LIVING ON LESS

Sufficiency-enabling Policies as a Lever for a Just Housing Transition in Germany

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Abstract

The urgent need for a just transition in housing in Germany, to reduce the global environmental impacts and mitigate the risks of green colonialism, requires the development of policies that enable sufficiency. In the housing sector, this primarily involves reducing floor area per person to significantly decrease energy demand. Research in this field has focused on core principles needed for a sufficiency transition, taking a universalistic and global approach. Sufficiency modelling has been limited by a restricted understanding of sufficiency implementation and feasibility. Furthermore, scholars have neglected the need for differentiation between households living in very unequally distributed living spaces. Research investigating country-specific political and policy environments that allowed for the emergence of high floor area per person households is lacking for almost all regions. Thus, academic policy proposals are often too general, not tailored to households with the largest floor areas, and do not consider regional historical policy contexts.

In this thesis, I aim to address this gap, using a mixed-method approach to comprehensively understand the German housing context for meaningful policy recommendations. With an agglomerative hierarchical clustering algorithm, I identify households with the highest floor area per capita, characterized as single, without children, older, living outside large cities, residing in (detached) single-family houses, owning their homes, having low incomes, and located in West Germany. The historical driver analysis reveals the influence of capitalist, market-oriented policies, which promoted home ownership as retirement security to decrease provisioning by the state. These policies included subsidies favouring ownership and single-family houses, as well as large-scale privatization and financialization, shifting the housing sector's focus to (international) investor profits rather than providing affordable and sufficient living space for all. Current policies miss the opportunity to redistribute floor area and hinder the flexible matching of housing supply and demand. Taking into account the identified target households and the historical context, a final critical reflection on existing policy proposals enriches the future design of sufficiency-enabling policies for the German housing sector and allows for a more accurate quantification of the impact reduction potential. This social science perspective allows sufficiency and industrial ecology scholars to situate their research in the German context and gain a deeper understanding of the historical drivers and enablers for sufficiency application.

Contents

Glossary

BBSR Bundesinstitut für Bau-, Stadt- und Raumforschung.

DBSCAN density-based spatial clustering of applications with noise.

ECA Economic Cooperation Administration.

EEMRIOA environmentally-extended multi-regional input-output analysis.

GHG greenhouse gases.

IE Industrial Ecology.

KDE kernel density estimate.

KfW Kreditanstalt für Wiederaufbau.

MSA Mutual Security Agency.

OECD Organisation for Economic Co-operation and Development.

REITs Real Estate Investment Trusts.

1 Introduction

In 2024, the German government announced that the climate targets to reduce greenhouse gases (GHG) by 65% compared to 1990 levels set for 2030 seemed for the first time within reach due to an ambitious decrease in GHG in 2023 (BMWK, 2024). However, this success cannot be claimed for all sectors, especially the building sector is lagging behind (BMWK, 2024). Despite a 40% decrease in GHG emissions from the housing sector in Germany between 1990 and 2014, progress has stagnated since then (Kobiela et al., 2020). Consequently, achieving the German government's climate target of cutting GHG emissions of the building sector by 69% compared to 1990 levels by 2030 appears to be an exceedingly challenging endeavour (Umweltbundesamt, 2023c). Similarly, the energy consumption of building-relevant activities has only decreased by 12% over the period 2008-2020 falling short of the targeted 20% reduction (Umweltbundesamt, 2023a). However, as the largest share of emissions of the housing sector stems from the heating of the living space, it is crucial to decrease its impact (Umweltbundesamt, 2023b). It seems inevitable to address and potentially revert the historic increase in floor area per capita, which rose from 22.3 m^2 in 1965 to 46.2 m^2 in 2015, to achieve substantial GHG reductions in the housing sector (Umweltbundesamt, 2023d).

Current measures for GHG reduction are focused on technological fixes like building better-insulated houses, applying energy-efficient appliances and providing more renewable energy to homes (BMUB, 2016). Past research has shown that these efficiency measures are not enough to reduce environmental impacts fairly (Bohnenberger, 2021; Ellsworth-Krebs, 2019; Hagbert, 2016; Viggers, Keall, Wickens, & Howden-Chapman, 2017). Especially the historical increase in floor area per person, offsets the efficiency gains achieved through technological innovations (Crawford, Bartak, Stephan, & Jensen, 2016; Viggers et al., 2017). This so-called rebound effect diminishes the absolute reduction in GHG emissions which is so urgently needed (Lorek & Spangenberg, 2019). Furthermore, the appliance of technology to reduce local impacts in Germany exacerbates current power structures between underdeveloping and underdeveloped countries (F. M. Dorn, 2022). Activist scholars often refer to 'green colonialism' in this context, highlighting the increasing pressure on for example Latin America to supply the rest of the world, predominantly the underdeveloping nations, with raw materials for the energy transition (F. M. Dorn, 2022). This practice shifts the burdens of the climate crisis from the underdeveloping nations to the underdeveloped nations. Thus, the German housing sector is in need of not only more ambitious measures but also ones that decrease absolute energy demand and, therewith, GHG emissions to achieve a just housing transition.

Scholars have started to give increasing attention to sufficiency solutions (Jungell-Michelsson & Heikkurinen, 2022). Sufficiency entails the vision that "reaching a state of 'enough' is desirable both from the perspective of ecosystems, as well as from the point of view of social and economic systems" (Jungell-Michelsson & Heikkurinen, 2022, p. 4). It is seen as complementary rather than substitutionary to efficiency measures: "Instead of relying on technological innovation alone, sufficiency enables social innovations" (Schneidewind & Zahrnt, 2014, p. 20). In the context of housing, this mainly translates into the reduction of demand for construction and living space (Lorek & Spangenberg, 2019). Due to the high correlation between floor area and energy consumption (Huebner, Hamilton, Chalabi, Shipworth, & Oreszczyn, 2015), thus, GHG emissions, the sufficiency discussion is predominantly shaped by the aim for a reduction of floor area per person (Bohnenberger, 2021).

2 Literature Review

The literature review introduces the research areas and concepts relevant to the work. Delving into the concept of sufficiency, overlaps and delimitations with the research field decent living standards are portrayed. Moreover, I summarise the research work of other scholars who are specifically concerned with sufficiency in the housing sector. The literature review covers as well a policy perspective on sufficiency.

2.1 The Concept Sufficiency

Stemming from the Latin word "sufficere", sufficiency is most often interpreted as "enoughness" (Bohnenberger, 2021; Jungell-Michelsson & Heikkurinen, 2022). The German discussion of sufficiency was initially shaped by Wolfgang Sachs in the 1960s and again later in 1993 and 1995 who criticised the "efficiency revolution" which neglects ecological limits and contributes to the structures driving inequality (Sachs, 1993). In their literature reviews, Jungell-Michelsson and Heikkurinen (2022) and Lage (2022) all differentiate between sufficiency understood from the consumer perspective as a self-imposed limitation and a macroeconomic perspective where sufficiency enabling societal structures are created by designing and implementing fitting policies. In comparison to microeconomic-oriented measures, macroeconomic ones "do not allocate the responsibility for change to individuals or businesses but emphasize the necessity for political change" (Lage, 2022, p. 10). This approach could potentially help in preventing rebound effects that can occur when sufficiency lifestyles are self-imposed (Sorrell, Gatersleben, & Druckman, 2020). Furthermore, the consumer perspective has the risk of "neglecting structural lock-in of individuals to undesirable consumption patterns and the powers of corporations in creating consumer demand for their products and service" (Spash & Dobernig, 2017, p. 1). Interpreting the concept of sufficiency on a macroeconomic level, therefore, translates into changes in the social and institutional environment that "make the good life easier" (Schneidewind & Zahrnt, 2014, p.16). These infrastructural conditions created by sufficiency-oriented policies foster social practices that conserve resources and circumvent those that demand excessive resource use (Lage, 2022; Lorek & Fuchs, 2013; Tröger & Reese, 2021).

Sufficiency is closely related to the concept of decent living standards, "a framework to estimate a practical threshold for the energy, GHG, and material consumption required to alleviate poverty"(Vélez-Henao & Pauliuk, 2023, p.1). Scholars in this field try to define universal sets of commodities and conditions needed for households to live a decent life (Rao & Min, 2018), as well as estimate the material requirements (Vélez-Henao & Pauliuk, 2023) and energy requirements (Millward-Hopkins, Steinberger, Rao, & Oswald, 2020) of reaching this threshold. For shelter, a minimum floor area per capita of 10 m^2 is proposed (Rao & Min, 2018). Moreover, decent living standard scholars also question the current provisioning of needs and acknowledge the necessity of strategies entailing sufficiency to stay within planetary boundaries (O'Neill, Fanning, Lamb, & Steinberger, 2018). A common denominator with the research field of sufficiency is the question "What means enoughness?". However, comparing the two research fields one can observe that sufficiency scholars put more emphasis on answering the question of how to reach sufficient living forms rather than on defining what a sufficiency threshold would look like (Jungell-Michelsson & Heikkurinen, 2022).

2.2 Sufficiency in the Housing Sector

Over the last decade, the increasing interest in sufficiency research has slowly reached the housing sector (Lorek & Spangenberg, 2019). Five different focus areas of sufficiency research in the housing sector can be identified. Firstly, scholars stress the necessity of sufficiency measures from a social justice, energy demand and global environmental impact perspective. Secondly, barriers and enablers to implement sufficiency principles are researched. Thirdly, historical and existing policies can be investigated with a sufficiency lens. Fourthly, recent literature exposes the lack of sufficiency representation in the current policy mix. Lastly, some scholars have proposed sufficiency policies adapted to the housing sector.

2.2.1 Need for Sufficiency Policies

In 2009, Muller (2009) already highlighted the ethical obligation to shift the focus towards sufficiency measures in the struggle for social justice in the energy space. Later, Lorek and Spangenberg (2019) recognise the limitations of efficiency measures as well as focusing on income growth and rebound effects and try to shift the public debate towards sufficiency-oriented solutions in the housing sector. Vita, Lundström, et al. (2019) compare the global environmental impacts of green consumption and sufficiency lifestyles in Europe. For the housing sector, they assume 90% less construction and an "eco-village" energy consumption characterised by zero energy demand (Vita, Lundström, et al., 2019). The sufficiency measures resulted in reductions in carbon and land footprints (Vita, Lundström, et al., 2019). However, the high aggregation of sectors and the country resolution did not allow for modelling more realistic and diverse policy proposals. Ellsworth-Krebs (2019) puts a strong emphasis on the tight relationship between house size and energy consumption. Thus, Vita, Lundström, et al. (2019) miss a crucial sufficiency measure in the housing sphere: reducing the floor area per person by the redistribution of existing living space. Hence, their results seem to underestimate the reduction potential of sufficiency measures in the housing sector and fail to represent the diverse set of policy instruments needed to effectively target the variety of households in the EU.

Another European analysis gives an estimate of a potential reduction in energy consumption through the implementation of sufficiency measures (Bierwirth & Thomas, 2019). The scholars acknowledge the need for measures fitted to the national context and household groups and call for further "assessments, modelling, policy development, and experiments in the area of sufficiency in buildings" (Bierwirth & Thomas, 2019, p.1152). Lastly, Huebner and Shipworth (2017) study the prospects of energy savings by downsizing the floor area of UK households. They identify a strong need for research on sufficiency measures, especially regarding psychological barriers and concrete policy implementation (Huebner & Shipworth, 2017).

2.2.2 The Barriers and Enablers to Living on Less

In a more general study about sufficiency, Tröger and Reese (2021) recognise the transformative character of the field of research. The aim for sufficiency cannot merely be achieved with a set of policy instruments, a societal transformation is needed (Tröger & Reese, 2021). Their interviews highlighted that economic norms and rules, infrastructural standards, path dependencies and the focus on the individual in transition research hinder the implementation of sufficiency (Tröger & Reese, 2021). Contrarily, mind shifts can be achieved by creating compelling degrowth narratives, (economically) incentivising ecological and social behaviour, creating time structures for behavioural change and favouring structures supporting shared

responsibility (Tröger & Reese, 2021). Furthermore, Lage (2022) sees the sufficiency sphere as an integral part of a broader socio-ecological transformation.

