015) criticised industrial ecology for missing a spatial and political dimension, and infused some "spatiality" into the field (Newell and Cousins 2015). Although earlier built material stock studies included spatiality as integral (Hiroki Tanikawa and Hashimoto 2009; Hiroki Tanikawa et al. 2015), the apolitical dimension is still a critique.

Nevertheless, industrial ecology is one of the schools at the root of the circular economy [11] and not only provides data and descriptive accounts, but also contributes to testing the impact and feasibility of solutions and strategies. Pomponi and Moncaster (2017) emphasised the need for a multidimensional approach in research and design in the built environment (Pomponi and Moncaster 2017). Hence, this article revisits the theoretical considerations of political–industrial ecology (Newell and Cousins 2015; Danneels, Juwet, and Bruggeman 2018; Breetz 2017; Cousins and Newell 2015). For the remainder of this chapter, the political ecology component is the system science that critically analyses the roots and context of the current problem (vacant houses) as well as barriers to and opportunities for social transition. Pomponi and Moncaster (2017) called for a behavioural dimension. This manuscript addresses this by integrating well-established concepts of consumer studies and the housing adjustment theories. The underutilisation of a house, or the quality of material stock use, is not only a result of technical factors, but also the result of social factors and specific user behaviour. According to Morris and Winter (1975), homeowners assess the conditions of the house with the help of norms. If the housing conditions do not comply with these norms, a housing need deficit will occur and can lead to an adjustment, like renovation, expansion, or moving out, unless the constraints (e.g., income) are too high.

Hence, in the political ecology component, we look at the impact of political, social, and economic factors on these housing norms. The understanding of these housing norms is also used to inspire the quantitative (industrial ecology) part of this research.

The industrial ecology component of this approach is system science, which provides solutions for the future and data on the feasibility of these solutions. Combined into a theory of political–industrial ecology, they will function as the theoretical basis for this chapter, which seeks to integrate different perspectives into a holistic critical lens.

1.2. Adding a Spatial and Temporal Perspective on the Circular Built Environment

The integration of spatial analysis, typically for disciplines like geography, can be increasingly observed in industrial ecology research. Understanding the spatial patterns of urban metabolism not only leads to a holistic view of a city as a system, but also acknowledges the uniqueness of every urban system. Place-sensitive data—quantitative and qualitative—and analyses and calculations can help us to better understand why products, programs, and ideas lead to success or failure in one place but not in another, and can help us to find city-specific circular models (Julie Marin and De Meulder 2018b). In industrial ecology, defining the system boundaries, i.e., at which level a study can be conducted (local, national, regional, or global), is one prerequisite of many tools, such as life cycle assessment (LCA) and material flow analysis (MFA). In this manuscript, the boundaries equal the municipal boundaries of Kitakyushu. Although some materials require more global circular strategies, like rare metals that are mined and processed in a few places across the world, building materials are widely available; building materials mostly reflect local availability as well know-how, national building standards, and other local characteristics because the construction and use of houses are mediated through local people (Cox 2016; Leonard, Perkins, and Thorns 2004). Hence, it seems appropriate to propose local circular strategies for the existing building material stocks and flows in a city, rather than to integrate a wider and more global economy. Industrial ecology is starting to encourage spatially explicit analysis rather than mere

statistical analysis without a spatial dimension because the former provides more contextual insights that can help policymakers and other stakeholders to better understand and manage their cities and the stocked capital (Miatto et al. 2019). For instance, a spatial analysis of the material stock in Padua, Italy displayed an uneven spatial distribution of building materials; whereas the historical centre has "old stock" with a high historical value, the suburbs are more prone to continuous urban renewal processes (Miatto et al. 2019). This insight can help the policymakers of Padua to decide to look into urban mining for the suburbs of Padua, and to look into the tensions between cultural preservation and other sustainability goals, like alternative and reduced energy use and spatial justice (Avrami 2016), which can be in turn used for remodelling the older parts of the city (Cheng et al. 2018). The 4D-GIS analysis, for instance, which was developed by Tanikawa and his colleagues and quantifies and locates construction material stocks over time at municipal and national levels, has since been widely used in case studies elsewhere (Lanau et al. 2019). In other words, they integrated a temporal perspective into the GIS tool, which locates the distribution of the material stock in a system, to track the spatial and temporal patterns of material stock over time (Lanau et al. 2019). This method gives insights into the average building lifetime of stock in various districts of a city, which can be used as a parameter for predicting the outflow of demolition waste, and, consequently, can predict opportunities for urban mining that add value to the economy, or be used to understand when renovation is needed based on building quality and lifespan (Miatto, Schandl, and Tanikawa 2017).

2. Materials and Methods

The empirical research that provides the basis for this article is built on a mixed-methods approach. It combines a quantitative assessment using GIS analysis and spatial statistics, and a qualitative assessment combining photo, news, and document analysis. The mixed methods approach also reflects the versatility of a theory of political–industrial ecology, which serves as the basis for this research. Furthermore, the research uses an adapted version of the model proposed in chapter 3 to evaluate the status of the existing housing stock and to derive policy recommendations.

The model proposed in chapter 3 provides a simple taxonomy to categorise building obsolescence in support of a circular or material stock-type society. However, to further assess possible circular strategies for the problem of vacant houses, more subcategories are needed.

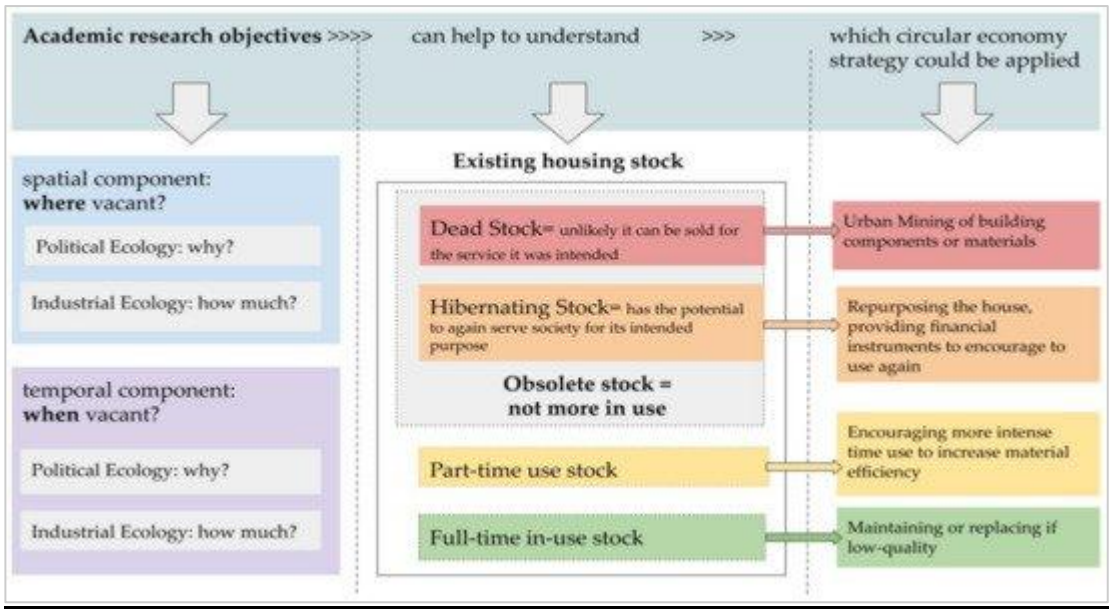
Therefore, we added the idea of dead and hibernating stock to the initial model (Figure 12).

In this regard, dead stock means stock that likely cannot be sold for the service for which it was intended and for which storage results in (high) social costs, while hibernating stock still has the potential to serve society again in the purpose for which it was intended.

Circular strategies for hibernating housing stock centre on reclaiming, which could involve renovation, retrofitting, and adapting different marketing strategies.

If a house is in a state of disrepair or is obsolete according to the current norms and standards, it is dead stock. In business, dead stock refers to the amount of a product that a company or institution has bought or made but is unable to sell, and storing it is costly. A vacant house could be considered as dead stock when the costs for keeping it are high, and if it is unlikely the house will get sold, as in the case of permanent stagnation such as in shrinking cities. The recommendation is to deconstruct the house and "mine" the materials or components, because such houses can cause health risks related to bad living quality (individual risks), social disorder (neighbourhood risks), and compact city planning (urban management risks) (see chapter 3). Urban mining refers to the recovery of "materials accumulated in the urban environment, which were not specifically designed for recycling or reuse" (Heisel and Rau-Oberhuber 2020).

Figure 12. Transdisciplinary view how scholars and practitioners can work together to cope with vacant housing within the boundaries of a certain place.[45]

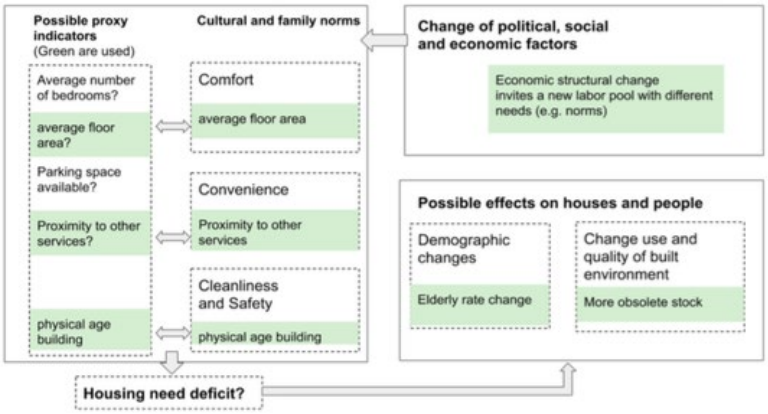


Source: (Wuyts et al. 2020)

The spatial and temporal components presented in Figure 12 can help us to understand the why, where, and how much of obsolete stock, to estimate its potential, and to predict why and when these material stocks became obsolete. However, as part of the temporal component of the model, the historical processes and the meaning associated with the social practice of "using a house" have to be analysed to identify the impact of the ideologies dictating industrial and housing policy in Kitakyushu. In other words, not only should material inputs be studied, but also nontechnical factors, like needs in terms of human resources and market regulations (Jabbour et al. 2019; Sing, Love, and Liu 2019), as well as the dynamics behind consumption, like changes in norms and codes of social practices over time (Camacho-Otero, Boks, and Pettersen 2018; Camacho-Otero, Pettersen, and Boks 2020). To acknowledge this, the model outlined in Figure 12 is complemented by an overview of the relationship between domains of practices, built material stock, jobs, and people (Figure 13).

Figure 13. Schematic overview of the relationship between norms, built material stock and people, and changes in political, social, and economic factors. The indicators serve as examples of how to measure the case of a house.

[45] In-use-stock could also be divided into part-time and full-time stock. In the case of part-time, more divisions could follow, but this is not in the scope of this PhD dissertation. This was only integrated in the figure 12, to be more complete.



Source: (Wuyts et al. 2020)

Moreover, it must be stressed that standards and norms are nurtured by the values and form of organisation of a society and therefore are continuously changing. Having said that, this change can be driven by powerful actors within or, in some cases, even outside of the society. For cases of housing, this means that stakeholders, like policymakers or the building industry, may intend to change the standards and norms to their benefit. An example in housing is the standardisation of qualities like safety, comfort, convenience, and cleanliness. Moreover, current narratives are commonly the result of path dependencies, causing difficulties in renegotiating them (Shove 2003). Taking this into account with regard to the disposable house culture in postwar Japan, building standard codes could guide decisions about which houses are delayed obsolete (i.e., houses that are obsolete in terms of social norms but still in circulation according to the local survey (Table 9) and the estimation based on our primary data collection (Table 8) and which are not. For example, when citizens look for new houses, they are advised to get houses built after 1981 because they have been built following stricter regulations regarding resistance to earthquakes. Figure 13 gives a schematic overview of the studied norms influencing everyday practices after Shove (2003); “comfort, cleanliness, and convenience” provides indicators to operationalise them and demonstrates their relationship and effect on the built material stock and people, but also the impact of political, social and economic factors, and economic structural change in particular, on these norms. The concept of housing adjustment theories, as proposed by Morris and Winter (1975), is integrated in this figure.

2.1. The method for estimating the obsolete dwelling material stock distribution within a city

This subchapter builds further by exploring a method applied to the case of Kitakyushu, Japan, winnowing the obsolete stock from the total stock for a given time. In particular in Japan, obsolete stock is increasingly accumulating as a result of the increase of vacant housing. The combination of the disposable house culture and shrinkage of population generates a high turnover of material flows and obsolete stock, not only in rural regions but also within cities like Tokyo. Based on interviews for previous research with a qualitative approach to understand the residential choices in Japan resulting to short lived use and abandonment (Wuyts et al. 2019), the departure point of this article is that the vacant state of a house is the result of a complex interplay of different factors including economic costs and benefits but also psychological costs and benefits for the involved families and individuals. A house is empty, and not demolished or in use, because of the humans through whose life it is mediated. Understanding obsolescence or vacancy calls for investigating housing consumption, or the lack thereof. The 4D-GIS database does not convey in particular this psychological and cultural dimension, which implies that the model will never be complete.

A priori this research, Tanikawa and undergraduate students built a 4D-GIS dataset for Kitakyushu to conduct previous material stock analysis. More specifically, Tanikawa and his team digitised and georeferenced maps for the years 1986, 1995, 2000, 2005, 2010, and 2014 to calculate the material stock, as proposed by Tanikawa et al. (2009), and divided them into in-use-stock and obsolete stock. The first step was primary data collection in selected neighborhoods in fall 2019 (table 8).

Table 8. "Features of the two districts of primary data collection.

District	Description
Yawata Higashi Ward	Residential area. Samples were taken in neighbourhoods on slopes near the industrial area, which was the industrial center as well in housing blocks with narrow streets. Because of the proximity to the central city area, the density of houses is relatively high, and the rate of poorly approachable houses is high .
Wakamatsu	Reclaimed city area formed by the Wakamatsu construction port project in the late Meiji era. Although the roads are relatively wide (compared with Yawata Higashi), the housing density is high, because of the average small house size. Many houses are old according to Japanese standards." (Wuyts et al. 2020a)

Source: Wuyts et al. 2020

The undergraduate student counted temporary and permanent empty houses by visual appearance, or rather by perception which house is temporary or permanent empty. For instance, "when the house looked in good shape and/or a sign indicating it was to rent or for sale was visible, a label of temporarily vacant was assigned to the house. When a house was in bad condition (for example, with significant damage to the outer walls, roofs, and windows), the label of permanent obsolescence was assigned.A 360-degree camera was put on the roof of a car to take pictures while driving in the target area. In addition, a survey was done by foot in areas inaccessible to cars. In total, of the around 2000 houses assessed, around 90 were considered obsolete. The information was digitised and added to the GIS database.

A factor analysis (multiple regression analysis) was conducted by the undergraduate student to understand which explanatory variables were significant. This was done more on an error and trial basis, and on the basis of the availability of data. Table 10 gives the choice of the factors. The model can be described by Equation (1):

$$y = X\beta + \varepsilon, \qquad (1)$$

where y: vector of vacant house ratio for every 100-m mesh, X:vector of explanatory variables,β: vector of coefficient, ε is an error term. The definitions of the variables (e.g. 500 meter distance from this service) are chosen based on the Kitakyushu City Location Normalisation Plan (Kitakyushu City 2019). The validity of the model is verified by comparing the number of vacant houses in each administrative district according to the local survey on the vacant houses from Kitakyushu City in the period 2014–2015 (Kitakyushu City 2016a; 2016b).

Table 10. Choice of factors, sorted according to the housing adjustment framework (Morris and Winter 1975).

"Housing need type or cultural norm type	Norm	Input variable (factor)	Description and more explanation about the input variable
Space norms	Comfort	Floor area	Floor area of the building (m2)
Tenure norms	/	No input variables	Data about home ownership cannot be retrieved from the current database.
Structure Type norms		No input variables	This manuscript focuses upon detached single family type housing.
Quality norms	Cleanliness & safety	Building age Flagpole area	Building age= 2018 - construction year Flagpole= houses with the center of gravity of the building at least 10 m away from the road are assumed to be "flagpole grounds" = 1
Neighbourhood norms	Convenience	Near station1 Near bus stop2 Near hospital 2 Near welfare facility2 Near elementary school1 Near industrial zone1 Nearest road width Housing density Inclination	Bolean variables **1** Within 500 meters: 1 **2** Within 300 meters: 1 These choices are based on Kitakyushu location optimization plan [50]. Nearest road width= the width of the road closest to the building (m) Housing density= average number of buildings per km2. Inclination= average value of inclination data closest to the building for each 100m mesh (°)
	Diversity	elderly single household ratio	percentage of households 65 years old or older in this housing block"

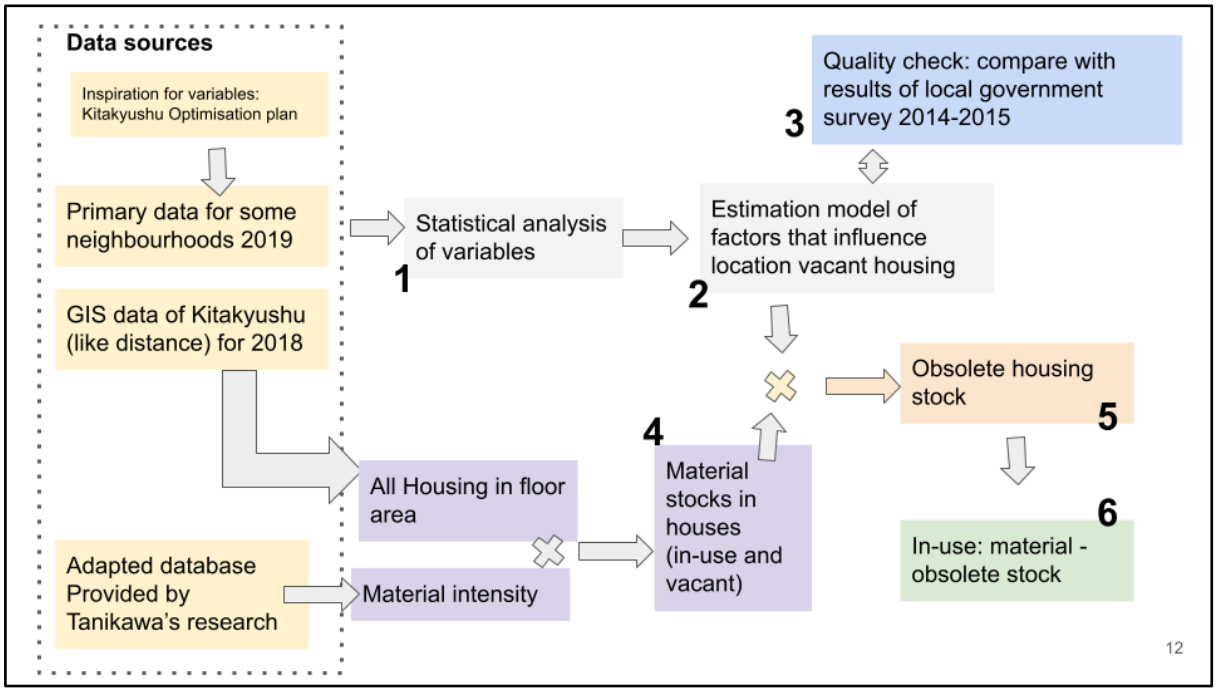
Source: Wuyts et al. 2020a

Lastly, the material stock of detached houses was calculated for every 100-m mesh. A 100-m mesh is a mesh-based polygon of 100 m by 100 m. The calculation followed the well-established approach

proposed by Tanikawa et al. (2009) and used method and material intensity coefficients for houses made with nine categories of stock-building materials. The materials covered in the analysis are expressed in millions of tonnes. The material intensity coefficient table is an updated version of the article by Tanikawa et al. (2009). Hence, the obsolete stock was estimated by multiplying the total material stock by the vacancy rate. The in-use stock was estimated by subtracting the obsolete stock from the total material stock.

Figure 14 gives an overview of the combination of methods and the order in which they are conducted[46].

Figure 14: Data sources and research flow for the quantitative part of this study



2.2. A qualitative assessment - or an economic geography lens

A qualitative assessment was carried out to prepare the quantitative assessment and to validate and complement its results. In the first phase, neighbourhoods or larger districts that have unique historical trajectories for primary data collection were identified. The necessary data were collected during field visits (July 2018–October 2019) and were drawn from observations and the analysis of historical photographs.

In addition, a desktop-based analysis of national and local policy reports on the construction and demolition of buildings was carried out to obtain further information on the historical metabolism of the housing stock in the neighbourhoods.

Last, a media analysis of local news was undertaken to bridge data gaps and gain insight into the societal discourse regarding the demolition and vacancy of residential buildings. For the second phase, the adapted model proposed by Wuyts et al. (2019) took centre stage. The results of the first round of the quantitative and qualitative assessment were used to classify the existing housing stock according to the ratings proposed in Figure 12 and to confirm the role that the domains of practice play (outlined in Figure 13).

[46] This figure was not in the original publication.

2.3. Triangulating data sources and findings[47]

This study used two quantitative data sources: 1) the survey from the local government conducted in 2014–2015 (Kitakyushu City 2016a; 2016b) and 2) the results of the undergraduate student (see also figure 14).

The first data source had some particularities which are described in a paper: "Regarding the local survey conducted in 2014–2015, the local government used visual data to count and categorise the vacant houses according to deterioration degree or risk (Kitakyushu City 2016a; 2016b). The risks were assessed based on location characteristics (neighbourhood norms, e.g., inclination of the closest road) and physical appearance (quality norms, e.g., uncontrolled growth of plants at the door). As staff of the local government conducted the survey and are the sole determinants of this risk assessment, these data have some built-in problems. Whereas neighbourhood norms involve subjective orientations toward basically objective matters, the latter is about subjective matters (Morris and Winter 1975). In addition, the agenda of the local government for this survey was not to support the building of a material stock-type society or circular built environment" (Wuyts et al. 2020).

The study consulted also maps "about land zoning and housing (and their attribute data), and local statistics about the age of the population for several districts and neighbourhoods (Kitakyushu City 2019b; 2016c)" (Wuyts et al. 2020a) in order to get a better understanding of the spatial and temporal relationships. The results of the estimation model were collected in an Excel sheet. So statistical data per neighbourhood about the economic structure, or in particular the kind of jobs (e.g. industry workers, construction workers, IT professionals) were collected. Several correlations were tested with the scatterplot function of Excel, but did not provide any significant correlations.

Lastly, I also calculated the divergences of findings (amount of vacant houses) for the different neighbourhoods to see if this was bigger for certain neighbourhoods and if this could perhaps be explained by the choice of the variables for the estimation model.

3. Results

Section 3.1 introduces the case study and presents the first round of findings on the city level. Section 3.2 zooms in on three selected districts and shows through a spatial–temporal lens that one impulse, the changing industrial structure, can have very different effects in different neighbourhoods. Furthermore, it demonstrates the need for local and place-sensitive strategies within a city to tackle the dynamics driven by global trends.

3.1. Estimating the place and quantity of obsolete (housing) stock

Whereas the national residential vacancy rate is 13.6%, the residential vacancy rate for Kitakyushu is 16.3%, according to the 2018 Housing and Land Survey of Japan (Japanese Ministry of Internal Affairs and Communications 2019) According to calculations based on the national survey, Kitakyushu counts 81,600 vacant dwellings, of which 24,800 are detached houses, 5100 are tenement houses, 51,500 are apartments, and 200 are of other classification. In 2018, only 9% of these detached houses were offered for rent and only 18% were for sale. While 95% of the vacant detached housing stock is made from wood, only 12% of the vacant apartments are made from wood. The government classified the vacant houses as high risk, medium risk, low risk, or no danger (Kitakyushu City 2016a; 2016b). All risky

[47] This subsection was not part of the original publication (Wuyts et al. 2020a)

vacant houses are dead stock and should be urban mined, while the houses classified as “no danger” are hibernating stock and can be redeveloped to serve the people in Kitakyushu. The survey classified 7296 vacant houses, of which 3397 cases (46.6%) were “risky”. Table 11 displays the numbers for Kitakyushu’s seven districts.

Table 11. Assessment of the vacant houses counted in 2014–2015 by the local government of Kitakyushu according to the degree of risk. All risky houses are dead stock, while the vacant houses without risk are hibernating stock. The percentage is the number of vacant houses compared to total vacant houses in this ward. Source: Kitakyushu City 2016a; 2016b.

	Dead Stock			Hibernating Stock	
Ward	High Risk (in %)	Medium Risk (in %)	Low Risk (in %)	No Danger (in %)	Total Vacant Houses
Moji	9.2	22.2	14.2	54.4	1573
Kokurakita	8.7	16.8	17.7	56.8	1005
Kokura Minami	3.1	15.5	16.7	64.7	618
Wakamatsu	9.9	14.5	25.3	50.3	736
Yahata Higashi	12.3	23.1	21.8	42.8	1764
Yahata Nishi	6.3	15.4	19.9	58.4	1201
Tobota	8.8	15.8	13.8	61.7	399
Total	8.9	18.9	18.8	53.4	7296

During the primary data collection in 2019, it was observed that neighbourhoods in the Yahatahigashi Ward have a higher vacancy rate, because this is the area with old housing for the labour pool of the industrial heydays. In neighbourhoods that were closer to the main train station, fewer vacant houses were observed. Although the average road is relatively narrow in some of these neighbourhoods, the proximity to the train station and the possibility of redevelopment make it more likely that abandoned houses will be quickly replaced by newer houses.

The factor analysis (Table 12) revealed that the significant factors were the average value of inclination data closest to the building for each 100-m mesh, the building year, the proximity to industrial zoning, and the number of buildings per neighbourhood. Inclination seems to be an important factor. In Japan’s disposable house culture, which conveys the observation that houses are seen as liabilities and not treated as assets, demolition costs are high, because often the roads in residential areas on steeper slopes are composed of steps, which restricts the access of trucks and heavy equipment to enter and dismantle. In addition, these areas are not attractive for car owners, so it is unlikely these houses will be chosen by potential buyers.

Table 12. Outputs of the regression analysis

explanatory variable	regression coefficient	adjusted RC	T value	adjusted T value
(constant)	-18.2699	-8.7	-0.031	-7.326**
inclination	0.0562	0.0554	2.501*	2.612**
nearest road width	-0.1601	-0.1666	-1.374	-1.464

flagpole [48]	0.2535		0.754	
floor area	-0.0017		-0.552	
housing density	0.0005	0.004	2.139*	1.727*
near industrial zone	1.5165	1.5025	2.097*	2.154**
elderly single household	-5.1807		-1.148	
building age	0.0412	0.0416	6.000**	6.168**
Proximity train station	0.757	1.1308	1.368	2.669**
Proximity bus stop	10.5308		0.018	
Proximity hospital	-0.2508		-0.731	
Proximity welfare facilities	0.9493		1.191	
Proximity elementary school	-0.3499		-0.878”	

***: 0.01 <p <0.05, **: p <0.01**
Source: Wuyts et al. 2020

The explanatory variables are based on the variables used in Kitakyushu City Location Optimisation Plan (Kitakyushu City 2019)[49].

Subsequently, we estimated the vacancy rate for all the areas in Kitakyushu by using these factors (Table 12), which will be discussed further in Section 3.2.
Table 14 presents the results of the estimated obsolete and in-use material stock for detached houses. Regarding the spatial distribution on a district level, a higher amount of obsolete stock was observed in Yahatahigashi, Moji, and Wakamatsu, neighbourhoods where houses are built on high slopes and close to each other. This manuscript uses the classification of the city road certified standards in Japan. A flat area means an area with roads with an average slope of 2.86◦ or less; a “less flat area” means an area with roads with an average slope between 2.86◦ and 5.71◦, a “sloped area” means an area of roads with an average slope between 5.71◦ and 9.09◦, and a “steep slope area” means an area with roads with an average slope higher than 9.09◦.

[48] Other word would be dead-end land.
[49] The reason for this choice is to align findings with indicators and variables that are already used by urban planners and policy makers, and not to re-invent indicators and variables.

Table 13. Comparing studies by the local government and the results of this study[50].

	Kitakyushu's Survey		Our Survey		
Ward	Risky Vacant Houses	Total Vacant Houses		Divergence *	Divergence **
Moji	686	1573	1059	148%	65%
Kokurakita	434	1005	375	268%	116%
Kokura Minami	218	618	331	187%	66%
Wakamatsu	366	736	650	113%	56%
Yahata Higashi	1009	1764	1009	175%	100%
Yahata Nishi	239	1201	462	260%	52%
Tobota	153	399	245	163%	62%
Total	3400	7296	4132	177%	82%

(*) Between total vacant housing (dead and hibernating stock) in local government survey and our model (**). Between risky vacant housing (only dead stock) and our model.

Table 14. Estimated obsolete and in-use material stock for detached houses (in millions of tonnes). Usage is the percentage of material stock that is in use.

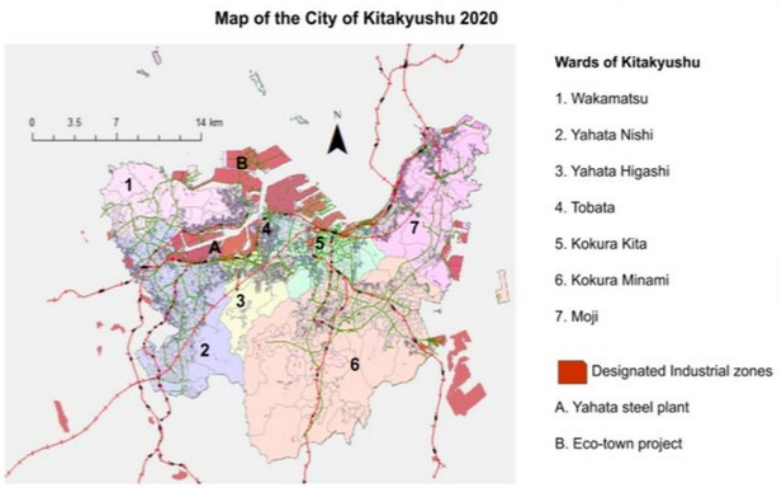
Area	Obsolete	In-Use	Total	Usage (%)
Kitakyushu (Total)	0.329	17.754	18.082	98.2
Flat Area	0.022	8.378	8.400	99.7
Less Flat Area	0.026	4.271	4.297	99.4
Sloped Area	0.057	2.415	2.471	97.7
Steep Slope Area	0.224	2.690	2.914	92.3

3.2. Zooming In: A Spatial–Temporal Analysis on the Level of Districts

The vacancies do not occur in the same quantity and quality in each district or neighbourhood. To understand the spatial distribution of vacant housing, we selected for further assessment Yahatahigashi, Yahatanishi, and Kokurakita, three dynamic districts with an interesting historical background and a high number of vacant houses according to a first estimation model and local survey results (Kitakyushu City 2016a,b) Figure 13 displays the seven districts of Kitakyushu, important railroads and highways, and designated industrial zones.

[50] Both results did not overlap each other entirely. First of all, because Kitakyushu's local government used other parameters, and it was not clear from their policy documents how they assessed (visual appearance, and gave some examples). They talk about high risk and risk. Therefore I also did two 'divergence calculations'. Secondly, because for each district there were no numbers. I had a table in excel where I copied the numbers of their vacancies, and then did an extrapolation in excel, so they were harmonized.

Figure 15: The districts of Kitakyushu designated as industrial zones and roads.



Source: Wuyts et al. 2020b, GIS: Kitakyushu City 2019

According to economic geography theories, the shrinking of an economic sector, population and housing are interlinked. Kitakyushu is clearly a shrinking city in terms of population, as a result of demographic and economic change. While other cities in Japan might face an increase of vacancy solely due to demographic changes (Kubo and Yui 2019), the patterns behind Kitakyushu's vacancy can be connected with it's past of 'heavy industry', so an economical lock-in effect is likely. The infrastructure and housing in certain neighbourhoods are locked in accommodating the past needs, namely the labor force of manufacturing. The factor of proximity to industrial zones is perhaps only relevant for Kitakyushu and other post-industrial cities which have neighbourhoods with manufacturing labor force concentrations, and as second criteria are built in less attractive areas for redevelopment.

The vacancies do not occur in the same quantity and quality in each district or neighbourhood. To understand the spatial distribution of vacant housing, we selected for further assessment Yahatahigashi, Yahatanishi, and Kokurakita, three dynamic districts with an interesting historical background and a high number of vacant houses according to a first estimation model and local survey results (Kitakyushu City 2016a; 2016b).

Demographic changes and the accumulation of vacancies are consequences of the perception of the current housing conditions as obsolete in terms of norms and standards. The study of the effect of housing norms on people is also pivotal to the design of a social circular economy because the main driver of this transition is to serve society as efficiently as possible. Hence, this manuscript investigates demographic and vacancy patterns and the narrative behind these changes. Smaller cities in postgrowth Japan tend to have different demographic and vacancy patterns than megacities like Tokyo (Nishiyama 2019). In bigger cities, suburbs tend to have a higher number of vacant houses, whereas, in smaller cities, an increase in vacant houses can be found in the city centre. Since the 1990s, attractive facilities and services, like department stores, banks, hospitals, and city halls, have relocated to suburban

locations (Nishiyama 2019). In the meantime, highways have been established in the suburbs, making travel by car increasingly convenient and comfortable in cities like Kitakyushu. Kitakyushu demonstrates an interplay of different factors, which are stronger in some districts than in others, because of place-specific historical trajectories of norms and other factors like economic structural changes.

Of the three districts studied, Yahatahigashi shows a negative trend in demographic patterns for the last three decades, and a higher percentage of empty houses, which seem to be delayed obsolete. Yahatahigashi district is situated around the old Yawata steel factory plants and has many hilly areas with a high housing density. The slopes are steep, but people built there back in the heyday of the steel factory, to be close to their work. Codes of safety, cleanliness, comfort, and convenience were different from today. Figure 16b shows a much bigger contrast compared with Figure 16a; the child population dropped by more than 50%, and there was a significant outflow of young people. While the histogram for 1989 seems balanced, the histogram for 2019 shows the opposite pattern. This can be explained by the fact that the heydays are over. Kitakyushu is investing in Industry 4.0. Consequently, manufacturing skills became obsolete. Even if the labour force gets retrained for Industry 4.0, there is not room for everyone because Industry 2.0 required a larger labour force than is needed in Industry 4.0 (Curran and Hamilton 2012, 2017). Hence, Yahatahigashi's population is shrinking rapidly, and it is no surprise that this is one of the districts most altered by vacant housing. Economic structural change often causes the displacement of long-term residents and a process of 'forgetting' (Curran and Hamilton 2017), but hilly districts like Yahatahigashi do not comply with the standards and codes of comfort, safety, and convenience of the new labour pool; the effect is that the older, long-term residents stayed and became elderly, while the younger labour force, with their manufacturing skills, moved away. The vacancies, especially in this district, are a combination of local industry decline and a lock-in effect that accelerates both the rise in vacancies and the outflow of young people. Hence, most vacant houses can be considered as dead stock because new families will not purchase these houses as they do not meet their norms. A risk is that these houses will become slum areas for the elderly who stayed behind, or those who do not have the income to migrate or replace the house with a new one. From a social circular economy perspective, deconstruction and urban mining of the secondary resources would be the best option. Ideally, the profit from these operations would be invested into schemes to provide better housing conditions for the long-term residents.

Figure 16. "Demographic patterns for three selected districts for 1989–2019. The statistics were recorded on September 30, except for 2019, when they were recorded on March 31. (a) Kokurakita, (b) Yahatahigashi, (c) Yahatanishi."

Figure source: Wuyts et al. 2020a, Data source: Kitakyushu City 2019b.

Both the centrally located Kokurakita and the peri-urban Yahatanishi seem to have more hibernating stock than dead stock based on our observations of the housing and demographic patterns. The Kokurita district can be considered to be a city centre as it is where the high-speed train stops, and it has old neighbourhoods with narrow streets that do not allow for a high amount of redevelopment to accommodate new standards and codes of convenience (for example, lack of space for creating more parking spaces for cars). In this area, NGOs and small enterprises that are reclaiming and repurposing vacant houses into galleries, offices, and so on, like the Kitakyushu Renovation School, are active. These activities also attract tech-savvy and creative people, who are hailed in Industry 4.0 visions. This small movement of young people recognizes the historical value of these buildings. Figure 16a shows a decline in younger age groups, which stabilized at the beginning of this century, with the sharpest decline noted for the number of children and the greatest rise seen in the 65–69 age group, which is a nationwide trend in the shrinking Japanese society. Although the current housing does not comply with the norms, this inflow of people has the resources (e.g., skills and income) to overcome the constraints and apply housing adjustments. Therefore, the large number of vacant houses could be considered as hibernating. Social circular economy strategies from the local government could include the availability of housing adjustment grants and fiscal instruments that encourage renovation.

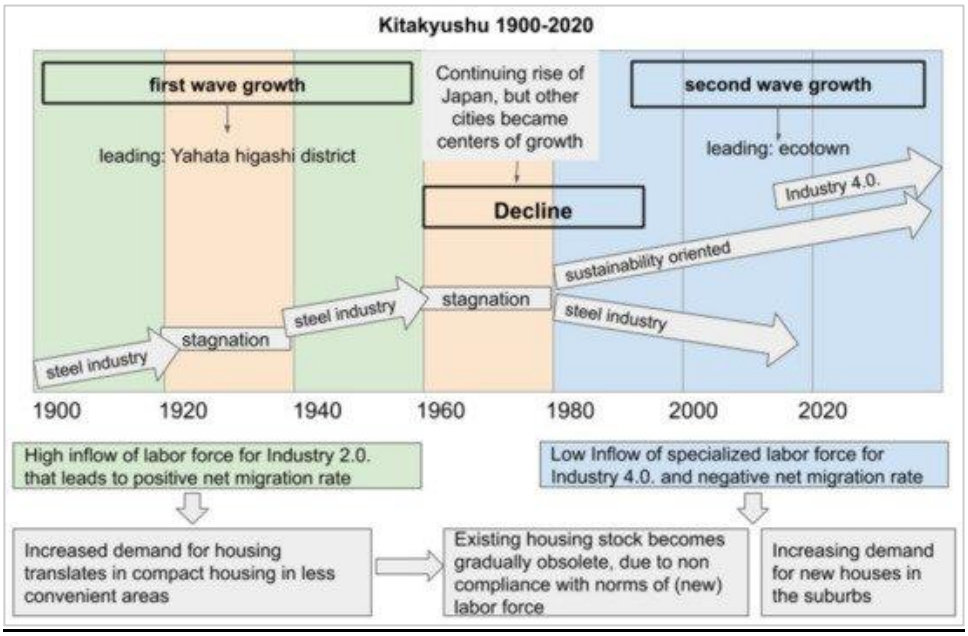
Yahatanishi district has less obsolete stock. This district in the south is a cleaned-up suburban area that is still a commutable distance from the city centre and provides easy access to highways and railroads. This district is less hilly and, by accommodating the new standards of safety, comfort, cleanliness, and convenience, experiences a fast urban renewal process. Although all three districts have been characterised by an outflow of young people in the last few decades, Yahatanishi seems to keep part of its productive and reproductive labour; however, the number of people of reproductive age is decreasing. Figure 16c shows a slightly more stable situation for this 30-year time span, which could relate to the revitalisation efforts by the local government in this neighbourhood. From a circular economy perspective, strategies for this district should focus upon encouraging longer use of the same house by implementing higher constraints for demolition and for migration. The vacant housing can be considered hibernating stock that can be ‘awakened’ by similar strategies.

3.3. Relationships between jobs, people and local house consumption

Political economy theorises the cycle of periods of new growth and stagnation in economies through, for example, Kondratieff waves (Grinin, Grinin, and Korotayev 2017), where a new growth phase implies a change in the sectoral and spatial structures of the economy. On a national scale, Kitakyushu is in stagnation; however, looking at the district scale, there is a spatial difference within the city. The districts that accommodate Industry 4.0. and the needs and norms of the labour force for housing face less severe stagnation than the districts that are more locked into Industry 2.0. (Figure 17). Although Industry 4.0 makes promises to reduce material waste, there are concerns that these new economic structures and technology innovations require more energy-intensive digital infrastructure and people skilled in creativity, and less of a labour force with ‘different skills’ on site (Curran and Hamilton 2017; Florida 2005). Coupled with the increase in vacant housing, the working structures that Industry 4.0 requires might attract a generation of young tech-savvy creative people who are not afraid to challenge the status quo of technology, but who are also part of the urban fabric and the disposable housing culture. To address this, since 2011, a renovation school has been held twice a year for students to learn do-it-yourself (DIY) construction and the business models to design a successful renovation project with limited start-up capital, resulting in new stores, cafes, share offices, guest houses, and other projects in Kitakyushu and beyond (Holden 2015). Media and local governments hail them, perhaps because these small enterprises are founded by the kind of citizens that a ‘Future City’ like Kitakyushu

needs (Japanese government 2018), citizens who will fuel (and capitalise on) new technologies and ideas for businesses. Most of these small enterprises do not need big spaces and require only a small supply of a specialised skilled labour force. The housing obsolescence reflects a shift in sectoral economic structures (from Industry 2.0 to Industry 4.0) and spatial structures, and its unintended consequences, such as the displacement of long-term residents and abandonment of their houses, and an inflow of high-income people with different needs represented in their choice of housing.