For the German housing context, Bohnenberger (2021) identifies key stakeholders and outlines the necessary strategies for successfully implementing sufficiency measures. Thus, understanding the barriers and motivations of households in their living choices gains importance. In a working paper, Pfnür, Lachenmayer, Bachtal, and Voll (2023) examine the attitudes of different German socio-demographic groups towards their future living situation and showcase that 37% of the respondents report living on too much space and are willing to give up on average 8.45% of their private space. However, variables like the net income limit the voluntary sacrifice of space, as with rising net household income the willingness decreases from 22% (net income under 1000€) to 10% (net income over 5000€) (Pfnür et al., 2023). Unfortunately, a mapping of the willingness to give up space and the actual floor area lived on is missing. Thus, it is difficult to identify the most relevant target group for sufficiency policies from the results. The identified low willingness to give up space can be partially explained by psychological barriers like the loss of ownership and independence, worries about managing belongings, lack of space for guests, and strong emotional ties to the home (Huebner & Shipworth, 2017). The role of municipalities is investigated in this context, too. Berndgen-Kaiser, Bläser, Fox-Kämper, Siedentop, and Zakrzewski (2014) emphasize the broad range of measures available to local authorities that could be used to enable sufficiency in the housing sector. Many barriers and enablers have been identified by past research. However, it seems like the results are kept very general and not specified in regard to the country background and target household group. Historical influences are neglected and the need for different strategies suited to a wide range of living forms and household compositions seems missing.

2.2.3 Historical Policy Analysis

The number of historical policy analyses with a focus on sufficiency is limited. A very high-level analysis of energy policies of the OECD countries highlights the current focus on efficiency measures and summarises broadly existing as well as new sufficiency policies for all sectors needing energy (Bertoldi, 2022). The study neither addresses the need for suitable policies for different sectors nor considers country-specific historic enablers of the efficiency fix. Zell-Ziegler et al. (2021) compare sufficiency-related policies of all European countries and pay attention to the sectoral differences. However, the analysis does not include current policies in place which are not sufficiency-related but the opposite, prohibiting sufficiency-oriented developments. Thus, we are lacking an understanding of which policies enabled the unequal distribution of living space, which is crucial to adapt current policies and design new ones towards sufficiency.

Callmer and Bradley (2021) investigate Swedish politics and policies for sustainable consumption and waste prevention in regard to sufficiency. Despite lacking a sectorial focus in their analysis, the scholars contribute to the discussion of sufficiency implementation by pointing out the necessity of a larger system change as current structures and policies do not allow for a sufficiency transition (Callmer & Bradley, 2021). Their results highlight the need for country-specific research in this field and raise the importance of understanding the given politics and policy barriers to applying sufficiency principles. Only two studies have been found analysing past and current policies of the German housing sector. However, both lack the sufficiency lens.

Berndgen-Kaiser et al. (2018) focuses on the comparison of policies of Germany with its neighbour's policies, of Belgium and the Netherlands and the policy overview of Richter (2023) is limited to a small selection of policies describing the current state of the housing market.

2.2.4 Lack in Current Policies

The uptake of sufficiency in academia has not yet reached the policy world. Two studies have focused on the integration of sufficiency measures in European policy-making. Zell-Ziegler et al. (2021) find that the measures vary widely for different sectors, for the housing sector the provisioning of information is most applied. In general, a lack of regulatory instruments and a focus on the micro-individual hinder a societal sufficiency transformation (Zell-Ziegler et al., 2021). Especially in Germany, the governmental climate action plans are centred around efficiency and technology-based solutions (BMUB, 2016) Contrarily, Lage et al. (2023) find that sufficiency measures are well represented in the outcomes of German and Swiss citizen assemblies while enjoying high approval of the participants. This discrepancy calls for a deeper analysis of past and current policies and their misfit with the urgently needed sufficiency policy proposals.

2.2.5 Proposals to Live Sufficiently

Researchers have come up with a variety of recommendations for policymakers on the implementation of sufficiency in the housing sector. Sandberg (2021) identifies three sufficiency policies in the context of housing: decreasing the floor area, a shift in the building type and more shared living spaces. The highest impact reduction potential is associated with decreasing the floor area per person (Sandberg, 2021). Her research is focused on the individual behavioural change needed rather than how policies could enable a sufficient lifestyle. Lorek and Spangenberg (2019) acknowledge the need for policies limiting the floor area per capita but do not engage in a more detailed discussion on its design. The book "The politics of sufficiency: making it easier to live the good life" by Schneidewind and Zahrnt (2014) dedicates one chapter to the exploration of sufficiency measures in the German housing sector. They stress the importance of prohibiting the construction of single-family houses and individualistic apartments and demand more shared facilities (Schneidewind & Zahrnt, 2014). However, again no concrete policy proposals are developed and especially a discussion of the needed reduction of floor area per person is missing.

Bohnenberger (2021) summarize the four most common themes of sufficiency policy proposals for the German housing market "Reduction of housing space from the 'wanted' to the 'needed' amount", "Substitution of housing needs", "Flexibilization of temporal and spatial supply and demand of housing" and "Optimization of the spatial and temporal match of housing consumption" (Bohnenberger, 2021, pp. 175-176). Due to the focus on the stakeholder perspective, the study again does not provide a detailed understanding of the concrete policy instruments needed. Clearly, the need for policy instruments that reduce the floor area per person is a common denominator. In 2024, Zell-Ziegler et al. (2024) created a database with many sufficiency-related policy proposals collected from a multitude of sources ranging from locally implemented instruments to research recommendations. One section is dedicated to policies aiming at reducing the floor area per person (Zell-Ziegler et al., 2024). The proposals of Zell-Ziegler et al. (2024) are:

- "Right to exchange flats
- Moving bonus
- Moving advice
- Advice for change of use
- Fiscal relief for subleasing
- Subsidies for small flats
- Subsidy for splitting Single-Family-Houses
- Investment grants for housing cooperatives
- Financial support for buying shares of housing cooperatives
- Bonus payment for sufficient living
- Design of development plans with diverse and mixed-use
- Training offensive for existing buildings (offers by chambers of crafts)
- Training offensive for existing buildings (training content)
- Permit and promote alternative housing
- Tax free home-sharing".

Despite being more precise than the general recommendations of the before-mentioned literature, the policies do not specifically target the group of households with the highest floor area per person and are not fitted to the historical drivers of high floor area per person in Germany. Therefore, to fully utilise the extensive database, it is essential to understand the local context in which the policies should be applied and to identify the target group that will or should be affected.

3 Research Scope and Objective

3.1 Research Gap

Past literature has proven the need for the implementation of sufficiency principles from many angles, allowing for the development of sufficiency policy proposals. However, current research is shaped by a global universalistic approach to sufficiency, neglecting country-specific enablers and barriers to the transition. Furthermore, modelling attempts are restricted by their limited understanding of sufficiency implementation and feasibility for specific sectors and countries. Differences between households in one country regarding the size of their living space have been marginally studied and especially the materialisation of households with a high floor area per person through the political and policy environment has been insufficiently researched.

3.2 Research Questions

To fill the research gap and advance the discussion on concrete sufficiency-enabling policies for the German housing sector, it is necessary to both identify households living in excessively large spaces and understand the political and policy environment that has allowed these households to emerge. Hence, I will analyse the following research and sub-research in this paper:

1. How have demographic trends and historical policies influenced the distribution of residential spaces in Germany, and how can the underlying inferences be used to design sufficiency policies that aid in a

just housing transition?

1.1 What socioeconomic characteristics are associated with households occupying the highest floor area per person?

1.2 What historical policies and demographic trends since 1950 have driven the emergence of high floor area per person households?

1.3 How have the historical policies and demographic trends allowed the materialisation of the unequal distribution of living space?

1.4 How can insights from demographic trends and historical policies be leveraged to design sufficiency-enabling policies that target households with the highest floor area per person?

3.3 Research Approach

To answer the research questions, a mixed-method approach is suitable for this analysis (Figure 1). The advantage of taking a mixed method approach is that the generalizability of the quantitative analysis can be enriched by a contextual understanding gained in the qualitative analysis (Migiro & Magangi, 2011).

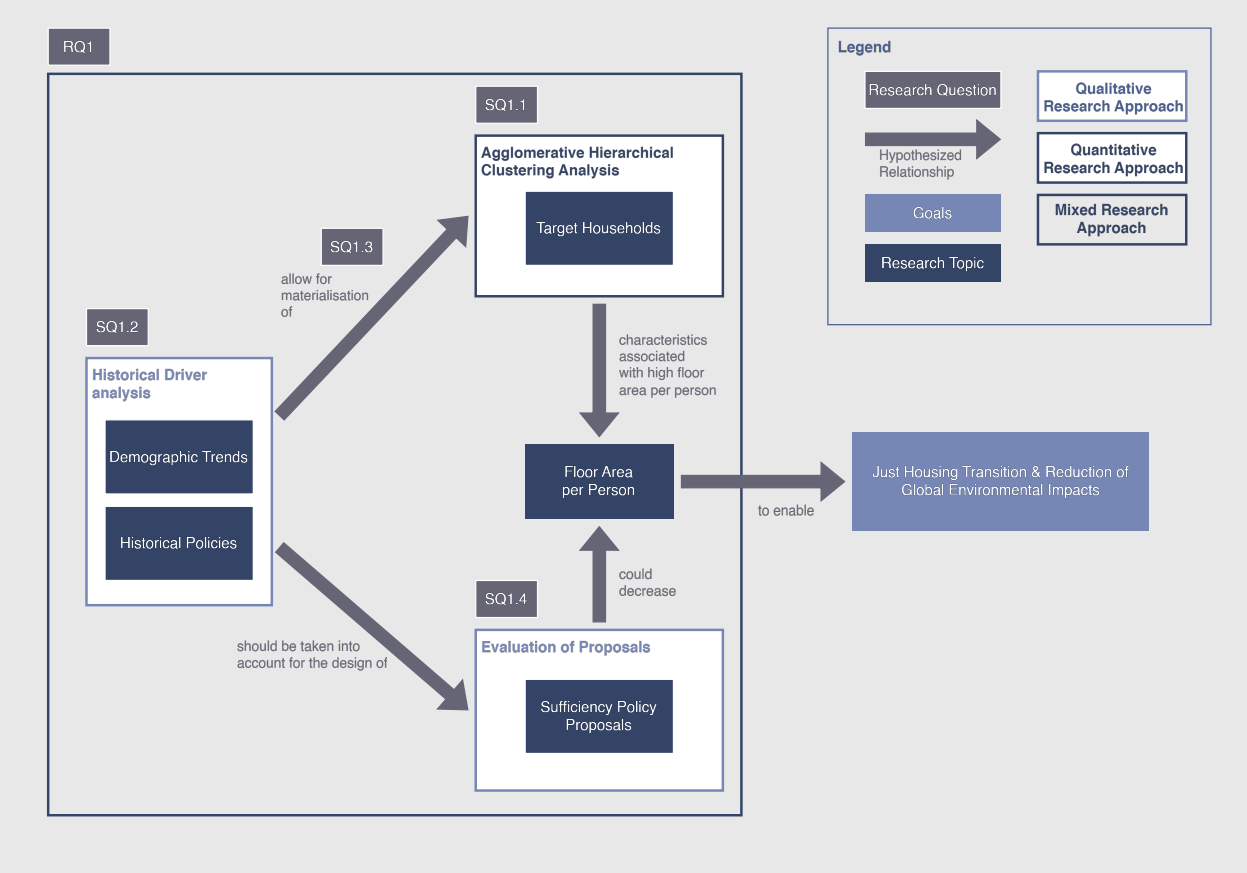

Figure 1: Research approach diagram describing the mixed methods approach taken in this thesis. The guiding main research question and sub-research questions are indicated in grey boxes next to the according research step. The research topics are embedded in the related research approaches which can be quantitative or qualitative. The arrows indicate hypothesised relationships between the research topics. The research objective is highlighted in light blue.