Figure 17. "The relationship between unemployment (labour force) and the demand for housing for Kitakyushu over the last 120 years and the unintended effects on the built material stock."



Source: Wuyts et al. 2020a

In addition, many young people who do not challenge the status quo leave the city to obtain education and seek more thriving business opportunities, with the hope of climbing in social status. They often do not return to Kitakyushu. This idea of social mobility has been ingrained in the Japanese mentality since World War II, when the corporate sector became the heart of society, and does not accommodate a lot of flexibility regarding career changes or choice of location of housing. Japan, including Kitakyushu, is locked into a set of sociocultural and socioeconomic patterns, fostered by historical processes driven by the rise of more capitalist market–growth-oriented values, perhaps at the expense of the citizens and their connection with their land and their homes. However, Industry 4.0 might attract a new generation of young Japanese workers who can cope with the changes, like the massive rise in vacant housing, and help the elderly who are left behind.

Furthermore, in the research on circular economy, not much attention has been given to the human dimension or human resources (HR) essential for this transition (Jabbour et al. 2019). There has also been a lack of focus on integrating a social justice perspective (Kirchherr, Reike, and Hekkert, n.d.); structural barriers (such as the working culture with its norms) hinder people from educating themselves and preparing to move from one labour pool to another. This would explain some unintended

consequences of the displacement of long-term residents in places like Kitakyushu; they might, even more than usual, have the "right skills and HR" necessary for maintaining and restoring abandoned houses in the first place. In other words, for a circular approach, a city would need to stop the outflow of the labour force with the necessary skills for urban mining as well as attract an inflow of young workers who are open to such innovative transformations.

In addition, time is a central factor in the transition from linear to circular housing models. Even though time is a resource, it is also a condition for social reproduction, like using, maintaining, and renovating houses, or learning skills. In other words, people participating in such a transition need time to either teach or learn the requisite skills and knowledge. Decisions regarding home building are often seen as a masculine task (Cox 2016). This implies that in Japan, a country with distinct gender roles, men, in particular, need time to acquire these skills or search for the right labour, which calls for a gender dimension to material stock studies (Wuyts 2018). In the current capitalist model driving housing and other provisioning systems in modern, fast-paced society, time is perceived as a scarce commodity. This idea of time as a cost is reflected in the choice of action plans on abandoned housing of Kitakyushu's government based on convenience; it describes "arrangements, devices or services that helped save or shift time" (Shove 2003). Convenience is a herald of the fast-paced urban society. Although some people might see the newest norms and standards of convenience as criteria or indicators of wellbeing, they are not positive for everyone. A revisiting of the norms and standards of convenience and other domains is one of the prerequisites of the transition toward a circular built environment and the prevention of obsolete stock accumulation.

In addition, it is no surprise that Yahatahigashi has more dead than hibernating stock when compared with the two other districts, because this neighbourhood is locked in its industrial past and cannot accommodate the newest norms and codes. Based on these findings, the local government should especially design urban mining strategies, like opening a market for secondhand building materials, performing a deeper house-by-house assessment, and making a cost–benefit analysis, so that this district can encourage the local industry to not demolish these houses, but to instead deconstruct them and add value to the local economy by selling the building materials or components to growing markets in Japan and abroad—one recent study suggested sending Singapore's building components to Indonesia's growing market (Arora et al. 2020). The local government can support the residents of Kokurakita with measures to stimulate renovating and "awakening" hibernating stocks, maybe with funds for preserving historical value. Yawatanishi's neighbourhood seems to be the result of interplay between the "favourable conditions" for the newest norms and the standards of the market. Its built environment seems to be altered more by market forces and national neoliberal housing policies (Kubo and Yui 2019) than by policy measures. If local governments do not have more power to interfere with these market forces and national housing policies, they might not have many options for this neighbourhood.

Chapter 5: Discussion and Conclusion

1. Summary of the main outcomes

This dissertation aimed to answer the following questions:

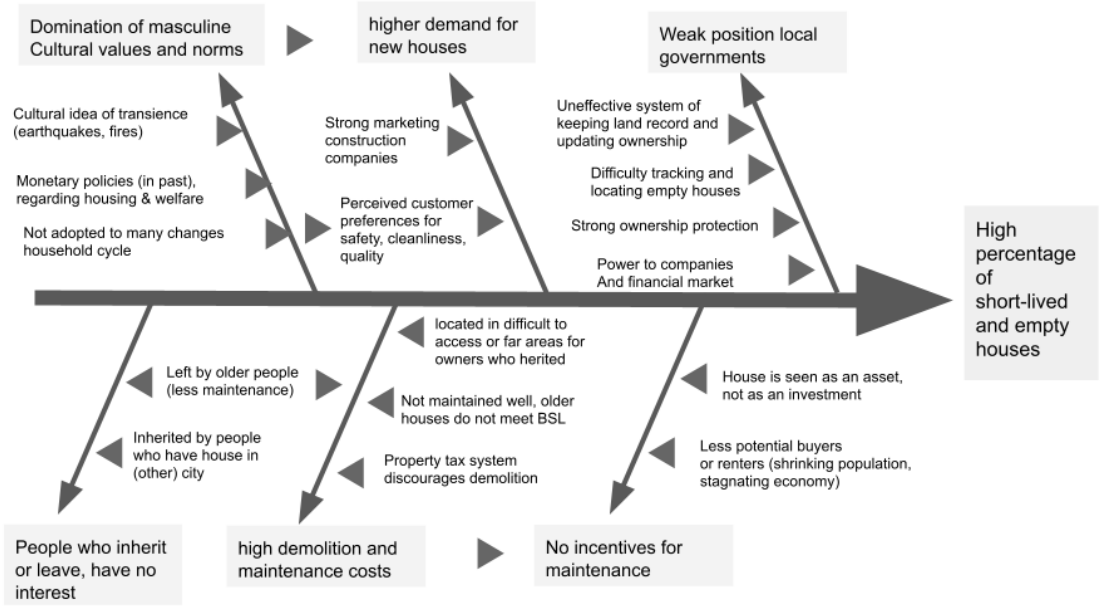
1. Why are short-lived and vacant houses a problem for sound material cycles?
2. Why is there a high percentage of short-lived and vacant houses in Japan?
3. What is the estimated 'potential' in obsolete housing stock in light of sound material cycles?
4. What are circular actions to cope with short-lived and vacant houses?

The main outcomes are as following:

1. The high amount of short-lived and vacant houses in recent times in Japan can be explained with a historical sensitive reading of housing consumption, the changes in the way people live and the interplay with housing and other policies. There are many stakeholders involved, who have their own motivations and views. These problems are wicked problems and cannot be solved easily. This is a problem in light of sustainable material management, because these are often waste or ineffective use of materials that could have serviced society longer. We have many finite resource supplies. Renewable construction materials also need regeneration time, so if the use is shorter than the regeneration time, then these resources can also be finished.
2. One way forward is looking into sound material cycle or circularity strategies in order to secure resources and reduce material consumption, which means finding ways to prevent short service life of houses that still exist, or end-of-use-strategies for vacant housing.
3. A combination of GIS and material stock studies can help to inform decisions about vacant buildings, but preferably in combination with data that can help to assess if this is feasible and socially just. Feasibility can be estimated by understanding the dominating family and cultural needs for housing in that area.

The following fishbone diagram (fig. 18) summarises the systems thinking study about the challenge of the high percentage of short-lived and vacant houses, or the fast housing metabolism in Japan. The key causes are the domination of masculine values and norms in Japanese society, affecting the consumption and encouraging newness and individual success. In addition, the power structures (not enough power for local governments, but a lot of power to construction companies, speculating investors...) are in favor of profit-oriented, and not necessarily sustainability-oriented drivers. The spatial drivers framework by Marin & De Meulder warned of the negative consequences of policies that are only led by one or more worldviews or drivers.
In addition, Japan, as a conservative society, and the construction sector, which is conservative (not only in Japan, but also in other highly developed countries) are coping with a lot of lock-in effects, as a consequence of decisions made by different stakeholders in the past, resulting in high costs for activities that could be categorised as circular economy (maintenance, urban mining etc.).

Figure 18: Fishbone diagram summarizing the systems thinking exercise of the two challenges



The current activities that are now used are mostly short term and technocentric solutions. New buildings, which satisfy the newest energy norms, do not automatically lead to better operational energy use.

2. Discussion of the main findings and future directions

2.1. Representation of the case studies for Japan and other countries

One of the main discussion points is the representativeness of the framework and even the systems thinking, analysis and synthesis of the challenges of vacant and short-lived houses in Japan.

Empty houses can be there for different reasons. In hedge cities, empty buildings would be often the result of speculation; hence, reclaiming empty houses would not be feasible, because often circular actions would be considered too low value compared with new construction (Williams 2019). Different strategies have to be implemented to counter the speculation, but this was not in the scope of this dissertation. Some cities in Japan are hedge cities. Tokyo, Yokohama, Nagoya and Fukuoka are examples. The framework would not be applicable in the same sense as shrinking cities. Kitakyushu, Onomichi and other cases (including in more rural areas) visited in this study are examples of shrinking cities. In these places, ‘newness’ co-exist with preserving old ideas and principles.
The research also witnessed in these places communities with other values and worldviews that could be described as feminine in Hofstede’s model; valuing care and history more than newness and prestige. Simply put, there is a big contrast between hedge cities in Japan dominated by technocratic views and cities and villages in shrinking regions, where other values and worldviews have a chance to co-exist with the capitalist stream. Policy makers should harness this co-existence by providing a discriminatory system that supports not-capitalist and not-industrial worldviews. Especially in Kitakyushu, different systems and circularity discourses exist, but it would be good to monitor the situation of non-industrial circular practices and actors, like for example the Kitakyushu Renovation School, rather than to focus solely on redevelopment projects. In addition, there is also a concern of the sponge effect (when vacant houses are not claimed), which are underutilized spaces for serving society (as a place for living, as a green place). However, in Onomichi, we saw how these places rewilded and became playgrounds for

childrens or natural area spaces. In the light of COVID-19, we (re)discovered how important it is for mental and physical health and biodiversity to have green spaces nearby. The risk lies in the collapse danger if the building materials are not mined properly.
Is this model applicable for other countries? In the whole world, there are shrinking regions: post-socialist East-Europe, post-industrial sites in the United Kingdom and the United States… Although Kitakyushu is a post-industrial city, comparison would be difficult, because there are other norms and standards, introduced by policy and/or science.
Japan has another context than most countries and therefore it would be good to have a comparative study to understand the unique context of Japan better. In a shrinking region in the Netherlands, Parkstad is designing circular area development. There are no other studies or cases in other countries to compare and apply this framework and findings. Circular area development plans in general are still in initial phases for most countries, including European Union Members, and mostly involve hedge cities or cities with a strong financial, creative and social capital.

2.2. A hierarchy of circular practices in the construction sector in cities and future directions

Chapter 3 (based on Wuyts et al. 2019) and chapter 4 (based on Wuyts et al. 2020) presented a set of circular actions for the construction sector in circular cities, with a focus on end-of-use life actions for mostly vacant houses and suggestions of policies that should impede the short average service time, both to support sound material cycles or circularity.

A set of these practices is only a small portion of what circularity to urban planning means. Circularity is not only about maximizing/optimising resource utilization, but includes increasing capacity of urban ecosystems to regenerate (Jo Williams 2021). Other researchers proposed hierarchies of circular actions inspired by previous hierarchies, such as the Ladder of Lansink introduced in the Netherlands and Flanders in the 1970s, and the waste hierarchy directive of the European Union, which give preference to how waste should best be treated. One recent hierarchy is proposed by Flemish landscape architects, where: "In circular urbanism, as much is adapted as possible and as little is built as possible. At best, it is dismantled, rearranged and adapted, repaired and, at best, overgrown."(Marin & De Meulder 2021). They propose five strategies:

1. Letting nonhuman nature overgrow
The most desired strategy should be the one of **regenerating nonhuman and human nature**, which implies a normative stance of prioritizing values like posthumanist care, public and nonhuman health and collective wellbeing above profit and individual success. According to a well-established body of academic research on the nexus of natural wealth and health, green space can provide many health benefits: helping in the healing process to chronic diseases, coping with psychological stress during lockdown, preventing chronic diseases and reducing the risk for communicable diseases. In Korea, researchers found evidence that overgrown abandoned places have an effect on mental health (Jin et al. 2021). In Onomichi, activists also said they would let overgrow vacant structures, or demolish it and let it become playgrounds. However, one concern among different interviewees was the spread of pests. As public hygiene is still prioritized in Japan, this might create tensions.
Politics of slowness to help the 'slower citizen' are favored more than politics of speed and convenience for a few. The aforementioned criteria are very strongly inherent in this strategy. The time required for natural recovery should be factored into the lifespan of buildings and infrastructure, for renewable resources like timber (Ramage et al. 2017). Regenerating does not only mean creating 'new' greenness, but first of all preserving healthy soil and vegetation. Urban developers should step away from (mono-functional) zoning, and work with and not against nonhuman nature. This might require clean-ups of

brownfields, underutilised spaces and make or find surfaces for urban greening, which is known to have various ecosystem services (Lovell and Taylor 2013) and contribute to the health and wellbeing of citizens (Wolch, Byrne, and Newell 2014; A. C. K. Lee, Jordan, and Horsley 2015). Importantly is connectivity: Access and proximity to resilient green infrastructure and space in cities have been/should be considered more in urban planning, as more studies and practice show the benefits of connectivity for physical and mental health of humans (WHO-Europe 2021). In other words, private green and blue surfaces that only benefit a few, are not enough.

2. Not building

The second strategy is **not building**, which means satisfying needs like housing in other ways, for example through virtual space and changing the ways how we shop (e.g. e-commerce), where we work (e.g. telework). This strategy is often mentioned in the same breath as conservation, efficiency improvements, resource sharing, space as a service and virtualization (Paiho et al. 2020; Jo Williams 2021). Temporary use of empty spaces (cfr. (Németh and Langhorst 2014) could also be classified under this strategy. Other ideas are sharing space, which implies often adapting existing structures so they become multifunctional (Bouchet-Blancou 2020). The second strategy of circular urbanism cannot be really applied to abandoned materials. By reclaiming and giving a 'new purpose', this action falls under the third strategy.

This strategy also envelops maintenance. Maintenance can involve different stakeholders. One problem that I read in previous research, is that rational landlords and owners might not want to invest in housing maintenance and repair in stagnant areas (see (Lowry 1960). Research could investigate the impact of housing cooperatives/organisations which operate beyond a profit-logic.

3. Repurpose the construction

The third strategy is to **repurpose the building**, which can imply retrofit and renovation in order to comply with new cultural (energy, safety…) and housing norms and standards. Indubitably, in some contexts, there will still be a demand for space and materials. Vacant buildings and obsolete infrastructure could be repurposed. However, it is important to not repurpose all vacancies, so the real estate price does not increase too fast at expense of more vulnerable and long term residents. Repurpose buildings could also address the problem of short-lived buildings.

4. Urban mining and recirculation

The fourth strategy is to **recirculate** materials embodied in these buildings. These refers to actions like urban mining/harvesting to close loops, and preferably in a market with a radius which is as small as possible. Chapter 4 illustrates a tool that can contribute to the identification and location of these materials for recirculation, but chapter 4 also calls to look first if the building cannot be repurposed, which is a more desirable strategy. However, this strategy raises other concerns and questions.

Local markets for secondhand building components and deconstruction firms (cfr demolishing) could be set up, which means development of material banks, like the pioneering project in Leuven (Julie Marin, Alaerts, and Van Acker 2020) These activities would create job creation; however, in Japan, this could create tensions, as the population is shrinking and immigration has been discouraged through policies in the past decades. That would also mean to recruit and (re)train labor power with the necessary skills.

In addition, one has to zoom out to the bigger area. Are these houses and the land and material they occupy accessible? Some places also have a particular topography: many abandoned houses are situated next to steep slopes with no or bad access for motorized vehicles. This means high demolition costs. The costs (including risks) are not in break-even with the benefits. The list of requirements (technical, economic, spatial, legal…) is not extensive. Circular business models could provide some solutions to

improve the benefits, but this requires research of the market and which local and national policies are necessary.
Moreover, some houses are dead and others are hibernating (Wuyts et al. 2020) Many houses in Japan are slums, or at least of low-quality, not meeting all standards and norms. They are dead housing stock and it is better to demolish, but there is also a social justice component: what can governments offer them in exchange? Social housing in well-connected areas? How to 'democratize' (see Marin & De Meulder 2018) the material flows and stocks? This means research in the extent of accessibility and especially ownership of data and materials.

5. New Construction
The last strategy is **circular (new) construction**. While the third and fourth are end-of-use strategies that focus on cheristing existing structures, this strategy focuses on the beginning-of-use or the design phase of the life cycle of a building. This refers to the composition and way of designing (e.g. modular design), new materials which extraction and production has lower environmental and social impact. In the study of measures, I observe that stakeholders look into designs for more quality-oriented future designs that could 'live longer', but in this hierarchical perspective this is less desired than looking for another purpose of existing structures. If no other choice, a priority should be given to building materials of renewable nature and low recovery time, like hemp and bamboo, and to a lesser extent to timber, although there are also other criticisms of for example on the way of sourcing materials like hemp and bamboo. This path would also include the integration of the traditional knowledge of construction in Japan in the construction sector; the use of natural materials like wood. The cycle of wood is as long as the service time of houses. The carbon would cycle, and not be released in the atmosphere, as with the use of other building materials like concrete and steel. There are other natural building materials which have even shorter cycles of growth and renewal, like hemp and bamboo. Exploring the promotion of natural building materials (taking into account the physical properties and performance regarding energy performance, isolation, stabilization of indoor moisture) would also be part of the circular economy; as long new resources are planted to compensate for the loss of the used natural resources. As natural building materials can become mature in a couple of years (for example 4 years for hemp),these alternatives seem to fit more with the wicked challenges of short-lived houses in Japan, and are more feasible than a cultural transformation. However, there are other sustainability indicators that have to be taken into account (land consumption, water consumption, by these plants, biodiversity loss etc).
Regarding new designs, designers always have to cope with uncertainties of what will be the norms and standards in the future and if they actually create future value. To address the specific factors like the change of family situation or so, ideas are to explore the impact and feasibility of transforming underutilized existing housing, or at least designing, adaptable housing. If houses could be adapted to new family and cultural needs, or change in national norms and regulations, the house would be able to serve society longer. However, we cannot imagine the material needs of people - or the cultural housing norms- in the future. Even if modular design, for example, enables recirculation in the future, there is a chance that these materials are not desired. One famous example in Flanders are the postwar modular buildings by architect Willy Van Der Meeren, who used asbest. At that time, the hazardous impacts of asbestos were not known and were seen as materials that could be recirculated because of this model. He did not know -and no scientific evidence existed in the 1960s- that these building materials are dangerous, and would not be reusable in the future.
One advantage would be the introduction of baseline studies to measure the impact in a later stage and better documentation through for example material passports. However, this strategy should also be least considered as we focus on existing structures.

6. Continuously testing and evaluating impact of future and ongoing measures
Research in other countries have demonstrated that optimisation of existing regimes, like recycling, or incineration, can stand in the way of more desirable circular or sound material cycle practices (e.g. (Van den Berghe, Bucci Ancapi, and van Bueren 2020). An initial hypothesis, which is not in the scope of the objectives, is that Japan is a victim of its own (recycling) success. Demolition, and downcycling materials at the end of their life is not the most desirable strategy. Therefore, this research looked into other pathways. However, it was out of the scope of this research to find evidence if these strategies are indeed more sustainable, to which extent, or even feasible (e.g. economic costs), and to which extent. Noteworthy, there are different indicators to measure sustainability and costs and benefits. It would be a direction for future research to see if the hypothesis of recycling is true, and that it makes sense to continue recycling, and what can be done (in terms of labor tax and material tax for example) to facilitate more sound material cycles and circularity.