To counteract the generalistic and universalistic approach of past research in the field of sufficiency, the analysis will start by answering sub-research question 1.1 by clustering German households with respect to their living space size. The clustering analysis is used to identify the socioeconomic characteristics of households with a high floor area per person, allowing for a more differentiated perspective on the results of the historical increase in floor area per person. To answer sub-research question 1.2, a historical driver analysis sheds light on the policies and demographic trends that are related to the floor area increase in Germany. In this research step, I aim to close the gap in our understanding of the political and policy environment that has shaped the residential space distribution in Germany from a sufficiency perspective. Following, I reflect on the results of the clustering analysis taking into account the insights from the historical driver analysis, putting the socioeconomic characteristics into context. Answering sub-research question 1.3, it becomes evident to what extent the historic drivers might have enabled the materialisation of high floor area per person households. Finally, I use the understanding gained in the mixed method approach to evaluate existing sufficiency policy proposals from the literature and place the results in the general political environment to answer sub-research question 4.

4 Methods

As described in the research approach, the research follows a mixed method approach combining qualitative and quantitative analysis. In the following paragraphs, I outline the specific methodology used to answer the main research question as well as the sub-research questions.

4.1 Using Socio-economic Data to Investigate High Floor Area per Person Households

To answer sub-research question 1.1, I performed an agglomeration hierarchical clustering analysis on a dataset containing socioeconomic information on German households.

4.1.1 Representative Dataset for German Households

To understand what socio-economic and housing-related characteristics drive a high floor area per person, the population survey "LebensRäume" is analysed. The population survey was performed in 2012 by the "German Federal Institute for Research on Building, Urban Affairs and Spatial Development" (Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR)) in order to understand the relationships between housing conditions and satisfaction, relocation mobility, employment and economic status of households, overall life satisfaction, and regional classifications. The respondents were randomly chosen in a step-wise process. Germany was divided into 53.000 areas and a representative sample was drawn from each area totaling 3900 respondents. (Böltken, Sturm, & Walther, 2014)

4.1.2 Data Preparation and Exploration

Firstly, I chose relevant variables from the survey data (Table 1 and Appendix A.1). Secondly, I cleaned the data by treating missing values and hot-one encoding categorical variables (Appendix A.2). Thirdly, I investigated the data for outliers understanding the underlying distribution of the relevant variables. Fourthly, a correlation matrix exhibits potential multicollinearity that should be taken into account when interpreting the results of the following analysis (Appendix A.3).

Table 1: Selected variables of interest for the cluster analysis of the population survey "LebensRäume" by Böltken et al. (2014). All variables with 1 and 0 can be interpreted as percentages of the whole category. Only for the category housing type the variable "other" was dropped and the sum of all housing types does not equal 100%.

Category	Variable	Unit	Meaning
Floor area	floor area per person	m^2 per person	*Total floor area of dwelling divided by number of household members*
	floor area per household	m^2 per household	*Total floor area of dwelling including bathrooms etc.*
Demographics	number of persons	-	*Total count of household members*
	number of children	-	*Total count of children below 18 years old*
	number of 18y 65y	-	*Total count of 18-65 year olds*
	number of over 66y	-	*Total count of 66 year olds and over*
	with partner	-	*(yes=1, no=0)*
West/East	west	-	*(west=1, east=0)*
City Type	large city	–	*(yes=1, no=0)*
	medium city	-	*(yes=1, no=0)*
	large small town	-	*(yes=1, no=0)*
	small small town	-	*(yes=1, no=0)*
	rural community	-	*(yes=1, no=0)*
Housing Type	detached house	-	*(yes=1, no=0)*
	attached house	-	*(yes=1, no=0)*
	multifamily house	-	*(yes=1, no=0)*
	apartment block	-	*(yes=1, no=0)*
	farm house	-	*(yes=1, no=0)*
Income class	low income class	-	*(yes=1, no=0)*
	low middle income class	-	*(yes=1, no=0)*
	middle income class	-	*(yes=1, no=0)*
	upper middle income class	-	*(yes=1, no=0)*
	high income class	-	*(yes=1, no=0)*
Ownership	ownership	-	*(yes=1, no=0)*

4.1.3 Agglomerative Hierarchical Clustering

One common approach, when trying to explore and summarize data rather than aiming at predicting outcomes or building models, is clustering (Waggoner, 2020). It is best described as "[...] a well-established unsupervised data mining approach that groups data points based on similarities" (Karthikeyan, George, Manikandan, & Thomas, 2020, p.1). In this thesis, I am using a hierarchical clustering algorithm. In contrast to k-means clustering, for hierarchical clustering, no assumptions on the existing cluster size and cluster

number are required (Waggoner, 2020). Furthermore, it does not suffer from random seed initialization like the k-means algorithm, translating into reproducibility of the results (Karthikeyan et al., 2020). Due to the small size of the dataset and the low noise, hierarchical clustering is again more appropriate than alternatives like for example the density-based spatial clustering of applications with noise (DBSCAN) algorithm.

Hierarchical clustering algorithms can be further classified into divisive and agglomerative. For this study, the more frequently used agglomerative hierarchical clustering algorithm is applied (Wierzchoń & Kłopotek, 2018, p.30). Agglomerative clustering starts with classifying all observations into singleton clusters (Wierzchoń & Kłopotek, 2018, p.30). In each clustering step a new cluster is formed from the existing clusters. The ward metric helps determine which clusters are best suited for merging. Hereby, "the sum of squares of distances between objects and the center of the cluster, to which the objects belong", thus, the within-cluster variance, is minimized (Wierzchoń & Kłopotek, 2018, p.30). I perform this clustering analysis with the hierarchical clustering function of the SciPy library (SciPy, 2024).

For distance-based clustering approaches, it is crucial to standardize the data to erase the unintended weighting of variables with larger units in the clustering analysis (Milligan & Cooper, 1988). Many different standardization techniques can be applied. For this dataset, the min-max standardization is the most appropriate. All variables are scaled to values between 0 and 1. The advantage hereby is that the hot-one encoded variables stay 0 and 1 and do not lose the shape of their distribution. However, important for this analysis is to find clusters that are distinct in their mean and distribution of the variable *floor area per person*. Thus, to ensure that the focus of the clustering is on identifying groups with different floor areas per person an intended weighting is applied to the variable. One has to consider that increasing the between-cluster difference for the distribution of the variable *floor area per person* might lead to a reduction in between-cluster differences for other variables. To ensure an optimal trade-off for the between-cluster difference of all variables, I performed a sensitivity analysis by investigating multiple weighting options for the variable *floor area per person* (Appendix A.5).

Following, a cutoff value for the accepted within-cluster variance has to be found, determining the number of clusters formed. Here an elbow plot can be used to identify clustering steps that only marginally increase the variance. It is important here to consider the interpretability of the cluster number, favouring a cluster number between 3 and 6, which allows for a detailed enough grouping, while having clusters with meaningful sizes. It is also of significance to consider the increase in within variance of the clusters when merging the clusters.

In the next step, the target cluster with a high floor area per person has to be identified. Including only households from the most extreme cluster regarding floor area per person could lead to a very small target group limiting the possible impact reduction of sufficiency measures. However, including too many clusters might impede finding a suitable sufficiency policy fitting to all households of the target cluster. A comparison of the mean and median floor area per person of all clusters as well as their cluster size helped to solve the dilemma.

Lastly, the socioeconomic and housing-related characteristics that are associated with a high floor area per person were identified and summarised for the following qualitative analysis.

4.2 Exploring Historical Drivers

Closing the knowledge gap of sufficiency-related historical drivers of the residential space distribution in Germany, an analysis of demographic trends and historical policies followed. A focus on the earlier identified characteristics was guiding and scoping the research process. The characteristics were used as keywords in the research process translating into the following search terms for the first round of literature review: *single-family homes Germany, home ownership Germany, demographic effects housing Germany, housing stock West Germany.* Additionally, the following search terms were used in German: *Einfamilienhäuser, Wohneigentum in Deutschland, Demographische Effekte Wohnen, Hausbestand West Deutschland.* To minimize the risk of confirmation bias the search terms were kept as neutral as possible, avoiding formulations such as "increase in" and "rise of". This enabled me to not only understand the results produced from the clustering analysis but also critically reflect upon them. In a second round, the snowball method allowed for a deeper investigation of the literature for each keyword. The first two literature reviews resulted in the definition of 6 new keywords for the last round of literature review, as many sources stressed their significance on the German housing trajectory (Search terms: *Deregulierung deutscher Wohnungsmarkt, Privatisierung deutscher Wohnungsmarkt, Hausbesitz Altersvorsorge Deutschland, Remanenzeneffekt, Lebenszykluseffekt, Kohorteneffekt*; Translation of German search terms: *Deregulation of the German housing market, privatisation of the German housing market, home ownership, retirement provision in Germany, remanence effect, life cycle effect, cohort effect*). The paper of Richter (2023), covering past policies of the German housing sector, was used to check if all important policies were included. To investigate current housing policies in place the website of the Federal Ministry of Housing, Urban Development and Building (Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen) served as a source (BMWSB, n.d.-c).

Three search engines were used, the Leiden University Catalogue as well as Google Scholar and Google. Sources were not limited to journal articles, but rather a broad range of literature was considered to understand the context as completely as possible. For example, to investigate the influence of American policies on the German housing landscape, websites about individual projects were taken into account (Industriekultur Krefeld, n.d.). The analysis is limited to the time period of 1950-2024 to include important post-war developments and recent historical events. Additionally, the scope is constrained to national developments. In total, I included 33 sources in the analysis. Following, one table was created listing all policies and demographic developments that have impacted the German housing history. Each table encompasses the name, a short description, and a time indication of each observation as well as the characteristics that were influenced by it (Appendix B). Lastly, a timeline was created summarizing historical policy developments and housing state updates to allow for a comprehensive overview and answering of sub-research question 1.2 (Figure 6).

4.3 Placing the Clustering Results in the Historical Policy and Demographics Trends Context

To address sub-research question 1.3, the identified socioeconomic characteristics of households with high floor area per person are contextualised within the political and policy environment as well as demographic trends. Each characteristic is mapped to relevant historical drivers identified in the historical driver analysis. This process involves cross-referencing the socioeconomic characteristics with the timeline of policy changes and demographic trends. The integration of these elements provides a nuanced understanding of the historical

drivers behind the materialization of high-floor area per person households, highlighting the interplay between policy decisions, demographic dynamics, and their resultant residential space distribution. In this thesis, I do not claim to prove causal links, but rather identify potential influential factors.

4.4 Evaluating of Proposed Sufficiency Policies with Respect to the Identified Target Household Group and the Historical Drivers of its Materialisation

Using the insights gained from the preceding analysis, I reflected on sufficiency-enabling policy proposals to enrich the discussion and design of the policies and enable policymakers to make use of the contextual knowledge gained. I answered here sub-research question 1.4. The analysis began with an examination of the sufficiency policy database created by Zell-Ziegler et al. (2024), which provides a comprehensive collection of policy proposals from academia and the policy sphere. Each policy was assessed for its relevance and potential impact focusing on households with the highest floor area per person. The evaluation of the policies was grounded in the historical context of policy decisions and demographic trends that have shaped these household characteristics over time. Hereby, a deeper assessment of the effectiveness of the proposed measures was possible, critically reflecting on the limitations of choosing policies as a main lever and embedding the results in the historical context of the German housing sector.

4.5 Research Flow Diagram

The following research flow diagram summarizes the research steps taken for the cluster analysis, the historical driver analysis and the concluding synthesis focusing on policy recommendations (Figure 2).

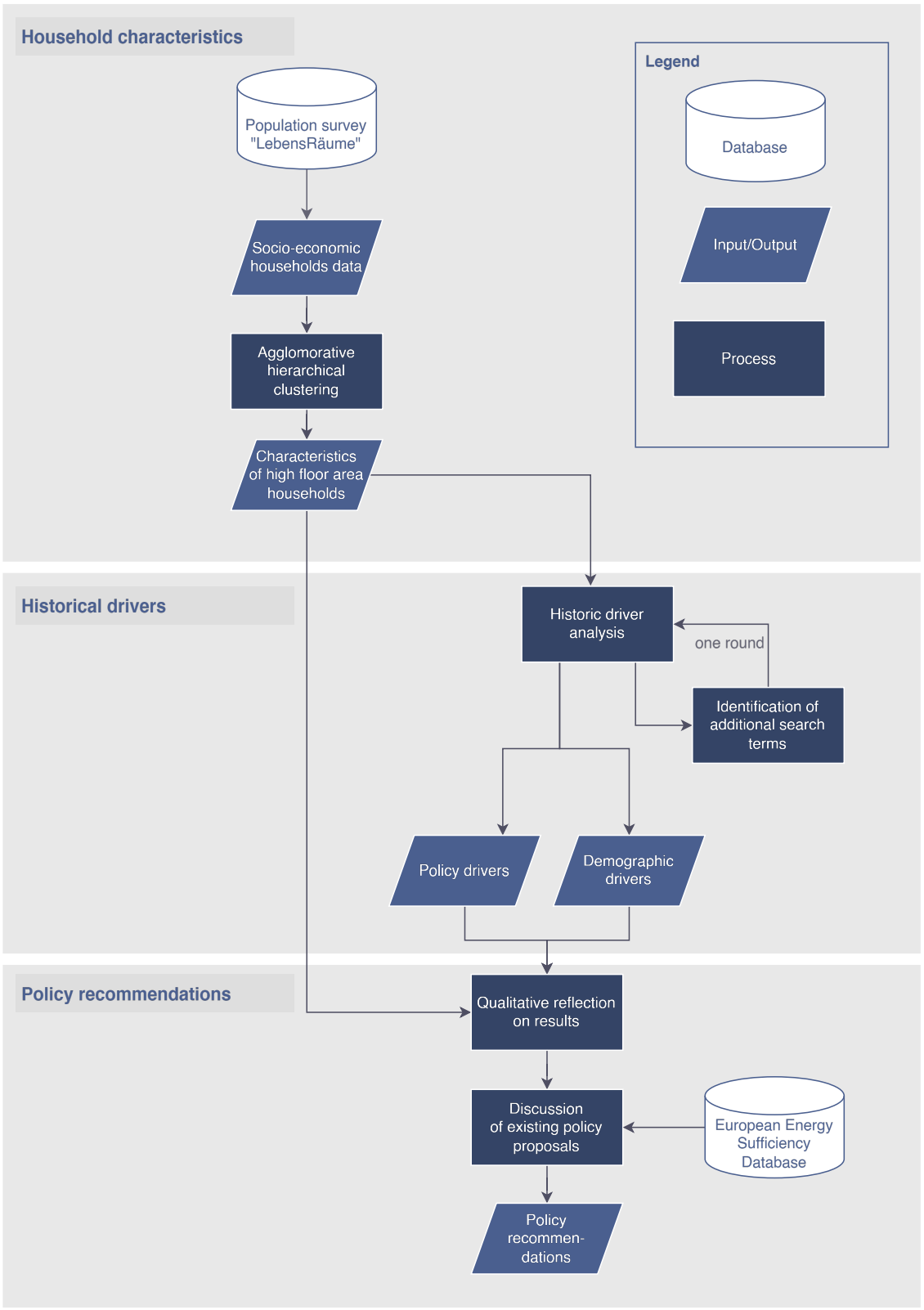

Figure 2: Research Flow Diagram divided into three phases, the clustering analysis focusing on the identification of the characteristics of high floor area households using the "LebensRäume" population survey (Böltken et al., 2014), the historical driver analysis and the synthesis with policy recommendations including the European Energy Sufficiency Database (Zell-Ziegler et al., 2024).

5 Results

In the following sections, I elaborate on the results produced by the mixed method approach combining a clustering analysis and a historical driver analysis. The results of the quantitative analysis are summarised in a list at the end of section 5.2. A comprehensive overview of the results of the historical driver analysis is given in the timeline in section 5.3. Subsequently, I synthesise the insights gained with a qualitative reflection and conclude with an evaluation of proposed sufficiency policies.

5.1 The Unequal Distribution of Living Space in Germany

The residential space in Germany has not only risen significantly over the past decade but is also characterised by great inequality. Figure 3 shows the distribution of the main variable floor area per person. The variable seems normally distributed but skewed to the right due to a few outliers above 150 m^2. The mean is around 54 m^2 and the median is a bit lower around 47 m^2 due to the bias of the outliers in the mean. 25% of the households live on average on 25.36m^2 per person whereas in one household in the sample the floor area per person amounts to 350m^2 (Table 2 and figure 3). Thus, the magnitude of the different floor areas per person for the households is quite drastic, as some people live on ten times as much floor area as the lower quartile of the distribution.

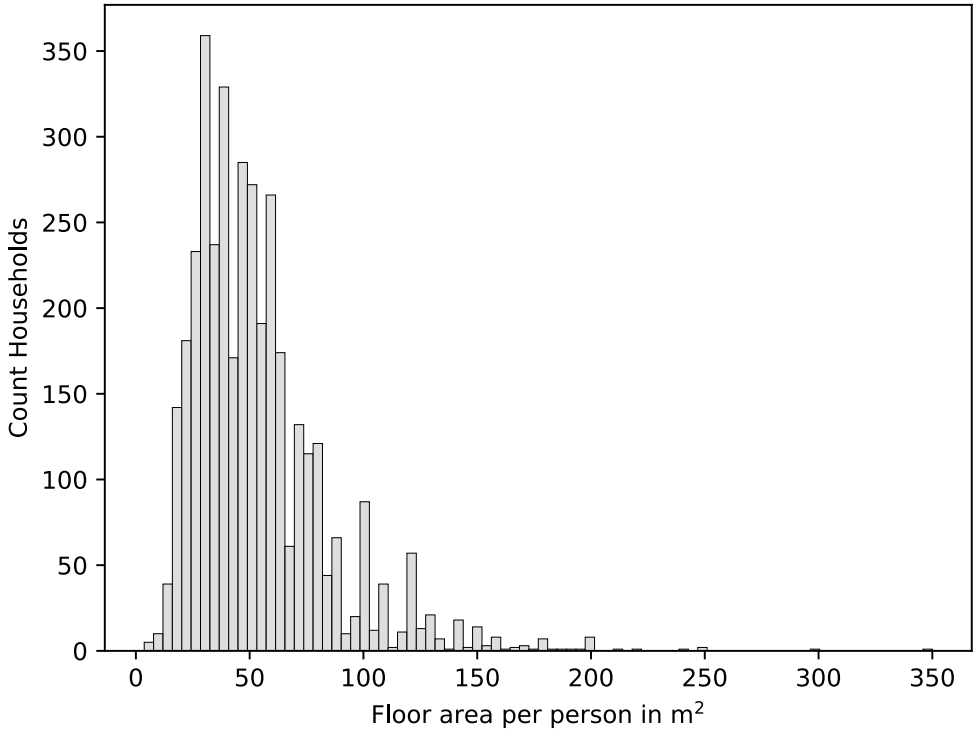

Figure 3: Histogram of the distribution of the variable floor area per person in m^2 for all households in the GESIS dataset "Lebensräume" (Böltken et al., 2014)

When comparing the mean of all variables for the different quartiles of the variable floor area per person, some tendencies can be deducted (Table 2). Higher floor area per person seems to be associated with fewer people in the household, greater total floor area per household, fewer children and only a few adults living in

the household. The respondents of the survey indicated to live less often with their partner when having a high floor area per person. The households with a greater floor area per person also tend to live more often in the west in a medium city, whereas a smaller floor area per person is associated with living in a larger city. Living in a detached house seems to be indicative of a higher floor area per person. Contrarily, living in a multifamily house seems to be rather linked to a small floor area per person. No distinctive pattern is visible for the different income classes. However, ownership seems to be associated with a higher floor area per person.

Table 2: Mean values for all variables for the quartiles of the variable floor area per person

Category	Variable	Quartiles			
		1	2	3	4
Floor area	floor area per person	25.36m^2	39.89m^2	55.97m^2	95.32m^2
	floor area per household	76.79m^2	90.77m^2	96.83m^2	134.19m^2
Demographics	number persons	3.13	2.29	1.74	1.46
	number of children	1.01	0.35	0.09	0.02
	number of 18y 65y	1.86	1.52	1.02	0.76
	number of over 66y	0.26	0.42	0.64	0.68
	with partner *(yes=1, no=0)*	0.73	0.66	0.56	0.39
West/east *(west=1, east=0)*	west	0.75	0.78	0.80	0.89
City Type *(yes=1, no=0)*	large city	0.41	0.31	0.29	0.23
	medium city	0.29	0.33	0.30	0.30
	large small town	0.14	0.18	0.17	0.22
	small small town	0.11	0.14	0.18	0.18
	rural community	0.04	0.04	0.05	0.07
Housing Type *(yes=1, no=0)*	detached house	0.14	0.29	0.36	0.53
	attached house	0.14	0.18	0.19	0.20
	multifamily house	0.64	0.46	0.40	0.23
	apartment block	0.06	0.06	0.03	0.02
	farm house	0.01	0.01	0.01	0.02
Income class *(yes=1, no=0)*	low income class	0.28	0.28	0.35	0.31
	low middle income class	0.20	0.14	0.15	0.19
	middle income class	0.31	0.27	0.26	0.24
	upper middle income class	0.15	0.19	0.15	0.15
	high income class	0.02	0.05	0.04	0.06
Ownership *(yes=1, no=0)*	ownership	0.23	0.42	0.56	0.74

5.2 The Elderly Single-Family House Owner

In order to identify distinct clusters that have the greatest similarity between in-cluster observations, a within-variance cut-off value must be determined. For this dataset, the within variance increases significantly after the 3779th clustering step (Figure 4). Suitable cutoff points for the within variance are 23, 30, 53 and 84, describing the maximum acceptable within-variance of the clusters (Appendix A.6). In appendix A.6, tables 9 until 16 describe the mean and median values for all variables for each cluster for the four chosen variance cutoff values. For this analysis, I decided to select the within-variance cutoff of 53, leading to 4

distinct cluster groups, due to the interpretability of the cluster differences. After carefully comparing the distribution of each cluster for all variables for the different weightings, I selected a weighting of 30 for the variable *floor area per person* as optimal (Appendix A.5). The sensitivity analysis allowed for robust results that are not subject to my personal biases.

Figure 4: Zoomed in elbow plot for the difference in the within-variance of the clusters after each clustering step using an agglomerative hierarchical clustering algorithm applying the ward distance metrics(weighting = 30)

The clustering choices have led to distinct clusters for the variable *floor area per person* (Figure 5). Especially, cluster 4 has little overlap with the other clusters. The earlier identified outliers characterise the high floor area per person cluster. Moreover, the four clusters with different socio-economic and housing characteristics, differ greatly in their size. Most households are grouped into cluster 2, and only around 250 of the total 3790 households end up in cluster 4 (Appendix A.7). This has to be kept in mind when choosing a target group for policy development.