2.3. Quantifying and locating obsolete housing stock: uncertainties[51]

Construction material stock studies have started to take uncertainty into consideration (Augiseau and Barles 2017; Sandberg, Sartori, and Brattebø 2014). For example, Tanikawa et al. (2015), in their bottom-up analysis of stock, looked into the reliability of the inventory data, the reliability of the material intensity factors, and the uncertainty in matching an inventory item to its correct material intensity by comparing the figures of several studies for several end-use categories (Tanikawa et al. 2015)]. This section zooms in on a new source of uncertainty: primary data collection to estimate the spatial patterns of vacancies. Section 2 in chapter 4 explained that the primary data collection of the local government has a different agenda than the primary data collection by this team. This agenda can influence the subjectivity of the assessment. In addition, the assessments behind both data collections involve quality norms, hence the assessment is subjective and automatically implies errors in data.

When we compare the results of this estimation study with the figures of vacant houses counted by the local survey per district (Table 13), the divergence is relatively high, especially for Kokurakita and Yahatanishi, which are flatter areas. The first district is close to the main train station, which makes this area prone to redevelopment, according to the location optimization plan of the city (Kitakyushu City 2019). The second, which has a lower percentage of obsolete housing stock, is a suburb with a higher inflow of youth and could reflect the fact that this area has neighbourhood and quality norms that are not outdated according to younger families. As our factory analysis integrated neighbourhood and quality norms, this could explain the high divergence. When we compare only the risky vacant houses (as this study only counted houses that are also in a certain state of deterioration), we see a strong divergence for Yahatahigashi, which is the district linked to the steel factory, as well, surprisingly, Kokurakita.

For a district like Yahatanishi that scores low in both comparisons, finding the relevant omitted factors would improve the estimation of vacancy level. However, these omitted variables might not be the explanatory factors for other districts. Hence, we need to zoom in to the district level and study in more detail the dynamics and patterns of people, jobs, wealth, and the built environment (Section 3.3). In addition, future research can focus more locally and select neighbourhoods, examining the housing conditions (including physical geography features), and constraints for users (including wealth and income), and do a marketing study on the housing needs of users and the impact of these needs on the

[51] Main part of this subsection is published in an original paper (Wuyts et al. 2020a)

housing consumption and the quality and degree of efficient use. However, such a study would require sensitive and/or nonexistent data on the users.
Another explanation can be found in the differences between assignment criteria used in the different primary data collection. In policy documents, the local government ranks vacant houses on how well they are managed and their cleanliness, age, and location factors, such as road width, house maintenance, the proximity of public transportation, and other provisioning systems. These indicators reflect the new cultural standards and norms of "comfort, cleanliness, convenience" (Shove 2003), and "safety" that have dramatically changed and are ingrained in Japanese institutions and mindset since the Second World War. However, the classification they used in their quantitative data implies that their motivation was to reduce danger and hygiene risks. The agenda of our primary data collection was to look for opportunities for circular economy strategies, not for reducing risks. Notwithstanding, a multidimensional approach is required in the transition toward a circular built environment (Pomponi and Moncaster 2017). Therefore, both data sources can be mobilised to understand the spatial patterns of obsolete stock and to design place-specific circularity strategies. Political ecology and political economy's criticality add the focus on social equity, which is often forgotten or marginalised in circular economy theory and practice (Kirchherr, Reike, and Hekkert 2017).

The "next steps for researchers to expand this model are to calculate the material stock embodied in the houses we classified as dead stock, as they seem to be more suitable for urban mining. However, even if it is possible to estimate how much wood, reinforced concrete, and steel is available, it is not possible to know their quality. Second, not all in-use housing is employed full-time, such as second homes or houses that are temporarily vacant for manifold reasons such as being on sale or having unclear ownership (periodic or temporary vacancy). Hence, it is vital to integrate the idea of full- or part-time use into material stock studies. Third, the quantitative assessment is static because we only used data on vacancy for one period. To move toward a dynamic model and test the sensitivity of input factors in the future, surveys have to be conducted over several years, which will make the model more complex, because the distribution of vacancy gets reshuffled over time (cf. urban life-cycle theories, e.g.,)" (Wuyts et al. 2020a). In the introduction to the problem of vacant houses, also the typology of vacancy revealed challenges, which were outside the scope of this dissertation: for example, how to detect disguised vacancy? This is one of the weaknesses of collecting primary data collection based on physical appearance. During the research in Japan, 'disguised vacant houses' were visited, which were still maintained once or more times a year by others (family members of the previous owner, neighbourhood people).

3. Conclusion and opinions

3.1. Contribution to society and research

To make an impact in the real world, academics have to engage with policy makers and other stakeholders. Not only by making other conceptual frameworks, collecting and analysing data, or teaching academic knowledge in classrooms, but also by communicating in a two-way with them. This implies a strong knowledge management, where the knowledge holders and/or creators also translate, mediate and start from the needs of society (Cash et al. 2003). For me, working in the name of sustainability means to start from the needs of society, but also reflect upon my knowledge, my own skills and network. These proposals are the result of my research of the problem of Japan's vacant houses and the short-lived houses in light of making the Japanese society more circular. These proposals should be seen as skeletons for practitioners, and still provide a lot of space for own filling and improvement. This study will never feel complete, but this dissertation is only the documentation of the beginning of a journey navigating through these wicked problems.

The understanding of the cause roots and the identification of pathways are only the start of a learning which needs the integration of more stakeholders - from different disciplines and sectors- in future steps. Calculations and accounts of material flows and stocks could help select pathways, but these materials should be complemented by social and policy research too in order to understand what is not only environmentally right, but also social robuust and just.
This research explored in a first phase how short-lived and vacant houses are a symptom of a complex array of interrelated variables and factors, like regulatory and environmental requirements, the dynamics of the urban housing market, and resident preferences that are rooted in the capitalist logic of property ownership and capital accumulation.

The originality of this thesis is manifold. It is one of the first explorations of circular area development. In addition, it departed from cases which deal with shrinkage, while practitioners and scholars study mostly spatial and urban circularity in regular, or even hedge cities.
Additionally, not much research departed with the vision that short-lived and vacant houses could be an opportunity for a circular or material stock type society, which was not done before in studies about vacant houses and shrinkage in Japan.

This dissertation contributes to the body of research on understanding and managing the impact of the consumption and production of housing. The focus is on the problem of short-lived and vacant houses, because the short use of materials and other resources embodied in these houses is a waste of resources. In emerging economic models and visions in sustainable development, like the ideology of circular economy or Japan's material stock type society, the extended use of physical provisioning systems of society, like buildings, are encouraged as a strategy to reduce the environmental impact. In addition, extending the use of houses has also economical and social benefits for the (potential) users and the neighbourhoods. Previous chapters zoomed in on "the dynamics of the built material stock and demography for three selected neighbourhoods" (Wuyts et al 2020a) and introduces the idea of obsolete housing norms and lifestyle choices that actually lead to obsolete housing stock if there are no possibilities to adapt these houses for reuse in compliance with the current popular housing lifestyle norms. Some neighbourhoods are obsolete due to the high density of difficult adaptable houses and need different strategies than neighbourhoods which have houses that might not be used, but could still be adapted for reuse.

3.2. Opinions

In her speech about the recent new Bauhaus initiative in the European Union (2020), Ursula Von Leyen also called for a cultural transformation as one of the requirements for a better, more beautiful and sustainable built environment[52]. The same advice is valid for the Japanese built environment: investing in technical innovations, new business models or different policies is not enough - and would even face rebound effects-, as long as the system in which all these technical, social and economic systems are embedded is not transformed.

The main focus on circularity is often on innovation and newness. The initial driver behind this study was also technocentric. The researcher was initially wired to believe that innovations, like for example the implementation of 'green materials' or new business models that encourage home ownership, would be the big silver bullet solution for many environmental troubles. The researcher was positioned in the drivers of 'innovating with flows', and to a lesser extent with 'optimizing flows' (Marin & De Meulder 2018). However, as a result of the conversations with different experts, the PhD study calls for a mix of drivers, as Marin & De Meulder also suggested for circular area development. A lot of CE discourse focuses also upon innovations, but often these innovations are only feasible and favorable for an elite

[52] https://ec.europa.eu/commission/presscorner/detail/en/AC_20_1916

of citizens (Calisto Friant, Vermeulen, and Salomone 2020) and can even lead to a negative impact on livability of the city (Zukin 2020).
Different approaches exist in the circular economy discourse, also in research and policies related to Japan. Some scholars are interested in how spatial data can contribute to achieving circularity and the indicators to monitor the transition toward a more circular metabolism (e.g. (Hiroki Tanikawa et al. 2020; Wuyts et al. 2020). By quantifying and locating materials, through 4D-GIS for example, one can identify the strategies and next steps to optimize flows and stocks. This is in compliance with the vision of the Ministry of Environment to create a material-stock type society.
As most building stocks world wide have been constructed, sustainability in the building environment could only be realized through better management of the existing stocks (Kohler and Hassler, 2002)
However, different local and national initiatives seem to focus on innovating flows and stocks. Japanese discourse is oriented towards 'new' technology, designs, cities, materials and land, and less focused on the potential of existing flows and stocks. It seems Japanese policy makers and industries share a certain CE worldview, resulting that they would rank smart-city projects indeed as CE best practices. In Kitakyushu; the eco-center development attracts an Industry 4.0., but the question remains: what with the old local residents who do not have the competences that Industry 4.0. requires? Ironically, the economic structural changes lead to even more obsolete dwelling stock in certain neighbourhoods, for which no CE innovations are adopted (Wuyts et al. 2020).

Less evidence is found about discourse around democratizing and contextualising flows. There are bottom-up projects, where local players experiment with finding new purposes for materials and abandoned houses, other infrastructure and places (e.g. Nagano Rebuilding Center, Onomichi Empty House Reclaiming Project), but this landscape is very fragmented, leading that these experiments and living circularity labs are not scaled up. These 'smaller players' could benefit from digital technology, for example, to create a digital market for the materials they 'mine'. Academics could create programs and calculate economic and environmental feasibility radius for the different materials.
Interactions between projects spearheaded by different worldviews could generate strategies and visions that might create benefits for many different stakeholders.

However, the deeper core problem might lie in the hegemony of one worldview. During this study, a new hypothesis arose that circularity or the Japanese concept of material stock type society are still embedded in a capitalist thinking and do not address the specific roots (Pirgmaier and Steinberger 2019), and in particular in Japan. Already in the 1970s, when sustainability was emerging, the omission of specific themes points to the dominant paradigms and beliefs that are often taken for granted in sustainable development, such as anthropocentrism, eternal economic growth, and material status symbols (e.g. postwar ideas like car ownership, single-family homes, smartphones) that are at the root of the current ecological and social crises. Already in the 1970s in the USA, the dominant social paradigm was the belief in progress, growth, science and technology, private market and the idea that nature is oppressed and usable: the paradigm of capitalism (Pirages and Ehrlich 1974). Nowadays, urban development agendas are still biased toward technology-driven industrial change and still embedded in neoliberal and capitalist paradigms (Kębłowski, Lambert, and Bassens 2020). This worldview is also present in Japanese national and local policies. More research should investigate how governance plays a role in circularity of construction materials and their embodiments, and more specifically, which shifts in policy instruments and strategies -or, as aforementioned- which cultural transformation - are needed to make the built environment of the 21st century more sustainable, just and beautiful.
Pirgmayer and Steinberg pointed out that we need different economic models which value for example better work-life balance or time for transfer of knowledge and skills and social reproduction (Pirgmaier and Steinberger 2019). Looking at Japanese housing economies, alternative economic models such as the human dimension integrating model of (Pietila 1997) or the donut economy model by (Raworth

2017b) could be the base for developing circular economy strategies that address deeper roots than material inputs and stocks. In future research, industrial ecologists can be innovative and gender transformative by dethroning the GDP and economic growth paradigm and making space for non-market valuation processes. Feminist ecological economics and ecofeminism provide already enough literature since the 1990s to draw inspiration from. This also implies accepting that non-market parts of our economy require qualitative research, the study of local and community based economies and using a paper format which allows the integration of knowledge and voices of communities, and not only to technocratic experts. Regarding topics, this also means to return to the studies of modes of provisioning, subsistence and commons, to the culture and behaviour that is intertwined with the middle-of-life of the materialities, and not only invest in technology and efficiency, or so called beginning-of-life and end-of-life solutions.

Moreover, although norms are subjective perceptions (Morris & Winter 1975), policy makers should revisit the use or update of standards in their policy making. One update of a standard could lead to new cultural housing norms which could make a significant part of the dwelling stock obsolete for the middle and higher class. This can raise the demand for housing and create new incomes for people active in the construction and demolition industry, as in the case of Japan, but this has also a high environmental impact in terms of resource consumption. If policy makers and entrepreneurs want to make cities more circular, it means they do not have to reserve only budgets for technical innovations, but also into behavioural campaigns that nudge users into pro-circular behaviour. This is in line with a very recent warning from scientists that not technology, but behavioral change, which requires structural change in our economy, tax systems and lifestyle have to be changed if we want to decrease resource consumption and pollution, especially in countries like Japan with a lot of affluent citizens (Wiedmann et al. 2020).

3.3. Final remark

This study applied a systems thinking approach to the challenge of short-lived and vacant houses in Japan in order to identify circular area development strategies which cope with a context of shrinkage. This study combined tools of industrial ecology, political ecology, feminist critical theory and history of innovation and local history. This dissertation cannot be situated in one disciple; it is a transdisciplinary research. Although industrial ecology profiles itself as a transdisciplinary research, the tools and methods are still embedded in certain norms and worldviews, which reinforces the inequalities and uneven distribution and access to resources that it tried to alter. Sabine Barles' highlighted the importance to contextualize resource flows, stocks and exchanges over a longer time, and therefore calling for a territorial ecology. Circular economy research and practice also sees the emergence of a conceptualization of territorial circular economy, as a reaction to the urgent need to scale up circular practices and think and design more in systems. The next steps would be identifying a combined holistic circular economy, combining tools and principles of industrial, political ecology and territorial ecology and economic geography and other fields. This study illustrated a way and put one of the first stones on what a territorial circularity approach could mean in the aegis of 21st century challenges and crises.

Acknowledgements

Truthfully speaking, four years ago I did not know where I would end. Thanks to the wise guidance of my supervisor and other members in the laboratory team, the on-site research training of the graduate school in the Japanese mountainous areas, the side-projects related to circular economy in Belgium, the insightful conversations at congresses and visits in Leuven, Daegu, London, Cardiff, Trondheim, Oslo and Gothenburg and also a bit of luck I have been able to deepen my research skills, my understanding of circular area development, sustainable consumption, material stock and flow studies, and my knowledge about Japan's culture. I was also grateful I could participate in the young researcher's school organised by the United Nations University on urban sustainability in megacities in spring 2018 and could work with other construction researchers on sustainability in housing. Also as a result of giving presentations during conferences in the United Kingdom (september 2018), South-Korea (december 2018), China (July 2019) and virtually (June 2020), I learned a lot and got more clues. At the end of this journey I got more ideas how to integrate circularity to spatial planning of local governments and which sort of actions, stories and campaigns we need to invoke pro-circular behaviour among citizens, managers of companies, policymakers and other stakeholders as well which pathways should be explored in the future, starting with what we already have, and if we need new constructions: natural building materials and urban mining).

This PhD thesis might carry my name, but behind me there is a whole network of amazing and beautiful people with whom this journey of four years would have not been possible.

First of all,I want to thank **Tanikawa Hiroki** sensei. I am grateful he accepted me into his laboratory team. Four years ago I did not imagine what a circular built environment could mean, understood how to calculate material stocks and did not understand Japanese culture. Thanks to his patience and his knowledge I have grown a lot. Secondly I want to thank **Shirakawa Hiroaki sensei** and **Tomita Takashi sensei**, as reviewers of previous PhD dissertations, challenging me to focus more on certain theories and ideas and acknowledging my limitations. I also want to thank the **Japanese government** for granting me the MEXT scholarship for a period of 3 years. I am also wholeheartedly grateful to the helpful staff members of the Graduate School of Environmental Studies, in particular **Hayashi Misa, Shibata Kaori, Rie Yoshikawa** and **Dr. So Hyun Chung,** for their advice and help with everyday struggles and administration. Special thanks goes to **Marie Hatada** for not only being a great secretary for the Tanikawa laboratory, but also for being a listening friend. I will also not forget all the students in our laboratory, in particular **Dr. Jing Guo** and **Morita Masato**. The latter I want to thank for being great co-authors. I learned a lot from you both and your ways of looking at metabolism helped me to deepen my own understanding. Special thanks goes to **Bungo Nishio**, my tutor in the first semester, and **Naho Yamashita** for other times you helped me with Japanese. I want to thank the research intern **Hseng Lenn Wang** for joining me to Ena in Gifu to investigate the lifestyle or motivation of the small group of Japanese people that reclaim and renovate vacant houses, for the organisation and for your inputs and thoughts

Several persons who I perceive as my 'non-official' mentors helped me a lot in different stages of this PhD study. I learned so much from **Dr. Alessio Miatto**, especially in the first year when he was a postdoctoral researcher and helped me with my first steps. **Dr. Federica Bono** gave me golden advice and emotional support in different stages of my PhD. *Grazie mille*. Thanks to **Dr. Julie Marin** and **Marjan Marjanovic**, I understand more about how to integrate circularity in spatial planning and the idea of a territorial approach to a circular economy.

I also want to thank the other co-authors of papers, conference proceedings, reports and paper proposals that I worked on, as first author, or as their co-author - of some which are accepted, still under review or in progress: **Alessio Miatto, Julie Marin, Marjan Marjonovic, Raphael Sedlitzky, Astrid Holzinger, Jan Brusselaers, Jing Guo, Tomer Fishman, Karl Vrancken, Mariana Ortegar-Ramirez, Phuc Ha Thi Ma, Doi Ryuusei, Festival Boateng, Darshana Jayasooriya, Felicia Mendy** and others that I might forget.

I want to thank the professors who were involved in the Onsite Research Training course in Japanese mountainous villages, and in particular **Dr Takafumi Miyasaka** (in particular you, because of all the reflections we shared), **Dr Yuji Kakimoto, Dr. Hirokazu Kato, Dr. Noriko Sugiyama, Hiromi Yamashita, Dr Yasuhiro Hirano, Dr Takano Masao and Dr. Noriyuki Kawamura**.
Of course I learned a lot from the anonymous reviewers of my accepted and rejected papers. Thanks to them I learned new things. I can be a perfectionist. So it was difficult to share my ideas, but sometimes it is better to expose your work and be vulnerable to criticism, so you get feedback that can help you to move on.

I want to also thank my friends worldwide, who supported me in the past four years, in their own ways. I will not name them, because I know I will forget some. But I want to thank especially **Mary Rangel Avila** and **Alberto 'Lepe'** for being my anchor in Nagoya, helping me with daily life, growing in terms of self care and self defence, and staying mindful and true to myself. I also want to express gratitude to the European friends that visited me in Japan and supported me there and from a distance: **Kristel Sieprath, Astrid Holzinger,** and **Joakim Nergaard Todnem**.

I want to thank my parents and my brother for giving me so much and expecting nothing but that I take care of my health.

In these four years, I also lost loved ones, like **Matthew 'Matt' Stephans**. We started our PhD journey in the same autumn of 2017, you in Ireland, and me in Japan, and shared so many insights and ideas. Unfortunately, after a half year the world had to let you go. I had hoped we would have tasted champagne or 'British tea' together in a field in Belgium to celebrate our achievements. I will drink one glass for you and dedicate this thesis partly to him, my dear friend. Therefore I dedicate one part of this thesis to him. The other part I dedicate to **my grandmother Maria 'Ivonne' Verhaert.** A pollarded willow woman who also said goodbye to the world, in the final year of my PhD journey.

ありがとうございました。

Bibliography

Academic publications

Abramson, Daniel M. 2016. *Obsolescence: An Architectural History*. University of Chicago Press.