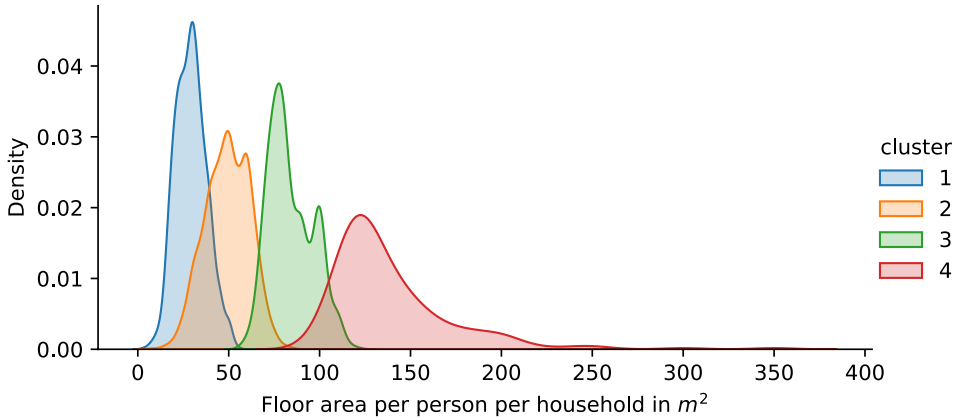

Figure 5: Kdeplot of the distribution of the variable floor area per person in m^2 for all households in the GESIS dataset "Lebensräume" for the four different clusters (weighting=30, cutoff=53) (Böltken et al., 2014)

To better understand the clusters and their characteristics, table 3 presents the four clusters with their mean values for each variable. In the appendix, the same table with median values can be found to understand the effect of outliers (Appendix A.6 Table 14). However, due to the binary variables from the hot one encoding, for the majority of variables, the median is only somewhat meaningful.

The households captured in the dataset, are characterised by a significant inequality in the *floor area per person*. Whereas cluster 1 has a low average *floor area per person* of 29.20 m^2, clusters 2, 3 and 4, have an average *floor area per person* of respectively 49.32 m^2, 84.00 m^2 and 138.90 m^2 (Table 3). Similarly, the *floor area per household* increases from 69.75 m^2 for cluster 1 to more than double 157.74 m^2 for cluster 4. It is interesting to note that the median *floor area per household* for cluster 4 is 132.00 m^2, which is significantly below the mean, indicating that cluster 4 is characterised by outliers. The *number of persons* living in the household decreases from cluster 1 to cluster 4. In the first two clusters on average 2-3 persons are living. In contrast, in cluster 3 and 4 on average only 1-2 persons are living. Focusing on the age distribution, we can observe the following trends: Clusters with lower floor area per person (1 & 2) tend to group households that have, on average, more adults aged 18 to 65 years and children. In contrast, households in clusters with higher floor area per person (3 & 4) typically have no children and often consist of either 0 or 1 adult aged 18 to 65 years, as well as 0 or 1 adult aged 66 years or older. Respondents of households in clusters 1 and 2 seem to be more likely to live with a partner. Cluster 3 has an average of 0.47 for the variable *with partner* indicating that the variable is not a distinct feature of this cluster as it can only be 0 or 1 for each household. Cluster 4 only has an average value of 0.1 meaning that most respondents of these households are indeed not living with a partner. The variable west shows the average location of all households for each cluster differentiating between 0 for east and 1 for west. 80% of the households in the dataset are located in the west. Thus, cluster 1 seems to have significantly more households in the east and clusters 3 and 4 more households in the west. The average values for the category *type of city* seem to be less distinct comparing the clusters. A noticeable pattern seems to be that households living on small floor area per person tend to be located in large cities while the households from cluster 4 are more prone to be located in

medium cities, large small towns and small small towns (Appendix A.4 figure 17 and appendix A.5 figure 41).

One of the most drastic differences between the clusters is evident in the variable *housing type*. Households with small floor area per person seem to be living almost exclusively in multifamily houses. Households with large floor area per person tend to live in mostly detached or sometimes attached houses. For the category *income class* such a distinct differentiation is not observable. Cluster 4 seems to have a relatively higher share of households (0.45 compared to 0.30 (cluster 1), 0.30 (cluster 2), and 0.29 (cluster 3)) lying in the lowest income class. Lastly, a higher floor area per person is to be associated with ownership. The average value for the variable ownership is only 0.11 for cluster 1, 0.60 for cluster 2, 0.72 for cluster 3, and 0.87 for cluster 4. In general, the clustering results are aligned with the preceding description of the quartile results (Table 2). However, the clustering algorithm seems to be more effective in grouping the households according to different sizes on floor area per person as the means of the other variables are more distinct for each cluster than for each quartile.

Table 3: Mean values of each cluster for all variables following the agglomerative hierarchical clustering algorithm. The cell colouring indicates the relative differences for each variable. Data used from the GESIS population survey "LebensRäume" (Böltken et al., 2014) (weighting = 30, variance cutoff = 53)

Category	Variable	Cluster			
		1	2	3	4
Floor area	floor area per person	29.20m^2	49.32m^2	84.00m^2	138.90m^2
	floor area per household	69.75m^2	101.38m^2	127.94m^2	157.74m^2
Demographics	number of persons	2.58	2.22	1.53	1.14
	number of children	0.62	0.37	0.02	0.00
	number of 18y - 65y	1.62	1.33	0.80	0.53
	number of over 66y	0.35	0.52	0.70	0.60
	with partner *(yes=1, no=0)*	0.67	0.63	0.47	0.10
West/east *(west=1, east=0)*	west	0.72	0.81	0.90	0.89
City Type *(yes=1, no=0)*	large city	0.42	0.30	0.22	0.17
	medium city	0.33	0.30	0.27	0.29
	large small town	0.13	0.19	0.23	0.24
	small small town	0.08	0.18	0.20	0.22
	rural community	0.05	0.04	0.08	0.09
Housing Type *(yes=1, no=0)*	detached house	0.08	0.38	0.51	0.68
	attached house	0.01	0.27	0.18	0.22
	multifamily house	0.80	0.31	0.27	0.07
	apartment block	0.09	0.02	0.02	0.00
	farm house	0.01	0.01	0.02	0.02
Income class *(yes=1, no=0)*	low income class	0.30	0.30	0.29	0.45
	low middle income class	0.24	0.12	0.20	0.17
	middle income class	0.31	0.27	0.22	0.22
	upper middle income class	0.12	0.19	0.15	0.10
	high income class	0.01	0.05	0.07	0.03
Ownership *(yes=1, no=0)*	ownership	0.11	0.60	0.72	0.87

To answer sub-research question 1.1, *"What socioeconomic characteristics are associated with households*

occupying the highest floor arena per person?", Table 4 shows that the following characteristics are linked to a high floor area per person in this dataset:

- single households
- no children
- high age
- outside large cities
- single-family houses (mostly detached)
- owning the home
- low income
- in the West of Germany

Table 4: Qualitative cluster description of the averages of the distinct variables grouped in floor area per person, socio-economic characteristics and housing characteristics

Family Urban Renter (cluster 1)	**Couple Urban Owner** (cluster 2)	**Elderly Owner** (cluster 3)	**Elderly Rural Single Owner** (cluster 4)
Floor area per person: **29.20** m^2	Floor area per person: **49.32** m^2	Floor area per person: **84.00** m^2	Floor area per person: **138.90** m^2
between 2-3 persons, more likely to have a child at home, mostly 2 adults between 18 and 65 years, more likely to live with a partner	around two persons, less likely to have a child at home, mostly 1 adult between 18 and 65 years and 1 above 65 years, more likely to live with a partner	between 1-2 persons, no children, 1 adult between 18 and 65 years and 1 above 65 years, sometimes living with a partner	mostly 1 person, no children, either one person between 18 years and 65 years or above 65 years, without partner, mostly low income
overrepresented in the east, located in a large or medium-sized city, multifamily house, renting	mostly located in a large or medium-sized city, attached, detached or multifamily house, mostly owning	overrepresented in the west, located on all city sizes but rural communities, mostly detached or multifamily houses, sometimes attached houses, mostly owning	located in a medium city, a large small town or small small town, mostly detached houses, sometimes attached houses, owning

In the appendix (Appendix A.8), I included a critical data science table listing the limitations of the dataset used, the analysis chosen and the interpretations extracted.

5.3 The Government's Promotion of Single-family House Ownership

The historical policy and demographics analysis sheds light on the drivers that enabled the development of households with the identified characteristics. Three distinct time periods are inductively identified from the historical policy analysis:

- **1950-1965:** Capitalist and market economy orientation in post-war West Germany facilitated by the USA
- **1990-2008:** Privatisation & Financialisation
- **2015-2024:** Promotion of ownership, rent control and support of alternatives

In Figure 6, a timeline of the described periods is portrayed. For a more detailed description of each policy, housing state or target see Appendix B.

5.3.1 Capitalist and Market Economy Orientation in Post-war West Germany Facilitated by the USA

The post-war construction era had a significant influence on Germany's housing infrastructure for the following decades up until today. After the Second World War the nation was facing a drastic housing shortage of up to 5 million homes (Voigtländer, 2009; Richter, 2023). The first Housing Act thus concentrated on providing practical and affordable housing in a short time. The early 1950s were especially characterised by state-financed construction of social housing (Voigtländer, 2009). These housing projects were defined by income limits and small dwelling sizes (Staub, 2017; Hinz-Wessels, Haunhorst, & Würz, 2013). Although social housing was widely accepted in the population (Voigtländer, 2009), the Western occupying forces (especially the USA), heavily opposed this rather socialist approach (Kändler, 2016, p. 309) and strived for the establishment of owner-occupied homes and individualistic lifestyles to increase capital and stimulate economic growth (Petsch, 1983). Thus, under the Marshall Plan, the US government issued two programmes to symbolically support the German housing reconstruction as well as ideologically influence the housing politics (Staub, 2017). With the Economic Cooperation Administration (ECA) programme in 1951 and the Mutual Security Agency (MSA) programme in 1953, the USA contributed with 3,300 and 4,500 housing units, respectively (Staub, 2017). However, instead of constructing the multi-family houses with a maximum floor area of 50 m^2 per residential unit, as agreed with the German government, more spacious terraced houses with owner-occupied flats or single-family houses were built (Staub, 2017; Industriekultur Krefeld, n.d.). The construction of suburban individualistic housing forms aimed at restoring the capitalist economic order (Petsch, 1983) and reestablishing patriarchal living structures (Hayden, 2017; Staub, 2017).

After the first Housing Act, policies were mainly focused on enabling German citizens to build and buy their own homes. The increasing state support for ownership can be seen in the Housing Construction Premium Act from 1952 (Petsch, 1983), and the Amendment to the Housing Construction Act from 1953 (Petsch, 1983). The Housing Construction Premium Act was aimed at reducing the costs for low-income households to afford a home, however, as the subsidy is only available up to two times, long durations of ownership are favoured (Voigtländer, 2009). The implementation of the policies had the consequence of a 10% higher financial support on owner-occupied buildings compared with similar objects rented out (Petsch, 1983). In 1955, the establishment of the commuter allowance further enabled the individualistic, patriarchal living forms in suburban areas (Bach, Kloah, & Kuhmann, 2007). The commuter allowance still applies today and has been increased over the years (Bundesregierung, 2023).