Adan, Olaf C. G., Julie Ng-A-Tham, Wojtek Hanke, Torben Sigsgaard, Peter van den Hazel, and Felicia Wu. 2007. "In Search of a Common European Approach to a Healthy Indoor Environment." *Environmental Health Perspectives* 115 (6): 983–88.

Ajayebi, Atta, Peter Hopkinson, Kan Zhou, Dennis Lam, Han-Mei Chen, and Yong Wang. 2020. "Spatiotemporal Model to Quantify Stocks of Building Structural Products for a Prospective Circular Economy." *Resources, Conservation and Recycling* 162 (November): 105026.

Akiyama, Yuki, Akihiro Ueda, Kenta Ouchi, Natsuki Ito, Yoshiya Ono, Hideo Takaoka, and Kohta Hisadomi. 2020. "Estimating the Spatial Distribution of Vacant Houses Using Public Municipal Data." In *Geospatial Technologies for Local and Regional Development*, 165–83. Springer International Publishing.

Akkerman, Abraham. 2009. "Urban Void and the Deconstruction of Neo-Platonic City-Form." *Ethics, Place & Environment* 12 (2): 205–18.

Aktas, Can B., and Melissa M. Bilec. 2012. "Impact of Lifetime on US Residential Building LCA Results." *International Journal of Life Cycle Assessment* 17 (3): 337–49.

Akyurek, K. B., and A. Ciravoğlu. 2017. "Developing a Quantitative Research Method on Planned Obsolescence in Architecture." In *PLATE: Product Lifetimes And The Environment*, 5–9. IOS Press.

Amenta, Libera, and Arjan Van Timmeren. 2018. "Beyond Wastescapes: Towards Circular Landscapes. Addressing the Spatial Dimension of Circularity through the Regeneration of Wastescapes." *Sustainability: Science Practice and Policy* 10 (12): 4740.

Arora, Mohit, Felix Raspall, Lynette Cheah, and Arlindo Silva. 2020. "Buildings and the Circular Economy: Estimating Urban Mining, Recovery and Reuse Potential of Building Components." *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2019.104581.

Attwood, Lynne. 2012. "Privatisation of Housing in Post-Soviet Russia: A New Understanding of Home?" *Europe-Asia Studies* 64 (5): 903–28.

Augiseau, Vincent, and Sabine Barles. 2017. "Studying Construction Materials Flows and Stock: A Review." *Resources, Conservation and Recycling* 123 (August): 153–64.

Augiseau, Vincent, and Eunhye Kim. 2021. "Inflows and Outflows from Material Stocks of Buildings and Networks and Their Space-Differentiated Drivers: The Case Study of the Paris Region." *Sustainability: Science Practice and Policy* 13 (3): 1376.

Avrami, Erica. 2016. "Making Historic Preservation Sustainable." *Journal of the American Planning Association*. https://doi.org/10.1080/01944363.2015.1126196.

Baba, H., Y. Akiyama, T. Tokudomi, and Y. Takahashi. 2020. "LEARNING GEOGRAPHICAL DISTRIBUTION OF VACANT HOUSES USING CLOSED MUNICIPAL DATA: A CASE STUDY OF WAKAYAMA CITY, JAPAN." *ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences* 6. http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=21949042&AN=145994980&h=zxSQL7QDd97CJMSkbM3doF6yj%2FJy47k%2FAw5SLX47K8o%2BKkEdWpi%2Bh2VGmbiMkjzYgNh4x3wOxde3lA0ijqx82Q%3D%3D&crl=c.

Bahers, Jean-Baptiste, and Mathieu Durand. 2017. "Le Retour de La Proximité ! Quelles Implications Pour Les Services Urbains En Réseau ?" *Flux*. https://doi.org/10.3917/flux1.109.0001.

Bahers, Jean-Baptiste, Audrey Tanguy, and Stephanie Pincetl. 2020. "Metabolic Relationships between Cities and Hinterland: A Political-Industrial Ecology of Energy Metabolism of Saint-Nazaire Metropolitan and Port Area (France)." *Ecological Economics*. https://doi.org/10.1016/j.ecolecon.2019.106447.

Barles, S. 2007. "Urban Metabolism and River Systems: An Historical perspective–Paris and the Seine, 1790–1970." https://hal.archives-ouvertes.fr/hal-00330804/.

Barles, Sabine. 2009. “Urban Metabolism of Paris and Its Region.” *Journal of Industrial Ecology* 13 (6): 898–913.

———. 2014. “History of Waste Management and the Social and Cultural Representations of Waste.” In *The Basic Environmental History*, edited by Mauro Agnoletti and Simone Neri Serneri, 199–226. Cham: Springer International Publishing.

Bastos, Joana, Stuart A. Batterman, and Fausto Freire. 2014. “Life-Cycle Energy and Greenhouse Gas Analysis of Three Building Types in a Residential Area in Lisbon.” *Energy and Buildings* 69 (February): 344–53.

Berrill, Peter, and Edgar G. Hertwich. 2021. “Material Flows and GHG Emissions from Housing Stock Evolution in US Counties, 2020–60.” *Buildings and Cities* 2 (1): 599–617.

B. Müller, Daniel. 2006. “Stock Dynamics for Forecasting Material flows—Case Study for Housing in The Netherlands.” *Ecological Economics: The Journal of the International Society for Ecological Economics* 59 (1): 142–56.

Bouchet-Blancou, Géraldine. 2020. “Manifeste Pour Un Urbanisme Circulaire. Pour Des Alternatives Concrètes à L’étalement de La Ville, Sylvain Grisot, Nantes: Dixit, 2020.” *Flux*, no. 1: 197–99.

Breetz, Hanna L. 2017. “Political-Industrial Ecology: Integrative, Complementary, and Critical Approaches.” *Geoforum; Journal of Physical, Human, and Regional Geosciences* 85 (October): 392–95.

Brown, Azby. 2013. *Just Enough: Lessons in Living Green From Traditional Japan*. Tuttle Publishing.

Brunner, Paul H., and Helmut Rechberger. 2016. *Handbook of Material Flow Analysis: For Environmental, Resource, and Waste Engineers, Second Edition*. CRC Press.

Brunner, P. H. 1999. “In Search of the Final Sink.” *Environmental Science and Pollution Research International* 6 (1): 1.

Buchanan, Andrew, David Carradine, Graeme Beattie, and Hugh Morris. 2011. “Performance of Houses during the Christchurch Earthquake of 22 February 2011.” *Bulletin of the New Zealand Society for Earthquake Engineering* 44 (4): 342–57.

Bullock, J. C., A. Kano, and J. Welker. 2017. “Rethinking Japanese Feminisms.” http://library.oapen.org/handle/20.500.12657/30212.

Cai, Wenjia, Liyang Wan, Yongkai Jiang, Can Wang, and Lishen Lin. 2015. “Short-Lived Buildings in China: Impacts on Water, Energy, and Carbon Emissions.” *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.5b02333.

Calisto Friant, Martin, Walter J. V. Vermeulen, and Roberta Salomone. 2020. “A Typology of Circular Economy Discourses: Navigating the Diverse Visions of a Contested Paradigm.” *Resources, Conservation and Recycling* 161 (October): 104917.

Camacho-Otero, Juana, Casper Boks, and Ida Pettersen. 2018. “Consumption in the Circular Economy: A Literature Review.” *Sustainability*. https://doi.org/10.3390/su10082758.

Camacho-Otero, Juana, Ida Nilstad Pettersen, and Casper Boks. 2020. “Consumer Engagement in the Circular Economy: Exploring Clothes Swapping in Emerging Economies from a Social Practice Perspective.” *Sustainable Development* 28 (1): 279–93.

Campbell-Johnston, Kieran, Joey Ten Cate, Maja Elfering-Petrovic, and Joyeeta Gupta. 2019. “City Level Circular Transitions: Barriers and Limits in Amsterdam, Utrecht and The Hague.” *Journal of Cleaner Production* 235 (October): 1232–39.

Cash, David W., William C. Clark, Frank Alcock, Nancy M. Dickson, Noelle Eckley, David H. Guston, Jill Jäger, and Ronald B. Mitchell. 2003. “Knowledge Systems for Sustainable Development.” *Proceedings of the National Academy of Sciences*. https://doi.org/10.1073/pnas.1231332100.

Cavaleiro de Ferreira, António, and Francesco Fuso-Nerini. 2019. “A Framework for Implementing and Tracking Circular Economy in Cities: The Case of Porto.” *Sustainability: Science Practice and Policy* 11 (6): 1813.

Çetin, Sultan, Catherine De Wolf, and Nancy Bocken. 2021. “Circular Digital Built Environment: An Emerging Framework.” *Sustainability: Science Practice and Policy* 13 (11): 6348.

Chávez, Abel, Chris Kennedy, Bin Chen, Marian Chertow, Tim Baynes, Shaoqing Chen, and Xuemei Bai. 2018. “Understanding, Implementing, and Tracking Urban Metabolism Is Key to Urban Futures.” *Urban Planet: Knowledge towards Sustainable Cities*, 68–91.

Checkland, Peter, and John Poulter. 2006. *Learning for Action: A Short Definitive Account of Soft Systems Methodology and Its Use for Practitioner, Teachers, and Students*. Vol. 26. Wiley Chichester.

Cheng, Kuang-Ly, Shu-Chien Hsu, Wing-Man Li, and Hwong-Wen Ma. 2018. "Quantifying Potential Anthropogenic Resources of Buildings through Hot Spot Analysis." *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2018.02.003.

Chertow, Marian R. 2000. "INDUSTRIAL SYMBIOSIS: Literature and Taxonomy." *Annual Review of Energy and the Environment* 25 (1): 313–37.

Cohen, Barney. 2006. "Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability." *Technology in Society*. https://doi.org/10.1016/j.techsoc.2005.10.005.

Cooper, Tim. 2008. "Slower Consumption Reflections on Product Life Spans and the 'throwaway Society.'" *Journal of Industrial Ecology* 9 (1-2): 51–67.

Cousins, Joshua J., and Joshua P. Newell. 2015. "A Political–industrial Ecology of Water Supply Infrastructure for Los Angeles." *Geoforum; Journal of Physical, Human, and Regional Geosciences* 58 (January): 38–50.

Cox, Rosie. 2016. "Materials, Skills and Gender Identities: Men, Women and Home Improvement Practices in New Zealand." *Gender, Place & Culture*. https://doi.org/10.1080/0966369x.2015.1034248.

Crutzen, Paul J. n.d. "The 'Anthropocene.'" *Earth System Science in the Anthropocene*. https://doi.org/10.1007/3-540-26590-2_3.

Curran, Winifred, and Trina Hamilton. 2012. "Just Green Enough: Contesting Environmental Gentrification in Greenpoint, Brooklyn." *Local Environment*. https://doi.org/10.1080/13549839.2012.729569.

———. 2017. *Just Green Enough: Urban Development and Environmental Gentrification*. Routledge.

Daigo, Ichiro, Susumu Hashimoto, Yasunari Matsuno, and Yoshihiro Adachi. 2009. "Material Stocks and Flows Accounting for Copper and Copper-Based Alloys in Japan." *Resources, Conservation and Recycling* 53 (4): 208–17.

Danneels, K., G. Juwet, and D. Bruggeman. 2018. "Stedelijk Metabolisme: Van Theoretisch Concept Naar Tastbare Praktijk." *AGORA Magazine*. https://ojs.ugent.be/agora/article/download/11668/11127.

De Angelis, Roberta. 2020. "Business Model Innovation in the Circular Economy: A Paradox Perspective." http://orca.cf.ac.uk/133243/1/Manuscript.pdf.

Deilmann, Clemens, Karl-Heinz Effenberger, and Juliane Banse. 2009. "Housing Stock Shrinkage: Vacancy and Demolition Trends in Germany." *Building Research and Information* 37 (5-6): 660–68.

Diamond, Jared. 2002. "Evolution, Consequences and Future of Plant and Animal Domestication." *Nature* 418 (6898): 700–707.

———. 2013. *Guns, Germs and Steel: A Short History of Everybody for the Last 13,000 Years*. Random House.

Döringer, Stefanie, Yuta Uchiyama, Marianne Penker, and Ryo Kohsaka. 2020. "A Meta-Analysis of Shrinking Cities in Europe and Japan. Towards an Integrative Research Agenda." *European Planning Studies* 28 (9): 1693–1712.

Erkman, S. 1997. "Industrial Ecology: An Historical View." *Journal of Cleaner Production*. https://doi.org/10.1016/s0959-6526(97)00003-6.

Fanning, Andrew L., Daniel W. O'Neill, and Milena Büchs. 2020. "Provisioning Systems for a Good Life within Planetary Boundaries." *Global Environmental Change*. https://doi.org/10.1016/j.gloenvcha.2020.102135.

Fischer-Kowalski, Marina, and Helmut Haberl. 1998. "Sustainable Development: Socio-Economic Metabolism and Colonization of Nature." *International Social Science Journal* 50 (158): 573–87.

Fishman, Tomer, Heinz Schandl, and Hiroki Tanikawa. 2015. "The Socio-Economic Drivers of Material Stock Accumulation in Japan's Prefectures." *Ecological Economics: The Journal of the International Society for Ecological Economics* 113 (May): 76–84.

Florida, Richard. 2005. "Cities and the Creative Class." https://doi.org/10.4324/9780203997673.

Fratini, Chiara Farné, Susse Georg, and Michael Søgaard Jørgensen. 2019. “Exploring Circular Economy Imaginaries in European Cities: A Research Agenda for the Governance of Urban Sustainability Transitions.” *Journal of Cleaner Production* 228 (August): 974–89.

Frenken, Koen, and Ron A. Boschma. 2007. “A Theoretical Framework for Evolutionary Economic Geography: Industrial Dynamics and Urban Growth as a Branching Process.” *Journal of Economic Geography* 7 (5): 635–49.

Frosch, Robert A., and Nicholas E. Gallopoulos. 1989. “Strategies for Manufacturing.” *Scientific American*. https://doi.org/10.1038/scientificamerican0989-144.

Frost, Peter K., and Andrew Gordon. 1995. “Postwar Japan as History.” *Journal of Interdisciplinary History*. https://doi.org/10.2307/205861.

Geissdoerfer, Martin, Paulo Savaget, Nancy M. P. Bocken, and Erik Jan Hultink. 2017. “The Circular Economy – A New Sustainability Paradigm?” *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2016.12.048.

Ghisellini, Patrizia, Catia Cialani, and Sergio Ulgiati. 2016. “A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems.” *Journal of Cleaner Production* 114 (February): 11–32.

Girardet, Herbert. 1996. *The Gaia Atlas of Cities: New Directions for Sustainable Urban Living*. UN-HABITAT.

Girard, Luigi Fusco, and Francesca Nocca. 2019. “Moving Towards the Circular Economy/City Model: Which Tools for Operationalizing This Model?” *Sustainability*. https://doi.org/10.3390/su11226253.

Girard, Luigi Fusco, Francesca Nocca, and Antonia Gravagnuolo. 2019. “Matera: City of Nature, City of Culture, City of Regeneration. Towards a Landscape-Based and Culture-Based Urban Circular Economy.” *Aestimum*, October, 5–42.

Goetz, E. G. 2012. “Obsolescence and the Transformation of Public Housing Communities in the US.” *International Journal of Housing Policy*. https://www.tandfonline.com/doi/abs/10.1080/14616718.2012.709671.

González, Rubén C. Lois, Rubén C. Lois González, María José Piñeira Mantiñán, and Sònia Vives Miró. 2020. “THE URBAN BUBBLE PROCESS IN SPAIN: AN INTERPRETATION FROM THE THEORY OF THE CIRCUITS OF CAPITAL.” *Journal of Urban and Regional Analysis*. https://doi.org/10.37043/jura.2016.8.1.1.

Gordon, Andrew. 1993. *Postwar Japan as History*. University of California Press.

Graedel, Thomas E. 2019. “Material Flow Analysis from Origin to Evolution.” *Environmental Science & Technology* 53 (21): 12188–96.

Gravagnuolo, Antonia, Mariarosaria Angrisano, and Luigi Fusco Girard. 2019. “Circular Economy Strategies in Eight Historic Port Cities: Criteria and Indicators Towards a Circular City Assessment Framework.” *Sustainability: Science Practice and Policy* 11 (13): 3512.

Grinin, Leonid E., Anton L. Grinin, and Andrey Korotayev. 2017. “Forthcoming Kondratieff Wave, Cybernetic Revolution, and Global Ageing.” *Technological Forecasting and Social Change* 115 (February): 52–68.

Guo, Jing, Tomer Fishman, Yao Wang, Alessio Miatto, Wendy Wuyts, Licheng Zheng, Heming Wang, and Hiroki Tanikawa. 2020. “Urban Development and Sustainability Challenges Chronicled by a Century of Construction Material Flows and Stocks in Tiexi, China.” *Journal of Industrial Ecology* 36 (July): 540.

Gutberlet, Jutta, Sebastián Carenzo, Jaan-Henrik Kain, and Adalberto Mantovani Martiniano de Azevedo. 2017. “Waste Picker Organizations and Their Contribution to the Circular Economy: Two Case Studies from a Global South Perspective.” *Resources*. https://doi.org/10.3390/resources6040052.

Haase, Annegret, Dieter Rink, Katrin Grossmann, Matthias Bernt, and Vlad Mykhnenko. 2014. “Conceptualizing Urban Shrinkage.” *Environment and Planning A: Economy and Space*. https://doi.org/10.1068/a46269.

Harvey, David. 1985. *Consciousness and the Urban Experience: Studies in the History and Theory of Capitalist Urbanization*. Johns Hopkins University Press.