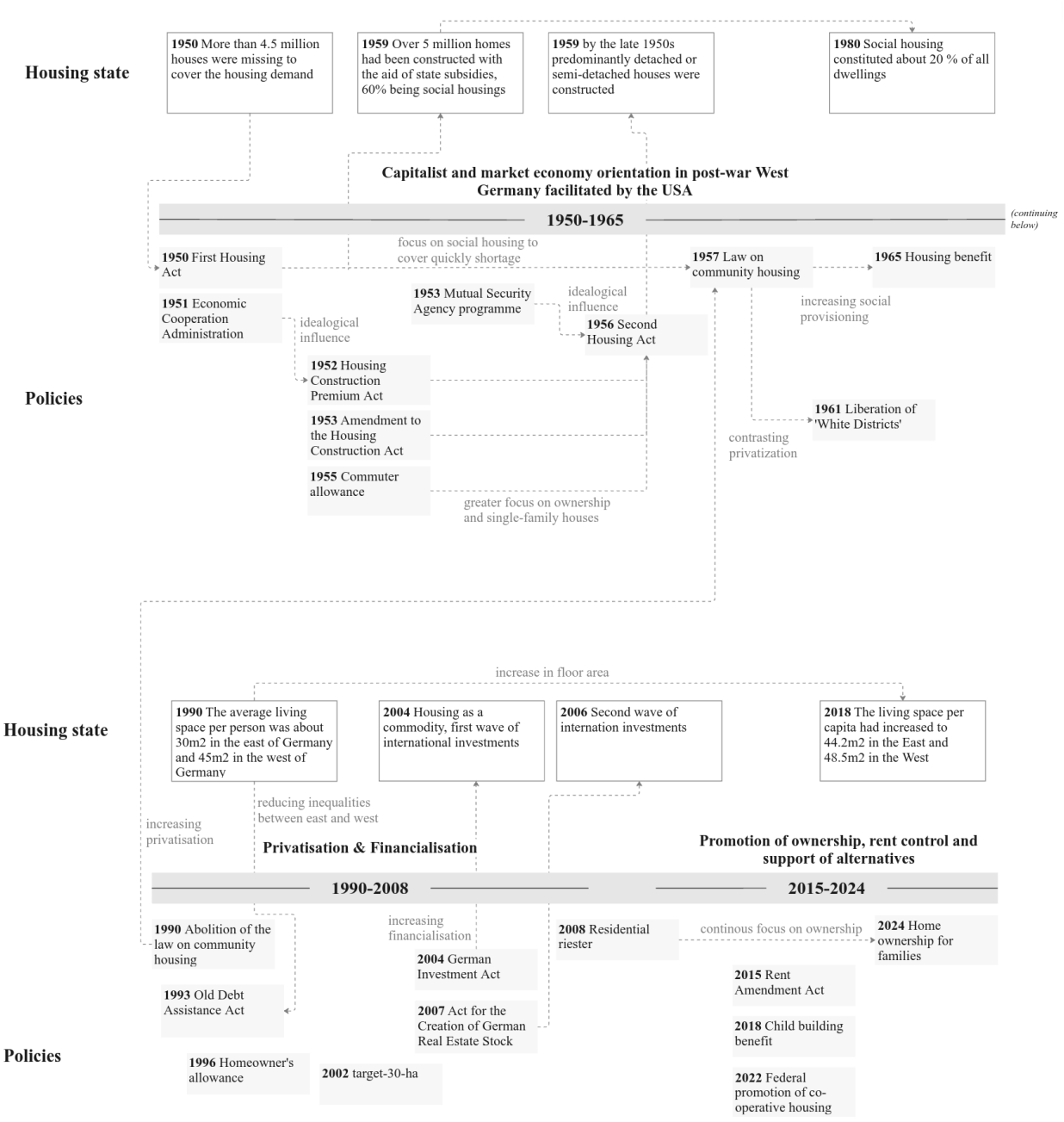

Figure 6: Timeline of the analysed national policies of the German housing sector from 1950 to 2024 divided into three periods. Included is anecdotal information about the state of the German housing stock collected from the literature review to give context to the policies. The arrows indicate connections between policies and the housing state of the time but do not symbolise causal relationships.

The Second Housing Act built upon the preceding developments and again put focus on the support of owner-occupied housing (Hinz-Wessels et al., 2013). In contrast, in 1957 the already pre-war existing law on community housing was extended (Bündnis 90/Die Grünen, 2015). Housing projects fulfilling the specified

requirements received state funds regulating the built development. Criteria for the community housing projects were the following. There was no profit maximization, with profits being limited and distribution restricted (Bündnis 90/Die Grünen, 2015). Business activities were confined to constructing small flats of up to approximately 120 m^2(Bündnis 90/Die Grünen, 2015; Bundesministerium der Justiz, 1969). Funds and assets were legally earmarked and restricted (Bündnis 90/Die Grünen, 2015). Any surplus generated had to be reinvested in new construction, ensuring an obligation to build (Bündnis 90/Die Grünen, 2015). Additionally, there were no ties to the profit-oriented construction industry (Bündnis 90/Die Grünen, 2015). This regulation remained unchanged in the new version of the law in 1969 (Bundesministerium der Justiz, 1969). However, the law on community housing wasn't able to combat the strong focus on owner-occupied spacious dwellings. By the late 1950s, nearly 60% of all apartments were constructed in either detached or semi-detached houses (Petsch, 1983).

Voigtländer (2009) describes the deregulation of the housing market that happened in 1961 by Paul Lücke, then Minister of Housing (Voigtländer, 2009). He liberated "white districts" where the housing shortage was below 3% (Voigtländer, 2009). By the late 1960s, almost all regions in Germany felt subject to the initiative (Voigtländer, 2009). Unfortunately, the so-called "liberalisation" of the housing market was not further described by Voigtländer (2009).

A last important policy from this time period was the introduction of the Housing Benefit in 1965 (Haustein, 2007). The housing benefit is designed to support low-income households in paying their rent. In 2019 the housing benefit totalled 153 euros per month per person (Richter, 2023). In the case that the tenant has almost no income and receives the citizen money ("Bürgergeld"), the state pays heating and housing expenses completely if the size of the apartment and the rent are considered reasonable (Richter, 2023). The initial post-war construction era began with a pronounced emphasis on social housing, however, quickly shifted to the support of home ownership and single-family houses, fostering individualistic, patriarchal living forms and a capitalistic economic orientation.

5.3.2 Privatisation & Financialisation

The second time period from 1990 to 2008 is characterised by an even stronger focus on deregulation. To reduce public costs, the housing market was privatised, financialised (Butterwegge, 2021) and expensive age provisioning ought to be provided partly through the support in home ownership (Helbrecht & Geilenkeuser, 2012; Zakrzewski, Berndgen-Kaiser, Fox-Kämper, & Siedentop, 2014). In 1990 the long-existing law on community housing was abolished by a coalition of centre-right, Christian and liberal parties (Butterwegge, 2021; Bündnis 90/Die Grünen, 2015). This was one of the many political decisions made since the 1980s that shifted housing policy towards private investors. The share of owner-occupied homes had risen to over 50% in the 1980s (Wagner & Mulder, 2000). In the 1980s, social housing constituted about 20% of all dwellings, but by the early 2000s, this had dropped to 6% (Richter, 2023). The number of social housing units in Germany decreased from 3.9 million in 1987 to 1.14 million in 2019 (Richter, 2023).

Another important event in 1990 was the reunification of West and East Germany. The average living space per person in 1990 was around 30m^2 in the former East and 45m^2 in the West (Richter, 2023).

Thus, following the reunification, the government was able to align the developments in the housing stock of East and West Germany towards private ownership. In 1993, the Old Debt Assistance Act targeted the housing industry, including municipal housing companies, local authorities, housing cooperatives, and private landlords in the new federal states and East Berlin, to improve their credit and investment capacity (Wissenschaftliche Dienste des Deutschen Bundestages, 2013; KfW, n.d.). It also aimed to enhance conditions for individual home ownership (Wissenschaftliche Dienste des Deutschen Bundestages, 2013; KfW, n.d.).

In 1996, the Homeowner's Allowance was introduced (Richter, 2023; Bundesministerium der Justiz, 2019). Again aiming at the support of individuals in acquiring their own homes. Eligible applicants for the Homeowner's allowance, including couples with incomes up to €70,000 (or €140,000 for couples with children, plus €30,000 per child), could receive an annual state subsidy (Richter, 2023). This subsidy amounted to 5% of construction costs for new buildings (up to €2,556 per year) or 2.5% of acquisition costs for old buildings (up to €1,278 per year), with an additional €767 per child per year (Richter, 2023). This support lasted for up to ten years. In 2002, the Homeowner's Allowance totalled 10 billion euros per year (Bartholmai, 2002). The homeowner's allowance was discontinued in 2006 (Richter, 2023).

In contrast to all the encouragement of buying and building of houses, in 2002, the target-30-ha was agreed on (Berndgen-Kaiser et al., 2018). The aim was to limit the area used for new construction and building development (Berndgen-Kaiser et al., 2018). The target was extended multiple times but nevertheless not reached by 2024 (Berndgen-Kaiser et al., 2018).

In the following years, the focus on private home ownership was extended by further financialisation of the housing market. In 2004, the German Investment Act permitted Hedge Funds in Germany, allowing foreign investors to enter the German housing market (Butterwegge, 2021). Over the decade, federal, state, and local governments have sold several hundred thousand flats from public housing stocks to private companies (Kemper, 2007; Wissenschaftliche Dienste des Deutschen Bundestages, 2013). Notable examples include the sale of GAGFAH, the housing association of the former Federal Insurance Institution for Salaried Employees, to Fortress Investment Group, the sale of Berlin's GSW to Cerberus/Goldman Sachs fund companies, and the sale of Dresden's WOBA to Fortress (Kemper, 2007). Whereas in other European countries, public-owned housing is most commonly sold to the previous tenant, in Germany 60 % of the flats were bought by international investors in large numbers and discounts (Wissenschaftliche Dienste des Deutschen Bundestages, 2013). A second wave of international commercialization of the German housing market has been recorded in 2006 (Wissenschaftliche Dienste des Deutschen Bundestages, 2013). In 2007, the Act for the Creation of German Real Estate Stock Corporations with Publicly Listed Shares allowed Real Estate Investment Trusts (REITs) to the German market (Butterwegge, 2021). REITs are listed corporations that invest in real estate while being exempt from corporate taxes (Butterwegge, 2021). These entities are required to distribute the majority of their income each year (Butterwegge, 2021). Consequently, rather than the REITs itself paying corporate taxes, investors are responsible for paying taxes on the dividends they receive (Butterwegge, 2021).

Lastly, in 2008, the Residential riester was introduced (BMWSB, n.d.-b). Aiming at financially supporting lower-income individuals and providing old-age provisioning through home ownership (BMWSB, n.d.-b).

Riester contract holders are entitled to allocate saved capital towards purchasing residential properties (BMWSB, n.d.-b). However, built-in restrictions on moving out or selling houses mean people may stay in their homes longer than necessary. Tax deductions are available for expenses related to old-age provision contracts, but Riester-contracted capital used for housing incurs retrospective taxation at retirement (BMWSB, n.d.-b). This tax is calculated based on a housing subsidy account and can be spread over 25 years or subject to one-off taxation, with only 70% of the amount taxed in the latter case (BMWSB, n.d.-b). The share of row and single-family houses of newly constructed buildings rose from 39.6 % in 1995 to 66 % in 2007, in East Germany even to 83.5 % in 2006 (Dollinger, 2009, p.110). Clearly, this second period was characterised by deregulation and privatisation, decreasing social provisioning by the state, and an ever-present focus on homeownership.

5.3.3 Promotion of Ownership, Rent Control and Support of Alternatives

The focus on the encouragement of home ownership has not shifted until today. The last decade has been shaped by policies that again reinforce the individualistic and capitalistic living forms once promoted in the 1960s by the USA. However, simultaneously the government had to react to the housing crisis partly sparked by the privatisation and financialisation of the last decades. In 2015, the Rent Amendment Act was passed. The nationwide Rent Amendment Act has been regulating permissible rent increases for existing flats since. While previous tenant protection measures primarily addressed existing rents, the introduction of the so-called Mietpreisbremse (rent brake) now restricts rents for new leases (Richter, 2023).

In 2018, the Child Building Benefit was introduced (KfW, 2021b; Richter, 2023). Families aiming to become homeowners have had the opportunity to apply for the subsidy, assisting with their down payment (Richter, 2023). Eligible families, with a taxable household income of up to €90,000 annually and €15,000 for each additional child, could receive €1200 per child annually for a maximum of 10 years, but this option was only available in 2021 (KfW, 2021b). However, one study revealed that this subsidy not only makes homeownership less attainable for lower-income households but also contributes to the escalation of prices for more expensive homes that are already out of reach for such households (Schmidt, 2019). This unintended consequence undermines the subsidy's initial intentions, potentially exacerbating the issue of rising house prices.