Hashimoto, Seiji, Hiroki Tanikawa, and Yuichi Moriguchi. 2007. “Where Will Large Amounts of Materials Accumulated within the Economy Go? – A Material Flow Analysis of Construction

Minerals for Japan." *Waste Management*. https://doi.org/10.1016/j.wasman.2006.10.009.
Hashimoto, S., Y. Moriguchi, T. Tasaki, and M. Masaharu. 2006. "Comparative Analysis on Images of Cycle-Oriented Society." *Journal of the Japanese Society of Waste Management Experts* 17 (3): 204–18.
Hattori, Keiro, Kiyonobu Kaido, and Mihoko Matsuyuki. 2017. "The Development of Urban Shrinkage Discourse and Policy Response in Japan." *Cities* 69: 124–32.
Hayunga, Darren K., R. Kelley Pace, and Shuang Zhu. 2019. "Borrower Risk and Housing Price Appreciation." *Journal of Real Estate Finance and Economics* 58 (4): 544–66.
Heisel, Felix, and Sabine Rau-Oberhuber. 2020. "Calculation and Evaluation of Circularity Indicators for the Built Environment Using the Case Studies of UMAR and Madaster." *Journal of Cleaner Production* 243 (January): 118482.
Hertwich, E., R. Lifset, S. Pauliuk, N. Heeren, S. Ali, and Q. Tu. 2020. "Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future." https://stg-wedocs.unep.org/handle/20.500.11822/34351.
Hoballah, Arab, Camaren Peter, and Programme Des Nations Unies Pour l'environnement. 2012. *Sustainable, Resource Efficient Cities: Making It Happen!* UNEP.
Hollander, Marcel C. den, Marcel C. den Hollander, Conny A. Bakker, and Erik Jan Hultink. 2017. "Product Design in a Circular Economy: Development of a Typology of Key Concepts and Terms." *Journal of Industrial Ecology*. https://doi.org/10.1111/jiec.12610.
Hotta, Yasuhiko, Lewis Akenji, Chika Aoki-Suzuki, Atsushi Watabe, Chen Liu, Jun Nakatani, Kiyo Kurisu, and Eri Amasawa. n.d. "Six Proposals for Future Policies towards Circular Economy and Society." https://www.iges.or.jp/en/publication_documents/pub/policy/en/6874/t20-japan-tf3-2-six-proposals-future-policies-circular-economy-society.pdf.
Humer, Alois, Raphael Sedlitzky, and David Brunner. 2019. "When Does Population Growth Pay off? A Case Study of Suburban Land Consumption to Assess the Lower Austrian Infrastructural Cost Calculator." *Journal of Housing and the Built Environment* 34 (1): 331–44.
Ianchenko, Alex, Kathrina Simonen, and Clayton Barnes. 2020. "Residential Building Lifespan and Community Turnover." *Journal of Architectural Engineering* 26 (3): 04020026.
Ibáñez, Cristian Suau. 2019. "Circular Design in Everyday Urbanism: Towards Regenerative and Restorative Dynamic Spaces in Cities." *Visions for Sustainability* 11: 9–16.
Iossifova, Deljana, Christopher N. H. Doll, and Alexandros Gasparatos. 2017. *Defining the Urban: Interdisciplinary and Professional Perspectives*. Routledge.
Irvine, Sigourney, and Xuemei Bai. 2019. "Positive Inertia and Proactive Influencing towards Sustainability: Systems Analysis of a Frontrunner City." *Urban Transformations*. https://doi.org/10.1186/s42854-019-0001-7.
Ishikawa, Masahiro, Keisuke Matsuhashi, Yuko Kanamori, and Toshinori Ariga. 2017. "Method of Grasping Detailed Regional Distribution of Vacant Dwelling Based on the Number of Dwellings and Households." *J City Plann Inst Jpn* 52: 689–95.
Ishikawa, M., K. Matsuhashi, T. Ariga, Y. Kanamori, and H. Kurishima. 2016. "Estimation of Current and Future Distribution of Vacant Dwellings within Municipalities: With a Focus on the Difference between the Numbers of Dwellings and Households." *Journal of the City Planning Institute of Japan* 51 (3): 833–38.
Jabbour, Charbel Jose Chiappetta, Joseph Sarkis, Ana Beatriz Lopes de Sousa Jabbour, Douglas William Scott Renwick, Sanjay Kumar Singh, Oksana Grebinevych, Isak Kruglianskas, and Moacir Godinho Filho. 2019. "Who Is in Charge? A Review and a Research Agenda on the 'human Side' of the Circular Economy." *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2019.03.038.
Japan, M. O. E. 1970. "Waste Management and Public Cleansing Law (Law No. 137)." *Tokyo, Japan*.
Jin, Hyun-Young, Youngsang Kwon, Seunghyun Yoo, Da-Hye Yim, and Sujin Han. 2021. "Can Urban Greening Using Abandoned Places Promote Citizens' Wellbeing? Case in Daegu City, South Korea." *Urban Forestry & Urban Greening* 57 (126956): 126956.
Jonker, J., N. Montenegro Navarro, D. Ludwig, H. Zoon, J. Voet, N. Van Stralen, R. van Ooijen, and R. Lammes. 2018. "Circular City Governance. An Explorative Research Study into Current Barriers and Governance Practices in Circular City Transitions across Europe."
Judd, Bruce. 2020. "A Review of 'The Rise in Vacant Housing in Post-Growth Japan: Housing

Market, Urban Policy, and Revitalizing Aging Cities', Edited by Tomoko Kubo and Yoshimichi Yui." *International Journal of Housing Policy* 20 (3): 457–60.
Kawai, Kohei, Masatomo Suzuki, and Chihiro Shimizu. 2019. "Shrinkage in Tokyo's Central Business District: Large-Scale Redevelopment in the Spatially Shrinking Office Market." *Sustainability: Science Practice and Policy* 11 (10): 2742.
Kębłowski, Wojciech, Deborah Lambert, and David Bassens. 2020. "Circular Economy and the City: An Urban Political Economy Agenda." *Culture and Organization* 26 (2): 142–58.
Kenis, Anneleen, Federica Bono, and Erik Mathijs. 2016. "Unravelling the (post-)political in Transition Management: Interrogating Pathways towards Sustainable Change." *Journal of Environmental Policy & Planning*. https://doi.org/10.1080/1523908x.2016.1141672.
Kenis, Anneleen, and Matthias Lievens. 2016. *De mythe van de groene economie*. EPO.
Kennedy, Christopher, John Cuddihy, and Joshua Engel-Yan. 2007. "The Changing Metabolism of Cities." *Journal of Industrial Ecology*. https://doi.org/10.1162/jie.2007.1107.
Kintrea, K. 2007. "Housing Aspirations and Obsolescence: Understanding the Relationship." *Journal of Housing and the Built Environment*. https://idp.springer.com/authorize/casa?redirect_uri=https://link.springer.com/article/10.1007/s10901-007-9087-4&casa_token=7ZR95leO2ckAAAAA:qxM5M9Wpk0ueCiGJqCwKDzeqnOv0f9TTVvX-_uAKnekXr-Vx8fH7DprJBrzfyQkoWghMa8eblgMTIDi-zA.
Kirchherr, Julian, Denise Reike, and Marko Hekkert. 2017. "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." *Resources, Conservation and Recycling* 127 (December): 221–32.
———. n.d. "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3037579.
Korhonen, Jouni, Antero Honkasalo, and Jyri Seppälä. 2018. "Circular Economy: The Concept and Its Limitations." *Ecological Economics: The Journal of the International Society for Ecological Economics* 143 (January): 37–46.
Krausmann, Fridolin. 2013. "A City and Its Hinterland: Vienna's Energy Metabolism 1800–2006." *Long Term Socio-Ecological Research*. https://doi.org/10.1007/978-94-007-1177-8_11.
Krausmann, Fridolin, Simone Gingrich, and Reza Nourbakhch-Sabet. 2011. "The Metabolic Transition in Japan." *Journal of Industrial Ecology*. https://doi.org/10.1111/j.1530-9290.2011.00376.x.
Kubo, Kazuyuki, and Pavement Team Leader. 2014. "Recycling in Japan." *Application of Reclaimed Asphalt Pavement and Recycled Asphalt Shingles in Hot-Mix Asphalt, Vols. TR Circular E-C188*, 60–66.
Kubo, Tomoko, and Michihiro Mashita. 2020. "Why the Rise in Urban Housing Vacancies Occurred and Matters in Japan." *The Rise in Vacant Housing in Post-Growth Japan*. https://doi.org/10.1007/978-981-13-7920-8_1.
Kubo, Tomoko, and Yoshimichi Yui. 2019. *The Rise in Vacant Housing in Post-Growth Japan: Housing Market, Urban Policy, and Revitalizing Aging Cities*. Springer.
———. , eds. 2020. *The Rise in Vacant Housing in Post-Growth Japan: Housing Market, Urban Policy, and Revitalizing Aging Cities*. Springer, Singapore.
Lanau, Maud, Gang Liu, Ulrich Kral, Dominik Wiedenhofer, Elisabeth Keijzer, Chang Yu, and Christina Ehlert. 2019. "Taking Stock of Built Environment Stock Studies: Progress and Prospects." *Environmental Science & Technology* 53 (15): 8499–8515.
Lanau, Maud, Ruichang Mao, and Gang Liu. 2021. "Cities as Organisms: Urban Metabolism of the Four Main Danish Cities." *Cities*. https://doi.org/10.1016/j.cities.2021.103336.
Lantz, Herman R., and Peter H. Rossi. 1957. "Why Families Move: A Study in the Social Psychology of Urban Residential Mobility." *Marriage and Family Living*. https://doi.org/10.2307/348888.
Lee, Andrew Chee Keng, Hannah C. Jordan, and Jason Horsley. 2015. "Value of Urban Green Spaces in Promoting Healthy Living and Wellbeing: Prospects for Planning." *Risk Management and Healthcare Policy* 8 (August): 131–37.
"Leegstaande Woningen Opsporen, Registreren En Aanpakken." n.d. Accessed November 3, 2020. https://www.wonenvlaanderen.be/lokale-besturen/leegstaande-woningen-opsporen-registreren-en-aanpakken.

Lee, J. Y., Hiroaki Sugiura, and Others. 2018. “Key Factors in Determining Internal Migration to Rural Areas and Its Promoting Measures: A Case Study of Hirosaki City, Aomori Prefecture.” *Policy Research Institute, Ministry of Finance, Japan, Public Policy Review* 14 (1): 153–76.

Leonard, Lorraine, Harvey Perkins, and David Thorns. 2004. “Presenting and Creating Home: The Influence of Popular and Building Trade Print Media in the Construction of Home.” *Housing, Theory and Society* 21 (3): 97–110.

Levin, Kelly, Benjamin Cashore, Steven Bernstein, and Graeme Auld. 2012. “Overcoming the Tragedy of Super Wicked Problems: Constraining Our Future Selves to Ameliorate Global Climate Change.” *Policy Sciences*. https://doi.org/10.1007/s11077-012-9151-0.

Lewis, Simon L., and Mark A. Maslin. 2015. “Defining the Anthropocene.” *Nature*. https://doi.org/10.1038/nature14258.

Liu, Guiwen, Kexi Xu, Xiaoling Zhang, and Guomin Zhang. 2014. “Factors Influencing the Service Lifespan of Buildings: An Improved Hedonic Model.” *Habitat International* 43 (July): 274–82.

Lovell, Sarah Taylor, and John R. Taylor. 2013. “Supplying Urban Ecosystem Services through Multifunctional Green Infrastructure in the United States.” *Landscape Ecology* 28 (8): 1447–63.

Lowe, Ernest A. 1997. “Creating by-Product Resource Exchanges: Strategies for Eco-Industrial Parks.” *Journal of Cleaner Production* 5 (1): 57–65.

Lowry, Ira S. 1960. “Filtering and Housing Standards: A Conceptual Analysis.” *Land Economics* 36 (4): 362–70.

Macpherson, W. J. 1995. *The Economic Development of Japan 1868-1941*. Cambridge University Press.

Magnaghi, Alberto. 2005. *The Urban Village: A Charter for Democracy and Local Self-Sustainable Development*. Zed Books.

Marin, J., and B. De Meulder. 2016. “Antwerp City Wastescapes. Historic Interplays between Waste & Urban Development.” *International Planning History*. https://journals.open.tudelft.nl/index.php/iphs/article/download/1261/1861.

Marin, Julie, Luc Alaerts, and Karel Van Acker. 2020. “A Materials Bank for Circular Leuven: How to Monitor ‘messy’ Circular City Transition Projects.” *Sustainability: Science Practice and Policy* 12 (24): 10351.

Marin, Julie, and Bruno De Meulder. 2018a. “Urban Landscape Design Exercises in Urban Metabolism: Reconnecting with Central Limburg’s Regenerative Resource Landscape.” *Journal of Landscape Architecture* 13 (1): 36–49.

———. 2018b. “Interpreting Circularity. Circular City Representations Concealing Transition Drivers.” *Sustainability: Science Practice and Policy* 10 (5): 1310.

Martin, R. 2000. “Institutional Approaches in Economic Geography.” *A Companion to Economic Geography*. https://onlinelibrary.wiley.com/doi/pdf/10.1002/9780470693445#page=91.

Matsumoto, Ken ’ichi, Yuki Yamamoto, and Nao Ohya. 2018. “Effect of Subsidies and Tax Deductions on Promoting the Construction of Long-Life Quality Houses in Japan.” *International Journal of Environmental Research and Public Health* 15 (11). https://doi.org/10.3390/ijerph15112376.

Mauser, Wolfram, Gernot Klepper, Martin Rice, Bettina Susanne Schmalzbauer, Heide Hackmann, Rik Leemans, and Howard Moore. 2013. “Transdisciplinary Global Change Research: The Co-Creation of Knowledge for Sustainability.” *Current Opinion in Environmental Sustainability*. https://doi.org/10.1016/j.cosust.2013.07.001.

Meadows, Donella. 2001. “Dancing with Systems.” *Whole Earth Review* 106: 58–63.

Meen, Geoffrey. 2016. “Spatial Housing Economics: A Survey.” *Urban Studies* 53 (10): 1987–2003.

Miatto, Alessio, Heinz Schandl, Luigi Forlin, Fabio Ronzani, Paolo Borin, Andrea Giordano, and Hiroki Tanikawa. 2019. “A Spatial Analysis of Material Stock Accumulation and Demolition Waste Potential of Buildings: A Case Study of Padua.” *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2018.12.011.

Miatto, Alessio, Heinz Schandl, and Hiroki Tanikawa. 2017. “How Important Are Realistic Building Lifespan Assumptions for Material Stock and Demolition Waste Accounts?” *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2017.01.015.

Minami, Kazunobu. 2016. “The Efforts to Develop Longer Life Housing with Adaptability in Japan.” *Energy Procedia* 96 (September): 662–73.

Moe, Japan. 2000. “Basic Act on Establishing a Sound Material-Cycle Society.”
Mohit, Mohammad Abdul, Mansor Ibrahim, and Yong Razidah Rashid. 2010. “Assessment of Residential Satisfaction in Newly Designed Public Low-Cost Housing in Kuala Lumpur, Malaysia.” *Habitat International* 34 (1): 18–27.
Mollaei, Aida, Nadine Ibrahim, and Komal Habib. 2021. “Estimating the Construction Material Stocks in Two Canadian Cities: A Case Study of Kitchener and Waterloo.” *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.124501.
Moriguchi, Yuichi. 2007. “Material Flow Indicators to Measure Progress toward a Sound Material-Cycle Society.” *Journal of Material Cycles and Waste Management* 9 (2): 112–20.
Morimoto, A. 2011. “The Effect of Shrinking City on Local Government Finance and Global Environment.” *Journal of the City Planning Institute of Japan* 46 (3): 739–44.
Morris, Earl W., and Mary Winter. 1975. “A Theory of Family Housing Adjustment.” *Journal of Marriage and the Family*. https://doi.org/10.2307/351032.
Morseletto, Piero. 2020. “Targets for a Circular Economy.” *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2019.104553.
Murayama, Akito. 2016. “Land Use Planning for Depopulating and Aging Society in Japan.” In *Urban Resilience: A Transformative Approach*, edited by Yoshiki Yamagata and Hiroshi Maruyama, 79–92. Cham: Springer International Publishing.
Nadler, David A., and Michael L. Tushman. 1997. “Implementing New Designs: Managing Organizational Change.” *Tushman, ML and Anderson, P. Eds*, 595–606.
Németh, Jeremy, and Joern Langhorst. 2014. “Rethinking Urban Transformation: Temporary Uses for Vacant Land.” *Cities* 40 (October): 143–50.
Newell, Joshua P., and Joshua J. Cousins. 2015. “The Boundaries of Urban Metabolism: Towards a Political–industrial Ecology.” *Progress in Human Geography* 39 (6): 702–28.
Nikulina, Varvara, Johan Larson Lindal, Henrikke Baumann, David Simon, and Henrik Ny. 2019. “Lost in Translation: A Framework for Analysing Complexity of Co-Production Settings in Relation to Epistemic Communities, Linguistic Diversities and Culture.” *Futures* 113 (October): 102442.
Nish, Ian. 2008. *The Iwakura Mission to America and Europe: A New Assessment*. Routledge.
Nishiyama, Hiroyasu. 2019. “A Problem of Vacant Housing in Local Cities: Utsunomiya City, Tochigi.” *The Rise in Vacant Housing in Post-Growth Japan: Housing Market, Urban Policy, and Revitalizing Aging Cities*, 123.
Noguchi, M. 2003. “The Effect of the Quality-Oriented Production Approach on the Delivery of Prefabricated Homes in Japan.” *Journal of Housing and the Built Environment*. https://idp.springer.com/authorize/casa?redirect_uri=https://link.springer.com/article/10.1023/B:JOHO.0000005759.07212.00&casa_token=TSjSgjoLRjcAAAAA:m2nXHriCFdnKIWOueySeqgHkIuhtFbrRoI0aZEmcDtB0yHtzrjeV0Bi0nmDSWu5PtUzd35QjUBrT9d5uJg.
North, Douglass C. 1990. “Institutions, Institutional Change and Economic Performance.” https://doi.org/10.1017/cbo9780511808678.
Ogunmakinde, Olabode Emmanuel. 2019. “A Review of Circular Economy Development Models in China, Germany and Japan.” *Recycling Today* 4 (3): 27.
Okamoto, H. 2006. “Switching to a Stock-Type Society—Creating Infrastructure in the Age of Long Lifespan Products.” Kajima Publishing Co.: Tokyo, Japan.
O’Neill, Daniel W., Andrew L. Fanning, William F. Lamb, and Julia K. Steinberger. 2018. “A Good Life for All within Planetary Boundaries.” *Nature Sustainability*. https://doi.org/10.1038/s41893-018-0021-4.
Ono, Takashi. 2018. “The Methodology of Inheriting the Traditional Townscape by ‘Re-Use’ the Heritage Buildings -Through Sharing the Case Studies in Japan and India -.” *International Journal of Engineering & Technology*. https://doi.org/10.14419/ijet.v7i1.4.9032.
Ortiz-Moya, Fernando, Yatsuka Kataoka, Osamu Saito, Bijon Kumer Mitra, and Kazuhiko Takeuchi. 2021. “Sustainable Transitions towards a Resilient and Decentralised Future: Japan’s Circulating and Ecological Sphere (CES).” *Sustainability Science*, March. https://doi.org/10.1007/s11625-021-00941-y.
Ozaki, Ritsuko, and John Rees Lewis. 2006. “Boundaries and the Meaning of Social Space: A Study of Japanese House Plans.” *Environment and Planning. D, Society & Space* 24 (1): 91–104.

Paiho, Satu, Elina Mäki, Nina Wessberg, Martta Paavola, Pekka Tuominen, Maria Antikainen, Jouko Heikkilä, Carmen Antuña Rozado, and Nusrat Jung. 2020. “Towards Circular cities—Conceptualizing Core Aspects.” *Sustainable Cities and Society* 59 (August): 102143.

Pallagst, Karina, Thorsten Wiechmann, and Cristina Martinez-Fernandez. 2013. *Shrinking Cities: International Perspectives and Policy Implications*. Routledge.

Peng, Wangchongyu, Weijun Gao, Xin Yuan, Rui Wang, and Jinming Jiang. 2019. “Spatiotemporal Differences in Determinants of City Shrinkage Based on Semiparametric Geographically Weighted Regression.” *Sustainability: Science Practice and Policy* 11 (24): 6891.

Petoskey, Jennifer, Missy Stults, Eileen Naples, Galen Hardy, Alicia Quilici, Cassie Byerly, Amelia Clark, Deja Newton, Elizabeth Santiago, and Jack Teener. 2021. “Envisioning a Circular Economy: The Journey of One Mid-Sized Midwestern City.” *Sustainability: Science Practice and Policy* 13 (6): 3157.

Pierce, Joseph, and Mary Lawhon. 2015. “Walking as Method: Toward Methodological Forthrightness and Comparability in Urban Geographical Research.” *The Professional Geographer: The Journal of the Association of American Geographers* 67 (4): 655–62.

Pietila, H. 1997. “The Triangle of Human Economy: Household-Cultivationindustrial Production. An Attempt at Making the Human Economy Visible in Toto.” *Ecological Economics: The Journal of the International Society for Ecological Economics*, no. 20.

Pirages, D. C., and P. R. Ehrlich. 1974. “Ark II; Social Response to Environmental Imperatives [by] Dennis C. Pirages [and] Paul R. Ehrlich.-.” http://agris.fao.org/agris-search/search.do?recordID=US201300544469.

Pirgmaier, Elke, and Julia K. Steinberger. 2019. “Roots, Riots, and Radical Change—A Road Less Travelled for Ecological Economics.” *Sustainability: Science Practice and Policy* 11 (7): 2001.

Planing, Patrick. 2015. “Business Model Innovation in a Circular Economy Reasons for Non-Acceptance of Circular Business Models.” *Open Journal of Business Model Innovation* 1 (11): 1–11.

Pomponi, Francesco, and Alice Moncaster. 2017. “Circular Economy for the Built Environment: A Research Framework.” *Journal of Cleaner Production* 143 (February): 710–18.

Pourebrahimi, Mohammad, Eghbali Seyed Rahman, and Pereira Roders Ana. 2020. “Identifying Building Obsolescence: Towards Increasing Buildings’ Service Life.” *International Journal of Building Pathology and Adaptation* 38 (5): 635–52.

Prendeville, Sharon, Emma Cherim, and Nancy Bocken. 2018. “Circular Cities: Mapping Six Cities in Transition.” *Environmental Innovation and Societal Transitions* 26 (March): 171–94.

Radzimski, Adam. 2016. “Changing Policy Responses to Shrinkage: The Case of Dealing with Housing Vacancies in Eastern Germany.” *Cities* 50 (February): 197–205.

Ramage, Michael H., Henry Burridge, Marta Busse-Wicher, George Fereday, Thomas Reynolds, Darshil U. Shah, Guanglu Wu, et al. 2017. “The Wood from the Trees: The Use of Timber in Construction.” *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2016.09.107.

Raworth, Kate. 2017a. “A Doughnut for the Anthropocene: Humanity’s Compass in the 21st Century.” *The Lancet Planetary Health*. https://doi.org/10.1016/s2542-5196(17)30028-1.