In 2018, the average living floor area per person had increased from 30 m^2 in the former East and 45 m^2 in the West in 1990 to 44.2 m^2 and 48.5 m^2 respectively (Richter, 2023). Thus, there is a clear upward trend in the average floor area per person, especially in the East of Germany.

After the abolishment of the Act on Communal Housing in 1990, the Federal promotion of cooperative housing was introduced in 2022 (BMWSB, n.d.-a). The federal government, in collaboration with the Kreditanstalt für Wiederaufbau (KfW) (Reconstruction Loan Corporation"), introduced a funding program for acquiring cooperative shares (BMWSB, n.d.-a). This program is available for both new cooperative ventures and for joining existing housing cooperatives (BMWSB, n.d.-a). It operates as a loan subsidy, with the interest rate subsidized from federal funds during the initial fixed-interest period (BMWSB, n.d.-a). Additionally, a significant portion of the loan debt is forgiven, amounting to a 7.5% repayment subsidy (BMWSB, n.d.-a). To qualify for the subsidy, it's necessary that the acquired cooperative shares are

intended for owner-occupancy of the cooperative flat and that the flat is utilized by the owner (BMWSB, n.d.-a).

Lastly, a policy promoting again home ownership, now especially for families, was passed in 2024 (KfW, 2024). The subsidy assists low to medium-income families with children in Germany in constructing or purchasing new, owner-occupied, and environmentally friendly residential properties (KfW, 2024). Key points include a promotional loan with an effective annual interest rate as low as 0.01% for climate-friendly new builds, applicable to both house construction and initial purchases of houses and condominiums (KfW, 2024). The maximum loan amount ranges from 170,000 to 270,000 euros for families with children and single parents, with subsidy amounts varying based on income levels (KfW, 2024). To sum it up, the third identified period has been shaped again by policies supporting the acquisition and construction of single-family houses fueling patriarchal and individualistic living forms. Homeownership is still seen as a strategy to provide security for the elderly. However, financial aid for alternative forms of housing development like cooperative housing and the rent control broadens the focus of current policies.

5.4 The Cohort, Age Life Structure & Remanence Effect

Next to the policies that influenced the building environment, three demographic effects have been commonly attributed to the rise in floor area per person in Germany, namely the cohort, the age life structure and the remanence effect (Raffelhüschen & Will, 2023). The cohort effect describes the increase in affluence over each generation and is tightly linked to the economic factors of the households like housing and heating costs as well as income (Pfnür et al., 2023). The age structure effect relates to the individual's increasing need for space over their lifetime, starting a family as well as rising income are common drivers (Pfnür et al., 2023). However, once the household size shrinks, many individuals hesitate to reduce their living space accordingly. This is explained by the remanence effect (Raffelhüschen & Will, 2023). The remanence effect is grounded not only in psychological drivers, such as an emotional attachment to the home but can also be intensified by economic conditions (Raffelhüschen & Will, 2023). Drastic increases in rents for smaller apartments and a shortage of their availability are contributing factors (Raffelhüschen & Will, 2023). Additionally, the 1980s until the early 2000s were shaped by a transition in living forms away from historic predominant ones (Buzar et al., 2007). Zakrzewski et al. (2014) and Buzar et al. (2007) describe a rise in single households, single parents, declining fertility rates, childless couples, smaller household sizes, later marriages and an ageing population. Furthermore, in a European comparison, Germans leave their parents' place already at a very young age of on average 23.8 years old (European average 26.4 years old), exacerbating the remanence effect (eurostat, 2023).

In the preceding two sections, I have answered sub-research question 1.2 *"What historical policies and demographic trends since 1950 have driven the emergence of high floor area per person households?"*. The historical analysis exposed related policies that were shaped by a focus on post-war reconstruction, home ownership, financialisation and privatisation. Moreover, the demographic development of the cohort effect, the age life structure effect and the remanence effect further stimulated the growth in floor area per person.

5.5 The Materialisation of High Floor Area Per Person Households through Historical Drivers

To relate the analysed policy and demographic developments with the identified characteristics of households living on a significantly high floor area per person, I discuss here, each characteristic and reflect on how past developments have further enabled or disabled their development.

5.5.1 The Direct Impact of Policies and Demographic Developments on the Increase in Floor Area

Over the years multiple factors exacerbated the increase in floor area per household indirectly as explained later. However, some policies directly shaped the sizes of living spaces. Firstly, the ECA and MSA programme introduced in the 1950s by the USA ignored the building requirements given by the German government regarding limited floor area and neglected the need for multi-family housing (Staub, 2017). Secondly, the reduction in the provisioning of social housing, which is commonly restricted in its size, contributed to the rise of spacious alternatives (Richter, 2023; Hinz-Wessels et al., 2013). Thirdly, the abolishment of the law on Communal Housing which supported the construction of apartments with a maximum floor area of 120 m^2, had similar effects (Butterwegge, 2021; Bündnis 90/Die Grünen, 2015). Lastly, the continuous financial support for the construction of spacious building types like single-family houses can be seen as an enabler of the floor area increase as well.

Additionally, the cohort, age life structure and remanence effect directly play into the rise of the floor area per person. Thus, demographic developments exacerbate the policy influence.

5.5.2 Market-economy Based and Individualistic Policies Enabled the Materialisation of Single Households with No Children and of High Age

That members of high-floor area households are often singles with no children in the house and of high age can be best explained by the remanence effect. Individuals stay longer than needed in their spacious homes due to many psychological and economic reasons (Raffelhüschen & Will, 2023). Policies that have requirements integrated that discourage homeowners from switching to a rental apartment, renting out their dwelling, or buying a smaller property can be seen as significant factors of the development, too. Examples are the Residential Riester introduced in 2008 (BMWSB, n.d.-b) or the Homeowner's Allowance of 1996 (Bundesministerium der Justiz, 2019). Furthermore, the financialization in 2004 and 2006 caused a sole focus on profits in the built environment, discouraging the construction of practical, affordable small buildings. Thus, even if individuals want to move out of their too-large homes, often smaller alternatives are missing.

5.5.3 Capitalist Drivers of the More Affluent West

The West of Germany was earlier exposed to the market-oriented influence of the USA and thus, more time was available to construct more spacious houses (Staub, 2017). Despite many efforts to close the gap between Eastern and Western German citizens, like the Old Debt Assistance Act in 1993 (Wissenschaftliche Dienste des Deutschen Bundestages, 2013), the difference in affluence is still prone. After almost 25 years of

reunification, in 2014, the wealth of households in eastern Germany had a mean value of 67,400 euros whereas western German households owned assets averaging 153,200 euros, with real estate ownership contributing the largest share to the wealth (Grabka, 2014). Thus, this unequal spatial distribution is also reflected in the floor area per person. In 2018, the floor area per person in East Germany was on average 44.2 m^2 and 48.5 m^2 in the West (Richter, 2023).

5.5.4 The Suburban Construction Boom

Households with a large floor area per person are most commonly found outside large cities. This characteristic was driven by a multitude of factors, one being the predominant focus on the construction of spacious single-family houses which require too much space for dense cities. This is one of the outcomes of the influence of the USA on the post-war built environment in the 1950s by for example the ECA and MSA programme. An establishment of individualistic and patriarchal living forms was aspired, only possible in suburban regions limiting women's access to working opportunities and increasing the workload of housekeeping (Hayden, 2017; Staub, 2017). Another policy enabling this development to suburban regions is the commuter allowance which made the travel to and from work more affordable and intensives the ownership of homes further away from work locations (Richter, 2023; Bach et al., 2007).

5.5.5 The Excessive Policy Focus on Single-family Houses

Similar to the suburban spread, the construction of the building type single-family houses was initialized by the ECA and MSA programme again encouraging individualistic and patriarchal living forms (Hayden, 2017; Staub, 2017). Furthermore, many policies in the housing sector of Germany, following the American intervention, were and are concentrated on the support of home ownership and construction, especially of single-family houses. These policies include: the Amendment to the Housing Construction Act (1953), the Second Housing Act (1956), Old Debt Assistance Act (1993), Homeowner's Allowance (1996), Residential Riester (2008), Homeownerhsip for families (2024). Thus, the German government encouraged over decades and still encourages the building and ownership of single-family houses.

5.5.6 Higher Concentration of Low-income Households

The clustering analysis revealed that households with a high floor area per person have more often a lower income compared to the distribution of the whole data set. Although this might be surprising, two arguments help to understand the results. Firstly, the dataset only asked the respondents on their current income, not accounting for past income and neglecting the potential wealth the individuals are holding. Thus, as the high floor area cluster group was also characterised by high age, this might resemble people receiving only their pension which might be substantially lower than their past income and not reflecting their current wealth (Pfnür et al., 2023). Accounting for the value of the property would allow us to understand this group of households more clearly. Secondly, old age provisioning has been partly outsourced to the individual by betting on home ownership (Helbrecht & Geilenkeuser, 2012; Zakrzewski et al., 2014). In the last decades, Germany has been shaped by a discussion on how to solve the national issue of "Altersarmut" (Old Age poverty), and scholars have critiqued the little support the elderly population is receiving (Niemeier, 2020). Thus, this higher concentration of low-income households might be partially explainable by the high age of the household group.

5.5.7 Aspiration of Ownership

One clear feature of the cluster group with a high floor area per person was the ownership of their homes. Again the idealisation of the self-owned single-family house in the early 1950s had a lasting impact (Staub, 2017). Therefore, ownership is seen as a sign of affluence and aspired by many. This development is not only tightly related to all policies supporting the acquisition of single-family houses (as listed in the paragraph before) but also to the lack of social provisioning by the state. Individuals were encouraged to buy property to be secured for later in their lives when state support is low (Helbrecht & Geilenkeuser, 2012; Zakrzewski et al., 2014).

Answering research question 1.3 *"How have the historical policies and demographic trends allowed the materialisation of the unequal distribution of living space?"*, the synthesis of the clustering and historical driver analysis has exposed many factors enabling the materialisation of households with a high floor area per person, from policies supporting home ownership and single-family houses to demographic developments like the remanence effect that exacerbate the influence of the policies.

5.6 Proposed Sufficiency Policies and Their Targeting of the Identified Characteristics

As introduced in the literature review (see section 2.2.5), the sufficiency policy database created by Zell-Ziegler et al. (2024) entails the most precise and comprehensive collection of policy proposals. I am briefly reflecting on their relevance for the German housing sector considering the results of my analysis. In Table 5, one can see the matching of the policies with the characteristics. One should note that I left out the low-income variable as the historic driver analysis showed that it adds little context when not taking into account past income as well as current wealth. Furthermore, the table only recognises when policies directly target the households with the identified characteristics.

Table 5: Proposed sufficiency policies for the housing sector by Zell-Ziegler et al. (2024) (for a more detailed description of the policies see Appendix C). The rating of the suitability of the policies to the identified characteristics is my own work. The columns indicate whether a policy targets households with the identified characteristics (x=yes). The order of the policies is unintentional.