———. 2017b. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Chelsea Green Publishing.

Reade, Eric. 1985. “Britain and Sweden: Premature Obsolescence of Housing.” *Scandinavian Housing and Planning Research* 2 (1): 27–43.

Reike, Denise, Walter J. V. Vermeulen, and Sjors Witjes. 2018. “The Circular Economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options.” *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2017.08.027.

Rincón, Lídia, Gabriel Pérez, and Luisa F. Cabeza. 2013. “Service Life of the Dwelling Stock in Spain.” *International Journal of Life Cycle Assessment* 18 (5): 919–25.

Ritchey, Tom. 2013. “Wicked Problems.” *Acta Morphologica Generalis* 2 (1). https://www.researchgate.net/profile/Tom-Ritchey/publication/236885171_Wicked_Problems_Modelling_Social_Messes_with_Morphological_Analysis/links/00463519e5f08e672a000000/Wicked-Problems-Modelling-Social-Messes-

with-Morphological-Analysis.pdf.
Rittel, Horst W. J., and Melvin M. Webber. 1973. “Dilemmas in a General Theory of Planning.” *Policy Sciences* 4 (2): 155–69.
Rodriguez-Anton, J. M., L. Rubio-Andrada, M. S. Celemín-Pedroche, and M. D. M. Alonso-Almeida. 2019. “Analysis of the Relations between Circular Economy and Sustainable Development Goals.” *International Journal of Sustainable Development and World Ecology* 26 (8): 708–20.
Sakamoto, Keisuke, and Makoto Yokohari. 2016. “Dynamic Characteristics of Emerging Vacant Houses and Abandoned Lands in Residential Neighborhoods.” *Journal of the City Planning Institute of Japan* 51 (3). https://trid.trb.org/view/1427898.
Sandberg, Nina Holck, Igor Sartori, and Helge Brattebø. 2014. “Sensitivity Analysis in Long-Term Dynamic Building Stock modeling—Exploring the Importance of Uncertainty of Input Parameters in Norwegian Segmented Dwelling Stock Model.” *Energy and Buildings*. https://doi.org/10.1016/j.enbuild.2014.09.028.
Sassen, Saskia. 2014. *Expulsions*. Harvard University Press.
Savini, Federico. 2019. “The Economy That Runs on Waste: Accumulation in the Circular City.” *Journal of Environmental Policy & Planning* 21 (6): 675–91.
Schad, Jonathan, and Pratima Bansal. 2018. “Seeing the Forest and the Trees: How a Systems Perspective Informs Paradox Research.” *The Journal of Management Studies* 55 (8): 1490–1506.
Schaffartzik, Anke, Juan Antonio Duro, and Fridolin Krausmann. 2019. “Global Appropriation of Resources Causes High International Material Inequality – Growth Is Not the Solution.” *Ecological Economics: The Journal of the International Society for Ecological Economics* 163 (September): 9–19.
Schandl, Heinz, Marina Fischer-Kowalski, James West, Stefan Giljum, Monika Dittrich, Nina Eisenmenger, Arne Geschke, et al. 2018. “Global Material Flows and Resource Productivity: Forty Years of Evidence.” *Journal of Industrial Ecology* 22 (4): 827–38.
Schiller, Georg, Alessio Miatto, Karin Gruhler, Regine Ortlepp, Clemens Deilmann, and Hiroki Tanikawa. 2019. “Transferability of Material Composition Indicators for Residential Buildings: A Conceptual Approach Based on a German-Japanese Comparison.” *Journal of Industrial Ecology*. https://doi.org/10.1111/jiec.12817.
Schulz, Christian, Rannveig Edda Hjaltadóttir, and Paula Hild. 2019. “Practising Circles: Studying Institutional Change and Circular Economy Practices.” *Journal of Cleaner Production* 237 (November): 117749.
Shimizu, K., and T. Sato. 2011. “Optimal Timing of Migration from Depopulation Districts in Urban Suburban Areas.” *Journal of the City Planning Institute of Japan* 46 (3): 667–72.
Shiroyama, Hideaki, and Shinya Kajiki. 2016. “Case Study of Eco-Town Project in Kitakyushu: Tension Among Incumbents and the Transition from Industrial City to Green City.” In *Governance of Urban Sustainability Transitions: European and Asian Experiences*, edited by Derk Loorbach, Julia M. Wittmayer, Hideaki Shiroyama, Junichi Fujino, and Satoru Mizuguchi, 113–32. Tokyo: Springer Japan.
Shove, Elizabeth. 2003. “Converging Conventions of Comfort, Cleanliness and Convenience.” *Journal of Consumer Policy*. https://doi.org/10.1023/a:1026362829781.
Sing, Michael C. P., Peter E. D. Love, and Henry J. Liu. 2019. “Rehabilitation of Existing Building Stock: A System Dynamics Model to Support Policy Development.” *Cities* 87 (April): 142–52.
Sultana, Farhana. 2020. “Political Ecology 1: From Margins to Center.” *Progress in Human Geography*, June, 0309132520936751.
Swyngedouw, Erik, and Nikolas C. Heynen. 2003. “Urban Political Ecology, Justice and the Politics of Scale.” *Antipode* 35 (5): 898–918.
Takeuchi, Kazuhiko. 2010. “Rebuilding the Relationship between People and Nature: The Satoyama Initiative.” *Ecological Research* 25 (5): 891–97.
Takeuchi, Kazuhiko, J. Fujino, F. Ortiz-Moya, B. K. Mitra, A. Watabe, T. Takeda, Z. Jin, S. B. Nugroho, H. Koike, and Y. Kataoka. 2019. “Circulating and Ecological Economy—Regional and Local CES: An IGES Proposal.” *IGES: Kanagawa, Japan*.
Tanaka, Masaru. 1999. “Recent Trends in Recycling Activities and Waste Management in Japan.” *Journal of Material Cycles and Waste Management* 1 (1): 10–16.
Tango, Makoto, Muneta Yokomatsu, and Tomoki Ishikura. 2011. “MOVING BEHAVIOR, USED

HOUSE MARKET AND PLICY EFFECT OF EXTENDING THE LIFE TIME EXPECTANCY OF RESIDENTIAL HOUSING." *Journal of Japan Society of Civil Engineers, Ser. D3 (Infrastructure Planning and Management)* 67 (January): 495.

Tanikawa, H., T. Fishman, and K. Okuoka. 2015. "The Weight of Society over Time and Space: A Comprehensive Account of the Construction Material Stock of Japan, 1945–2010." *Journal of Industrial*. https://onlinelibrary.wiley.com/doi/abs/10.1111/jiec.12284?casa_token=GaHTuyzQJDQAAAAA:moXJFJ4zsgLTQvQ5u5YfGqH2LR5aA1olln-r1YvHDMn4nEbcUEAfYucQY9jRXEKO3U1YbrhFSRttP3Kg.

Tanikawa, Hiroki, Tomer Fishman, Seiji Hashimoto, Ichiro Daigo, Masahiro Oguchi, Alessio Miatto, Shigesada Takagi, Naho Yamashita, and Heinz Schandl. 2020. "A Framework of Indicators for Associating Material Stocks and Flows to Service Provisioning: Application for Japan 1990-2015." *Journal of Cleaner Production*, December, 125450.

Tanikawa, Hiroki, Tomer Fishman, Keijiro Okuoka, and Kenji Sugimoto. 2015. "The Weight of Society Over Time and Space: A Comprehensive Account of the Construction Material Stock of Japan, 1945-2010." *Journal of Industrial Ecology*. https://doi.org/10.1111/jiec.12284.

Tanikawa, Hiroki, and Seiji Hashimoto. 2009. "Urban Stock over Time: Spatial Material Stock Analysis Using 4d-GIS." *Building Research and Information* 37 (5-6): 483–502.

Tanikawa, Hiroki, Shunsuke Managi, and Cherry Myo Lwin. 2014. "Estimates of Lost Material Stock of Buildings and Roads due to the Great East Japan Earthquake and Tsunami." *Journal of Industrial Ecology* 18 (3): 421–31.

Tapia, Carlos, Marco Bianchi, Georg Pallaske, and Andrea M. Bassi. 2021. "Towards a Territorial Definition of a Circular Economy: Exploring the Role of Territorial Factors in Closed-Loop Systems." *European Planning Studies*, January, 1–20.

Thapa, Kamakshi, Vibhas Sukhwani, Sameer Deshkar, Rajib Shaw, and Bijon Kumer Mitra. 2020. "Strengthening Urban-Rural Resource Flow through Regional Circular and Ecological Sphere (R-CES) Approach in Nagpur, India." *Sustainability: Science Practice and Policy* 12 (20): 8663.

Thomsen, André, and Kees van der Flier. 2011. "Understanding Obsolescence: A Conceptual Model for Buildings." *Building Research & Information*. https://doi.org/10.1080/09613218.2011.576328.

Thomsen, André, Kees van der Flier, and Nico Nieboer. 2015. "Analysing Obsolescence, an Elaborated Model for Residential Buildings." *Structural Survey*. https://doi.org/10.1108/ss-12-2014-0040.

Tong, Xin, Tao Wang, Yanguang Chen, and Yutao Wang. 2018. "Towards an Inclusive Circular Economy: Quantifying the Spatial Flows of E-Waste through the Informal Sector in China." *Resources, Conservation and Recycling* 135 (August): 163–71.

Tsui, Tanya, David Peck, Bob Geldermans, and Arjan van Timmeren. 2020. "The Role of Urban Manufacturing for a Circular Economy in Cities." *Sustainability: Science Practice and Policy* 13 (1): 23.

Usui, Hiroyuki, and Joan Perez. 2020. "Are Patterns of Vacant Lots Random? Evidence from Empirical Spatiotemporal Analysis in Chiba Prefecture, East of Tokyo." *Environment and Planning B: Urban Analytics and City Science*, October, 2399808320956656.

Van den Berghe, Karel, Felipe Bucci Ancapi, and Ellen van Bueren. 2020. "When a Fire Starts to Burn. The Relation between an (inter)nationally Oriented Incinerator Capacity and the Port Cities' Local Circular Ambitions." *Sustainability: Science Practice and Policy* 12 (12): 4889.

Van den Berghe, Karel, and Martijn Vos. 2019. "Circular Area Design or Circular Area Functioning? A Discourse-Institutional Analysis of Circular Area Developments in Amsterdam and Utrecht, The Netherlands." *Sustainability: Science Practice and Policy* 11 (18): 4875.

Vandenbroeck, Philippe. 2012. *Working with Wicked Problems*. King Baudouin Foundation.

Vanderstraeten, L., F. Vastmans, and M. Ryckewaert. 2016. "Leegstand in Vlaanderen. Mogelijkheden En Beperkingen van de Verschillende Databanken." Steunpunt Wonen, Leuven.

Volk, Rebekka, Richard Müller, Joachim Reinhardt, and Frank Schultmann. 2019. "An Integrated Material Flows, Stakeholders and Policies Approach to Identify and Exploit Regional Resource Potentials." *Ecological Economics: The Journal of the International Society for Ecological Economics* 161 (July): 292–320.

Walker, Anna M., Katelin Opferkuch, Erik Roos Lindgreen, Alberto Simboli, Walter J. V. Vermeulen, and Andrea Raggi. 2021. “Assessing the Social Sustainability of Circular Economy Practices: Industry Perspectives from Italy and the Netherlands.” *Sustainable Production and Consumption* 27 (July): 831–44.

Wang, Jian, Zhuqing Yang, and Xuepeng Qian. 2020. “Driving Factors of Urban Shrinkage: Examining the Role of Local Industrial Diversity.” *Cities* 99 (April): 102646.

Wang, Jingjing, Yurong Zhang, and Yuanfeng Wang. 2018. “Environmental Impacts of Short Building Lifespans in China Considering Time Value.” *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2018.08.314.

Waswo, Ann. 2013. *Housing in Postwar Japan - A Social History*. Routledge.

Wiedmann, Thomas, Manfred Lenzen, Lorenz T. Keyßer, and Julia K. Steinberger. 2020. “Scientists’ Warning on Affluence.” *Nature Communications*. https://doi.org/10.1038/s41467-020-16941-y.

Williams, Jo. 2021. *Circular Cities: A Revolution in Urban Sustainability*. Routledge.

Williams, Joanna. 2019a. “Circular Cities.” *Urban Studies*. https://doi.org/10.1177/0042098018806133.

———. 2019b. “Circular Cities: Challenges to Implementing Looping Actions.” *Sustainability: Science Practice and Policy* 11 (2): 423.

———. 2019c. “The Circular Regeneration of a Seaport.” *Sustainability: Science Practice and Policy* 11 (12): 3424.

Winistorfer, P., Z. Chen, B. Lippke, and N. Stevens. 2007. “Energy Consumption and Greenhouse Gas Emissions Related to the Use, Maintenance, and Disposal of a Residential Structure.” *Wood and Fiber Science*. http://wfs.swst.org/index.php/wfs/article/view/227.

Winterstetter, A., D. Laner, H. Rechberger, and J. Fellner. 2016. “Integrating Anthropogenic Material Stocks and Flows into a Modern Resource Classification Framework: Challenges and Potentials.” *Journal of Cleaner Production* 133 (October): 1352–62.

Wirth, Peter, Volker Elis, Bernhard Müller, and Kenji Yamamoto. 2016. “Peripheralisation of Small Towns in Germany and Japan--Dealing with Economic Decline and Population Loss.” *Journal of Rural Studies* 47: 62–75.

Witjes, Sjors, and Rodrigo Lozano. 2016. “Towards a More Circular Economy: Proposing a Framework Linking Sustainable Public Procurement and Sustainable Business Models.” *Resources, Conservation and Recycling* 112 (September): 37–44.

Wolch, Jennifer R., Jason Byrne, and Joshua P. Newell. 2014. “Urban Green Space, Public Health, and Environmental Justice: The Challenge of Making Cities ‘just Green Enough.’” *Landscape and Urban Planning* 125: 234–44.

Woo, Jeong-Beom, and Yong-Hoon Son. 2014. “Roles of NPO at Community-Building Project by Using Rural Vacant Houses - Focused on ‘Vacant House Recreation Project of Japan’s NPO Corporation’ in Onomichi, Hiroshima.” *Journal of Korean Society of Rural Planning*. https://doi.org/10.7851/ksrp.2014.20.4.001.

Wuyts, Wendy. 2018. “Over Huisvrouwen En Leegstaande Woningen in Japan.” *AGORA Magazine*. https://doi.org/10.21825/agora.v34i4.11675.

———. 2019. “Facilitating the Implementation of New Circular Economy Practices in Higher Education Institutes.” https://odr.chalmers.se/handle/20.500.12380/300514.

Wuyts, Wendy, Alessio Miatto, Raphael Sedlitzky, and Hiroki Tanikawa. 2019. “Extending or Ending the Life of Residential Buildings in Japan: A Social Circular Economy Approach to the Problem of Short-Lived Constructions.” *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2019.05.258.

Wuyts, Wendy, Raphael Sedlitzky, Masato Morita, and Hiroki Tanikawa. 2020. “Understanding and Managing Vacant Houses in Support of a Material Stock-Type Society—The Case of Kitakyushu, Japan.” *Sustainability: Science Practice and Policy* 12 (13): 5363.

Xu, Hangtian, and Yiming Zhou. 2019. “Public Housing Provision and Housing Vacancies in Japan.” *Journal of the Japanese and International Economies* 53 (September): 101038.

Yamashita, S., and A. Morimoto. 2015. “Study on Occurrence Pattern of the Vacant Houses in the Local Hub City.” *Journal of the City Planning Institute of Japan* 50 (3): 932–37.

Yoshida, Fumikazu, Akio Hata, and Haruo Tonegawa. 1999. “Itai-Itai Disease and the Countermeasures against Cadmium Pollution by the Kamioka Mine.” *Environmental Economics*

and Policy Studies 2 (3): 215–29.
Zhang, Beibei. 2020. "Why Is Japan's Housing Vacancy Rate So High? A History of Postwar Housing Policy." *Social Science Japan Journal*. https://doi.org/10.1093/ssjj/jyz041.
Zukin, Sharon. 2020. *The Innovation Complex: Cities, Tech, and the New Economy*. Oxford University Press.

Digital report publication and announcements of official policy institutions

European Commision. 2021. Circular Economy Action Plan (Accessed on 14 July 2021) https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en
Information Policy Division, 2018. Policy Bureau, Ministry of land, infrastructure and Transport. Historical Statistics of Japan 9. Construction. Accessed in October 2018 at. http://www.stat.go.jp/english/data/chouki/index.html.
IGES. 2019. Regional Circular and ecological sphere. Accessed in June 2021 at https://www.iges.or.jp/en/pub/regional-circular-and-ecological-sphere/en
Japanese Government. Growth Strategy 2018. Basic Outlook and Key Strategies. 2018. Available online: http://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/miraitousi2018_en.pdf (accessed on 11 December 2019).
Japanese Ministry of the Environment. Eco Town's Progress and Development. 2018. Available online: http://www.env.go.jp/recycle/ecotown/index.html (accessed on 20 February 2020).
Japanese Ministry of the Environment, 2000. The Challenge to establish the recyling-based society. https://www.env.go.jp/recycle/panf/fig/e-guide.pdf (accessed on 14 July 2021)
Japanese Ministry of Internal Affairs and Communications. Housing and Land Survey 2018. 2019. Available online: https://www.e-stat.go.jp/en/stat-search/files?page=1&toukei=00200522&tstat=000001127155 (accessed on 20 December 2019).
Kitakyushu City. Kitakyushu Vacant Housing (Action Plan). 2016a. Available online: https://www.city.kitakyushu.lg.jp/files/000740825.pdf (accessed on 10 February 2020).
Kitakyushu City. Kitakyushu Vacant Housing (Executive Summary). 2016b. Available online: https://www.city.kitakyushu.lg.jp/files/000740825.pdf (accessed on 10 February 2020).
Kitakyushu City University. *Kitakyushu City Planning GIS Data*, DVD version; Kitakyushu City University: Kitakyushu, Japan, 2016b.
Kitakyushu City. Location Optimization Plan. 2019a. Available online: https://www.city.kitakyushu.lg.jp/ken-to/07900223.html (accessed on 10 February 2020).
Kitakyushu City. Local Statistics of Population Census of KITAKYUSHU Government. 2019b. Available online: https://www.city.kitakyushu.lg.jp/soumu/file_0311.html (accessed on 10 February 2020).
Ministry of Land. Infrastructure and Transport. 2013. "Housing and Land Survey 2013. Accessed June 20, 2018. https://www.e-stat.go.jp/en/stat-search/files?page1⁄41&toukei1⁄400200522&tstat1⁄4000001063455.
Statistical Survey Department, Statistics Bureau. Ministry of internal Affairs and Communications. Historical Statistics of Japan. Chapter 2. Population and Households. Accessed in October 2018 at. http://www.stat.go.jp/english/data/ chouki/index.html.
United Nations, 2015. Sustainable Development Goals. Goal 11: make cities inclu- sive, safe, resilient and sustainable. June 20, 2018. https://www.un.org/sustainabledevelopment/cities/.
UNE, 2018. Global material flow database. June 20, 2018. http://www.resourcepanel.org/global-material-flows-database.
Yokohama City 2021. SDGs Future City. Accessed on June 2021. https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/ondanka/futurecity/sdgs/sdgsfuturecity.files/0033_20190424.pdf
Vlaanderen Circulair. 2020. Dossier Veerkracht- Enquête. Accessed on July 8. 2020 via https://www.vlaanderen-circulair.be/src/Frontend/Files/userfiles/files/Dossier%20Veerkracht.pdf

Websites of businesses, organisations and projects

Circular Yokohama 2020a. Circular Yokohama. Accessed June 2021. https://circular.yokohama/en/

Circular Yokohama 2021b. Kanazawa Living Lab. Accessed June 2021. https://circular.yokohama/en/projects/kanazawa-living-lab/

Metabolic. 2021. Systems thinking. Accessed March 2021. https://www.metabolic.nl/about/our-approach/

Solarcrew. 2021. Solar crew. Accessed June 2021. https://solarcrew.jp/

Superlocal 2021. Resultaten. Last accessed on June 27th, 2021: https://www.superlocal.eu/resultaten/

Digital news articles and blogs

Acaroglu L., 2017. Tools for systems thinkers: the 6 fundamental concepts of systems thinking, accessed at https://medium.com/disruptive-design/tools-for-systems-thinkers-the-6-fundamental-concepts-of-systems-thinking-379cdac3dc6a

Berg, Nate, 2017. Raze, rebuild, repeat: why Japan knocks down its houses after 30 years. The Guardian. 16 November. Last accessed in September 2018 at. https:// www.theguardian.com/cities/2017/nov/16/japan-reusable-housing-revolution.

Brasor, Philip, Tsubaku, Masako, 2017. Safety net law to offer new lease to abandoned buildings. Jpn. Times, 30 April. Last Accessed in September 2018 at https://www.japantimes.co.jp/community/2017/04/30/how-tos/safety-net-law-offer-new-lease-life-abandoned-buildings/#.W76Uwy2B1Bx.

Harding, R. Is This the Solution to Japan's Glut of Empty Homes? Financial Times. 17 July 2015. Available online: https://www.ft.com/content/79297b7e-24c6-11e5-bd83-71cb60e8f08c (accessed on 20 December 2019).

Holden, S. Renovation Culture in Kokura. Dispatches from Post-Growth Japan. 2015. Available online: https://medium.com/dispatches-from-post-growth-japan/renovation-culture-in-kokura-a8a1e3925750 (accessed on 20 December 2019).

Jones, Colin P.A., 2015. Perfect Storm of Factors Conspires to Empty Japan. The Japan Times, 10 May. Accessed on September 2018 at. https://www.japantimes.co.jp/community/2015/05/10/issues/perfect-storm-factors-conspires-empty-japan/#.W76T8y2B1By.

McMathis, J.. 2014. Disposed to disposable: Why homes don't last in the Land of the Rising Sun. June 4. Retrieved from http://ceramics.org/ceramic-tech-today/disposed-to-disposable-why-homes-dont-last-in-theland-of-the-rising-sun (Accessed: 26.04.18)

Other sources

Berg, L.V.D.; Drewett, R.; Klaasen, L.H.; Rossi, A.; Vijverberg, C.H. Urban Europe: A Study of Growth and Decline; Costs Urban Growth (curb) Project 1; Pergamon Press: Oxford, UK, 1982; Volume 1, pp. 24–48.

Britannica. 2020. Territory (ecology). Accessed on 15 September 2020 via https://www.britannica.com/science/territory-ecology

Hamilton, C. (2007). Self-creation under consumerism and the transition to an ecological consciousness. *Unpublished manuscript*.

Hasegawa, T., 2013. Introduction to the Building Standard Law-Building Regulation in Japan. 1-212. Building Center of Japan, Tokyo.

Interaction Design Foundation. 2021. What is design thinking? https://www.interaction-design.org/literature/topics/design-thinking

Kazuhiko, S. Development of government buildings and company housing at Yahata Works and urban area formation. *Urban Hous. Stud.* 2010, *68*, 37–42. (in Japanese)

Marin, J., De Meulder B. 2021. Time is Life. Ruimte (49):22-25. (in Dutch)

Marjanovic, M.,, Wuyts, W., Marin J., Williams J. "Uncovering the multiplicity of pathways to circular cities – the case of Alberta, Canada". Frontiers in the Built environment. (under review).

Meadows, D.H., 1998. Indicators and information systems for sustainable development.

Okamoto, H. *Switching to a Stock-Type Society—Creating Infrastructure in the Age of Long Lifespan Products*; Kajima Publishing Co.: Tokyo, Japan, 2006. (In Japanese)

Seiders, D., Ahluwalia, G., Melman, S., Quint, R., Chaluvadi, A., Liang, M., Silverberg, A., Bechler, C., Jackson, J., 2007. Study of Life Expectancy of Home Components. National Association Of Home Builders, Bank Of America Home Equity.

Vandenbroeck, P., 2017. Een Metabolische Manier van naar de Wereld Te Kijken; Labo Ruimte: Brussels, Belgium, unpublished. (in Dutch)

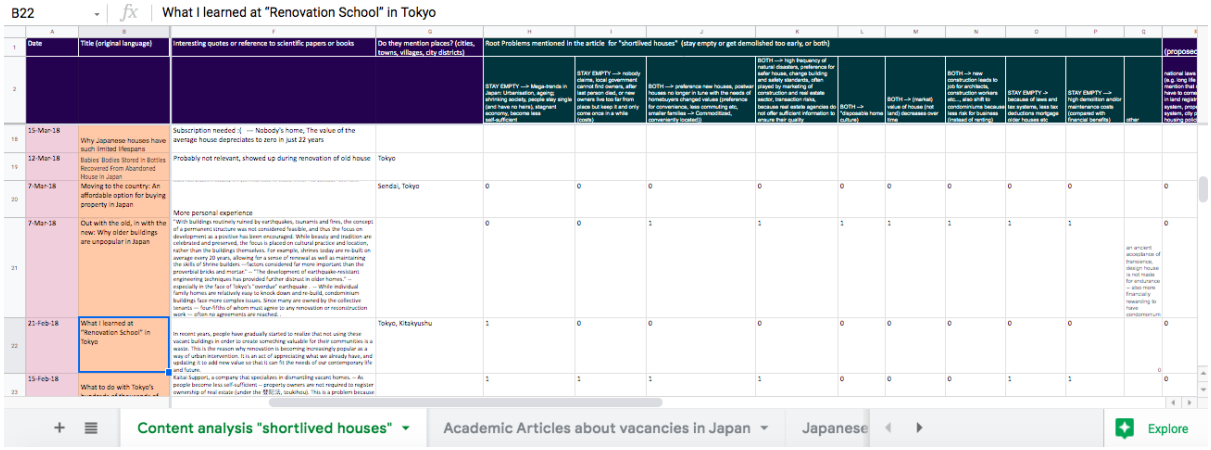
VVSG - Association of Flemish Cities and Towns. 2020. Boekvoorstelling Circulaire economie, Webinar, 28 May 2020 (in Dutch)

Willems, E.; Kuhk, A., 2021. Circulariteit. Nieuwe blauwdruk voor duurzaamheid?. Ruimte (49):10-13. (in Dutch)

Wuyts, W., Marin J. Nobody Matters in circular economy. Local environment (Under review)

Appendix 1: List of News Articles (used for chapter 3)

Figure: Screenshot of the database



You can send me an email inquiry to get access to this database.

Table: Publication year of the identified (English) popular media

Year publication	2019	2018	2017	2016	2015	2014	2013	before
Amount	4	15	9	5	12	6	4	2

Date publication	**Title**	**Publisher**	**Author (if given)**
31-Jul-18	Detroit vacant home sales lift recovery, sets example for aging Japan	Kyodo News	Minyoung Park
10-Jul-18	GOVERNMENT APPROVES NEW LAW TO DEAL WITH ABANDONED LAND ISSUE	Japan Property Central	
9-Jul-18	Real estate for the people: One man's mission turning vacant houses into homes for everyone	The Japan Times	Sakura Murakami
17-May-18	Au Japon, les squatteurs ont la politesse de ne pas se faire remarquer	Le Figaro (French)	Philippe Mouchel
11-Apr-18	What you should know before buying a vacant house in Japan	Realestate.co.jp	Jeff Wynkoop
11-Apr-18	Are you interested in akiya 空き家 (abandoned house) for free in Tokyo ? : How to find a house for almost nothing in Japan ?	Yamamoto Advisory	Toshihiko Yamamoto
15-Mar-18	Why Japanese houses have such limited lifespans	The Economist	

12-Mar-18	Babies' Bodies Stored In Bottles Recovered From Abandoned House In Japan	NDTV	NDTV
7-Mar-18	Moving to the country: An affordable option for buying property in Japan	Rethink Tokyo	Ben Tanaka
7-Mar-18	Out with the old, in with the new: Why older buildings are unpopular in Japan	Rethink Tokyo	Lily Crossley-Baxter
21-Feb-18	What I learned at “Renovation School” in Tokyo	Medium (blog)	Mariko Sugito
15-Feb-18	What to do with Tokyo’s hundreds of thousands of abandoned homes	Realestate.co.jp	
12-Jan-18	Japan’s hidden land crisis	Nippon.com	Yoshihara Shoko (research fellow land resources)
5-Jan-18	Reconstruction of an old apartment building – Rebuilt examples and problems	realestate-tokyo	xx
26-Dec-17	Japan’s glut of abandoned homes: hard to sell but bargains when opportunity knocks	The Japan Times	Alex Martin
16-Dec-17	For sale: The ‘ghost houses’ in Japan	The Hindu	Pallavi Aiyar
16-Nov-17	Raze, rebuild, repeat: why Japan knocks down its houses after 30 years	The Guardian	Nate Berg
26-Oct-17	Abandoned land will be the size of Austria by 2040	Quartz	Isabelle Steger
11-Sep-17	Vacant houses are undermining Tokyo... Distortions in a “Society with Excessive Residential Supply” Created by the Industry, Government and Private Sector	Discuss Japan (Japan Foreign Policy Forum)	NOZAWA Chie
15-Aug-17	Japan looks to put more abandoned property to use	Nikkei Asian Review	JST
9-Jun-17	Brokerage fees on cheap vacant houses may be increased	Japan Property Central	xx
30-Apr-17	Safety net law to offer new lease to abandoned buildings	The Japan Times	Philip Brasor and Masako Tsubaku
22-Jan-17	Akiya, vacant properties in Japan, a worsening situation	Yahoo Finance	ZUU Japan
5-Dec-16	New Rebuilding Center flourishes in Japan	Rebuildingcenter.org	xx

3-Dec-16	Abandoned buildings still house problems	The Japan Times	Philip Brasor and Masako Tsubaku
25-Oct-16	Wood, Mold, and Japanese Architecture	Nippon	Anne Kohtz
26-Sep-16	Kansai uses subsidies to fill empty homes, but persuading aging population to pull up stakes remains a challenge	The Japan Times	Eric Johnston
14-Jan-16	Living the akiya dream in Onomichi	BLOG - Dispatches from Post-growth Japan	Sam Holden
31-Dec-15	Renovation culture in Kokura	BLOG - Dispatches from Post-growth Japan	Sam Holden
31-Dec-15	What the U.S. Needs to Know About Japan's Vacant Property Crisis	Citylab	Matt Stroud
11-Dec-15	Tokyo real estate prices plummet as ghost homes on outskirts of city lie abandoned and unsold	ABC (Au)	Matthew Carney
27-Nov-15	Yokosuka City First To Tear Down a Vacant House Under New Law	Resoures Realestate	Jeff Wynkoop
23-Aug-15	A sprawl of ghost homes in aging Tokyo surburbs	New York Times	Jonathan Soble
24-Jul-15	Why foreign buyers are seeking ‘worthless’ wooden homes in Kyoto	Financial Times	Lucy Alexander
17-Jul-15	Is this the solution for Japan’s glut of empty homes	Financial Times	Robin Harding
10-Jul-15	Abandoned Homes haunt Japanese neighbourhoods	Bloomsberg	Maasaki Iwamoto
26-Jun-15	New life for old homes in Onomichi	Japan Property Central	xx
27-May-15	Law to allow razing abandoned dwellings seen not going far enough	The Japan Times	Kyodo
10-May-15	Perfect storm of factors conspires to empty Japan	The Japan Times	Colin P.A. Jones
6-Mar-15	Cheap rural homes come at a price	The Japan Times	Philip Brasor and Masako Tsukubu

12-Nov-14	Les maisons vides, un problème qui prend de l'ampleur au Japon	Nippon	Yoneyama Hidetaka
23-Oct-14	Japan blighted by zombie housing	Financial Times	
10-Oct-14	Empty homes: a growing problem for a shrinking nation	Nippon.com	Yoneyama Hidetaka
04-06-2014	Disposed to disposable: Why homes don't last in the Land of the Rising Sun	Ceramics	**Jessica McMathis**
2-May-14	Japan's disposable home culture is an environmental and financial headache	The Guardians	Elizabeth Braw
7-Jan-14	Abandoned homes a growing menace	The Japan Times	Yomoto Otake
5-Nov-13	Abandoned homes in an old Japanese mountain village	Tokyo Times	
4-Oct-13	This Japanese Shrine Has Been Torn Down And Rebuilt Every 20 Years for the Past Millennium	Smitsonian.com	Rachel Nuwer
15-May-13	Hoe Japan steeds meer op een verzameling spooksteden gaat lijken	Express (Dutch)	
14-May-13	Japan Is Filled With Vacant Houses As The Population Shrinks	Business Insider	Wolf Richter

Appendix 2: Participation in relevant events (2017-2021)

The following table gives an overview of relevant events (including the aforementioned events) in 2018-early 2021, that served the understanding, investigation and peer validation of this dissertation.

Table 6: List of relevant events (as observer, investigator, student, speaker) in October 2017-July 2021[53]

Date	Event	Key topics	Role	Learning outcomes
14-17 Jan 2018	Field trip to Hiroshima and Onomichi	Culture, Abandoned houses	Observer	Exploring Onomichi as case study; observing the challenges for circular demolition
9-12 Feb 2018	Second field trip to Onomichi	Abandoned houses	Observer, Investigator	Interviews about motivations, challenges of reclaiming abandoned houses, their beliefs of causes of disposable house culture, attending community meetings
04-11 March 2018	Prospert.net 2018 Young Researcher's school, Shonan International Village	Housing and Infrastructure in Megacities	Participant,	Skills research development - observation environmental projects in Yokohama - development of problem statement
27 March 2018	Visit Japanese architects in Brussels, Belgium	Difference housing cultures	Investigator	Context matters, about the technical properties and performance of wood as construction material
28 March 2018	Visit Greenville & revitalisation projects, Limburg, Belgium	Circular economy, regional development	Observer	Reflecting on circularity in practice in a shrinking region like Limburg, Belgium
31 May - 02 June 2018	First field visit Shirakawa-Cho and Higashi-Shirakawa (ORT)	Rural shrinkage, regional development	Observer	Start understanding diagnosis of problems in rural areas in Japan, like abandoned problems and policies
18-20 July	Fieldvisit Kitakyushu	Urban shrinkage	Observer	Visiting projects of redevelopment, understanding the history and building states
03-12 Aug 2018	Third field visit Onomichi	Abandoned houses	Observer, investigator	
16 Aug	Second field visit Shirakawa-Cho and Higashi-Shirakawa (ORT)	Regional development, rural shrinkage	Investigator	Workshop with local policy makers to deepen the diagnosis, interviews with focus groups
18 Aug	First field visit to Ena	Abandoned houses	Investigator, observer	Visiting small-scale projects of reclaiming houses, interviews
28-31	RGS-IBG annual	Abandoned	Presenter	Discussing ideas about the political ecology

[53] Noteworthy, not all learning experiences are documented (like informal observations of construction culture in Japan and regular courses and meetings at Nagoya University)

Aug	conference, Cardiff, UK	houses		behind the abandoned houses in Japan, with experts
15 Oct	Second field visit to Ena	Abandoned houses, rural development	Observer	Learning more about realities in rural areas in Japan
08 Dec 2018	Final event ORT	Rural redevelopment	Presenter, observer	Learning more about rural revitalisation and problems and challenges
10-12 Dec 2018	East-Asian regional alternative geography conference, Daegu	Rural and smart shrinkage	Presenter, observer	Learning more about the concept of rural and smart shrinkage, about the spatial development aspect
29 April-04 May 2019	Fourth field visit to Onomichi	Vacant housing	Investigator, observer	More interviews and documentations - follow up of previous owners of reclaimed vacant houses
Online interviews with Belgian stakeholders in construction and wood sector, working in circularity, to learn more about circular activities, challenges and aspects				
06-13 July 2019	ISIE conference, Beijing, China	Circularity - short lived buildings	Presenter	Getting feedback on my findings (of mostly first paper)
25-31 Oct 2019	Visit Gothenburg area, Sweden	Circularity-redevelopment	Observer	Via my Swedish professor, introduced to sustainability innovation projects in urban and rural context, and experts, learned more about circular area development
5-7 Nov 2019	1st Nordic conference on Zero Emission and Plus Energy Buildings, Trondheim	Performance buildings	Participant, observer	Spatial development around the construction sector, learning more about innovations and technologies, wood as construction material (performance, safety…)
8-9 Nov 2019	Field visits Oslo, Norway	Construction sustainability	Observer	Learning more from engineers in sustainability and constructions sector, working with wood as material
March 2020: WHO announced the COVID-19 pandemic, many learnings happened in the virtual space.				
Spring 2020	Launch of results 'local circular economy', Belgium	Circular area development	Observer	Deepening understanding local area development
Oct 2020	Python for beginners, Thomas Moore, Belgium	Software skills	Student	Programming
10-16 March 2021	Natural building course, Woonder, Belgium	Natural building materials	Student	Performance of natural building materials, implications for circularity of construction and spatial development
24-25/03/2021	Crossing Boundaries, IBA Parkstad, the Netherlands	Circularity-smart shrinkage	Observer	Final presentation of the circular estate project, complexity of circular deconstruction of buildings which were not designed for urban mining; policy

June 2021	Regional Studies Conference, online	Circularity - space - governance - society	Presenter, Participant	I learned more about ideas about urban planning and circular area/city development.

Publications

Journal Papers

1. **Wuyts, W.**, Marin, J., Brusselaers, J. and Vrancken, K., 2020. Circular economy as a COVID-19 cure?. *Resources, Conservation, and Recycling*, *162*, p.105016.
2. **Wuyts, W**., Miatto, A., Sedlitzky, R. and Tanikawa, H., 2019. Extending or ending the life of residential buildings in Japan: A social circular economy approach to the problem of short-lived constructions. *Journal of cleaner production*, *231*, pp.660-670.
3. **Wuyts, W.**, Sedlitzky, R., Morita, M. and Tanikawa, H., 2020. Understanding and Managing Vacant Houses in Support of a Material Stock-Type Society—The Case of Kitakyushu, Japan. *Sustainability*, *12*(13), p.5363.
4. **Wuyts, W.**, 2018. Over huisvrouwen en leegstaande woningen in Japan. *AGORA Magazine*, *34*(4), pp.32-35. (Dutch)
5. Holzinger, A., **Wuyts W.,** 2021. Cultural Heritage and Lifestyle Strategies in the Placemaking of Kaka'ako, Hawai'i, [Patrimoine culturel et stratégies de mode de vie dans le placemaking à Kaka'ako, Hawaï] Justice spatiale | Spatial Justice, *17*.
6. Guo, J., Fishman, T., Wang, Y., Miatto, A., **Wuyts, W**., Zheng, L., Wang, H. and Tanikawa, H., 2021. Urban development and sustainability challenges chronicled by a century of construction material flows and stocks in Tiexi, China. *Journal of Industrial Ecology*, *25*(1), pp.162-175.

Book chapters

1. **Wuyts, W**., 2020. Market distortions encouraging wasteful consumption. *Responsible Consumption and Production*, pp.443-453.

Conference proceedings and presentations

1. **Wuyts, W.** Marjanovic, M., 2021. *Combining circularity, health, and smart shrinkage – exploring new horizons in urban development research*, RSA's Regions in Recovery Festival, Circular Cities session, June 17th, online
2. **Wuyts, W**., Deneve E., 2020. *Citizen engagement': Language 'matters' - an ecolinguistic approach to engaging citizens in the circular economy*, Sustainable Action and Consumption Initiative Research Conference June, virtual.
3. **Wuyts, W. ,** 2020. *Recruitment of "less-traditional carriers" of circular economy practices - the case of C-Power in Flander*s, Sustainable Action and Consumption Initiative Research Conference June, virtual.
4. Phuc Minh T., **Wuyts W.**, Guo J., Doi. R. 2019. *Social acceptance of newcomers in rural mountainous areas- case studies in Shirakawa Town and Higashi Shirakawa Village*. Japanese environmental congress. September.
5. **Wuyts, W**., Miatto A. Tanikawa H. 2019. *Understanding and managing residential buildings in Japan's transition toward a stock type society*, 10th International Conference on Industrial Ecology 7-11 July Beijing, China
6. **Wuyts. W**, 2019., *Beautiful places in 21st century Japan: Post-growth Landscapes of Emptiness or Transforming Spaces towards Rural Resilience?*, East-Asian alternative geography conference, 10-12 December, Daegu, South-Korea
7. **Wuyts W**., 2018. *Vacant Houses in Japan - Onomichi Story,* (*RGS- IBG),* Annual International Conference of the Royal Geographers' Society with the Institute of British Geographers, *28-30 Augustus, , Cardiff, UK.*