Policy	**Single**	**No children**	**Elderly**	**Single-family houses**	**Ownership**	**Outside large cities**	**West**
1) Right to exchange flats	x	x	x	no	no	no	no
2) Moving bonus	x	x	x	x	x	x	no
3) Moving advice	x	x	x	x	x	x	no
4) Advice for change of use	x	x	x	x	x	no	no

Table 5: Proposed sufficiency policies for the housing sector by Zell-Ziegler et al. (2024) (for a more detailed description of the policies see Appendix C). The rating of the suitability of the policies to the identified characteristics is my own work. The columns indicate whether a policy is targeting Households with the identified characteristics (x=yes). The order of the policies is unintentional. (continued)

Policy	**Single**	**No children**	**Elderly**	**Single-family houses**	**Ownership**	**Outside large cities**	**West**
5) Fiscal relief for subleasing	x	x	x	no	no	no	no
6) Subsidies for small flats	x	x	x	no	no	x	no
7) Subsidies for splitting Single-Family-Houses	x	x	x	x	x	x	no
8) Investment grants for housing cooperatives	no	no	no	no	no	no	no
9) Financial support for buying shares of housing cooperatives	no	no	no	no	no	no	no
10) Bonus payment for living on small space	x	x	x	no	no	x	no
11) Design of development plans with diverse and mixed use	no	no	no	no	no	x	no
12) Training offensive for existing buildings (offers by chambers of crafts)	no	no	no	x	x	x	no
13) Training offensive for existing buildings (training content)	no	no	no	x	x	x	no
14) Permit and promote alternative housing	no	no	no	no	no	x	no

15) Tax free home-sharing	x	x	no	no	no	no	no

Only a few policies target the household group with the largest floor area per person. Policies that support alternative forms of living like co-operative housing (8, 9 and 14) are key to preventing future lock-ins through ownership and individualistic single-family houses, however, they do not directly target households currently living on too much space in single-family houses. Similarly, policies that provide sufficient housing options in the urban rental environment (1, 5, 6, 10 and 15) are necessary complementary measures to reduce environmental impacts and inequalities but nevertheless do not target the critical group of households living the most "insufficient lifestyle". Thus, key policies proposed by Zell-Ziegler et al. (2024) are the "moving bonus", "moving advice", "advice for change of use", and "subsidy for splitting single-family-houses". These policies are mostly targeted at households owning their single-family houses, of old age, living alone, and outside large cities, hence, addressing households that contribute significantly to the high energy demand of the housing sector. None of the policies is explicitly aimed at reducing the floor area of households in the West. The undifferentiated view of households in the research field of sufficiency is reflected in the results of the evaluation of the policies, which are barely tailored to the target group.

5.7 The (Un)Fit of the Policy Proposals Within the German Policy Context

To put the policy proposals into practice, one has to consider the policy environment already existing. The "moving bonus" aims to motivate small households living in large spaces to move to a more sufficient home by compensating them for the costs of moving (Zell-Ziegler et al., 2024). A local policy that comes close to this proposal can be seen in Frankfurt (Magistrat der Stadt Frankfurt am Main, 2018). Households living in publicly financed homes can get up to 7500€ financial aid when moving into a smaller flat (Magistrat der Stadt Frankfurt am Main, 2018). Unfortunately, especially homeowners who have a great resistance to moving are not targeted by this measure. Thus, on the national level, policy levers have to be found that include households living in privately owned houses.

In addition to the fiscal measure, the offer of "moving advice" should be considered (Zell-Ziegler et al., 2024). "Moving advice" refers to the services provided by Municipal Action Centres, offering advice on relocation, subletting, and home exchange, specifically targeting senior citizens who have more than 80 m^2 of living space per person (Zell-Ziegler et al., 2024). In the German state Baden-Württemberg, the regional project "Raumteiler" was initiated (Städtetag Baden-Württemberg, n.d.). Local non-profit organisations matched individuals with no accommodation with households that wanted to share their space (Städtetag Baden-Württemberg, n.d.). Although this initiative reached households living on too much space, the scale was marginal, in one city only about 117 people found a new home during this time (Städtetag Baden-Württemberg, 2022). A proactive strategy on the national level where elderly citizens living in excessively large spaces are approached could be taken into account.

The policy proposal to provide "advice for change of use" describes support given from municipal action centres on issues relating to building regulations for extensions or changes of use. In 2016, BBSR already investigated the legal changes necessary and the potential to create living space with roof extensions (Korinke et al., 2016). The created living space is targeted at middle and high-income households in urban

areas and thus, the measure is not fitted to the creation of affordable housing by the division of single-family houses outside large cities (Korinke et al., 2016).

Lastly, an important policy proposal is the "subsidy for splitting single-family-houses" (Zell-Ziegler et al., 2024). Currently, only the transition to a more barrier-free place is eligible for funding. Homeowners can receive a grant of up to 2,500€ for individual measures and 6,250€ for creating an age-appropriate house standard (KfW, 2021a). This measure could be extended to the division of single-family houses for sufficiency purposes.

On one hand, the exemplary existing local policies demonstrate the feasibility of the proposed measures within the German context. On the other hand, it is evident that current measures do not target the right households, are insufficient in scale, and lack the necessary expansion.

Furthermore, the historic driver analysis exposed the excessive focus of past policies on ownership, individualistic living forms in single-family houses and market-based solutions. Thus, policies like the Residential riester that discourage homeowners with tax burdens to rent out their houses, sub-rent rooms or move out, are outdated and actively prohibit flexibility in the housing demand and supply and therewith, the materialisation of sufficiency in the housing sector (BMWSB, n.d.-b). The implementation of sufficiency-enabling policies, therefore, has to be accompanied by a revision of past policies that hinder a just housing transition.

5.8 Sufficiency as a Societal Transformation

The clustering analysis, which highlights the characteristics of households with ample living space, and the historical driver analysis, which indicates how past policies have led to an increase in floor area, reveal that a consumer-focused approach to sufficiency (Vita, Lundström, et al., 2019; Sandberg, 2021) diminishes the potential for a sufficiency transition. This loss in impact can be explained by the underlying causes of the unequal distribution of living space which are rooted in a deeper societal orientation towards capitalist values. The market-economy-based approach fuelled the housing crisis and enabled the materialisation of a very inflexible unequal distributed residential space in Germany. Hence, as Tröger and Reese (2021) and Lage (2022) point out, a deeper societal transformation is required. To reach energy and impact reductions through sufficiency-enabling policies, we do not only need to design and implement new policies but reverse historic large-scale privatisation of the housing market (Wissenschaftliche Dienste des Deutschen Bundestages, 2013), revise capitalistic oriented policies and shift the focus of the housing sector from profit for (international) investors to the provisioning of sufficient, affordable and fairly distributed living space.
Thus, answering sub-research question 1.4 *How can insights from demographic trends and historical policies be leveraged to design sufficiency-enabling policies that target households with the highest floor area per person?*, it becomes evident that the historical policies focused on home ownership, single-family houses and the financialization of the housing sector need to be taken into account when developing sufficiency policies. However, finding suitable policies targeting the household group with the highest floor area per person is not sufficient as the analysis exposed that next to updating past policies a deeper societal transformation has to accompany the shift in policies to achieve a general decrease in living space per person and a more equal residential space distributing.

6 Discussion

In this discussion section, I aim to integrate my concrete results into a broader context. I will elaborate on my enrichment to the research field, limitations of the study and future research identified.

6.1 Inequality in Residential Space

Inequality has been studied from many perspectives and for various aspects of our lives. For the housing sector, this discussion has been mainly limited to real estate prices (Bartels & Schröder, 2020), the availability of affordable housing and rent increases (Butterwegge, 2021; Bartels & Schröder, 2020) as well as the individual opportunity to ownership (Voigtländer, 2009). The unequal distribution of living space is only marginally touched upon. Cludius, Noka, Galster, and Schumacher (2022) take a look at the average floor area per person for different income deciles, singles, partners with children and without children, people in pension and students. My research enriches the discussion by analysing the households for ten different socioeconomic variables (*floor area per person, floor area per household, number of persons, age, with partner, west/east, city type, housing type, income class and ownership*), giving a more nuanced picture of the inequality. I extended the clustering algorithm by a weighting of the main variable, which allowed me to identify distinct household groups regarding the floor area per person. The results of my analysis largely match with the observations of Cludius et al. (2022) for the variables represented in both studies. Identifying singles, partners without children and people of old age as high floor area per person household. Only for the variable income, my results differ. This deviation can be explained twofold, firstly as mentioned earlier my dataset might not capture all resources of income, secondly, the clustering technique enabled me to group households in different clusters based on their within variance. Thus, in the observations of Cludius et al. (2022), the high floor area per person households with low income might be lost due to their low count, as only averages of the income deciles are portrayed. Hence, my analysis adds another layer to the discussion of the unequal residential space distribution in Germany.

6.2 Moving Away from Universalistic Sufficiency Principles

Sufficiency principles and policy proposals developed by scholars in the past have been characterised by a universalistic and generalistic nature (Schneidewind & Zahrnt, 2014; Sandberg, 2021; Lorek & Spangenberg, 2019). The closely related research field, decent living standards, is prone to the risk of universalising, too. Even when regional differences are acknowledged, the aim to set global limits prevails. Researchers introduced a minimum floor area per capita of 10 m^2 (Rao & Min, 2018). In the German context, with an average floor area per capita of 46.2 m^2 in 2015 (Umweltbundesamt, 2023d), a reduction of the floor area per person to 10 m^2, to enable decent living standards while decreasing environmental impacts, would translate into a drastic downsizing and seems unachievable in the near term future. However, it is important, as my analysis shows, to differentiate also households within the country considering the wide distribution in the floor area per person. The lowest quartile living on 25.36 m^2 is relatively close to living on a "sufficient" floor area. In contrast, it is important to shift the focus on the upper quartile living on 95.32 m^2. By applying a global approach, the research field sufficiency lacks an understanding of the historical policy and demographic context for different countries, regions or cities. Furthermore, household groups are not differentiated but treated as equal, ignoring existing inequalities, especially for residential space. With this

thesis, I aim to counteract this trend. I have integrated the sufficiency discussion in the country context of Germany embedding it in the historical policies and demographic trends as well as identifying the household group living on the floor area of others.

6.3 Challenging the Residential Norm

The promotion of home ownership and the construction of single-family houses have often been portrayed as desirable. The question of inequality is mostly centred on the affordability for low-income households and whether policies effectively support these households in the acquisition of homes (Schmidt, 2019). Yet, my thesis challenges the presumption that single-family houses and ownership are beneficial for society in itself. Moving the inequality discussion from accessibility to homeownership to a more fundamental dialogue of who should own residential space, who benefits from housing trends and which political system enabled the unequal distribution of space. Thus, my historical driver analysis adds to the literature of neoliberal critics on the housing sector (Butterwegge, 2021).

6.4 A Social Science Perspective for Industrial Ecology

IE, defined as "the study of systemic relationships between society, the economy, and the natural environment", focuses on the technology-led reduction of environmental impacts considering socio-economic factors (Internation Society for Industrial Ecology, n.d.). The research field of IE is largely centred on efficiency-oriented technological solutions that have the aim of reducing impacts per defined unit. However, IE is often lacking a social science perspective. Behaviour shifts that could lead to absolute demand reductions are overlooked and little incorporated into modelling attempts. Vita, Hertwich, Stadler, and Wood (2019) made a step towards closing this gap by comparing green consumption with sufficiency lifestyles. Their global analysis indicated promising impact reductions from the behavioural changes and therefore, justified further research on sufficiency. The results of the mixed-method approach allow for a deeper understanding of the country context and the target groups for the measures, enabling more realistic and meaningful modelling. For example, the study of Huebner and Shipworth (2017) estimating energy savings from reducing floor area per person in the UK could be replicated for Germany, using more accurate estimates as the target group is identified. Coming back to the study of Vita, Lundström, et al. (2019), in which the environmental impacts of the different lifestyles are modelled with EEMRIOA, my results could lead to concrete improvements of the underlying assumptions. EEMRIOA is a tool that allows tracking impacts of product categories or industry sectors of a nation along their supply chain and accounts for the trade between multiple regions. With EEMRIOA one can adapt the final demand of the consumer (e.g. household energy consumption) as well as the production recipe of a sector like construction (e.g. no new residential construction). Vita, Lundström, et al. (2019) define their sufficiency lifestyle as 90% less construction and zero energy demand for the housing sector globally. However, the preceding analysis has shown that these assumptions have to be customised for different countries concerning their household target group and policy environment. An EEMRIOA analysis of the most promising identified policy proposals for sufficiency in the German housing sector could bridge the gap between impact modelling and policy analysis. Vita, Lundström, et al. (2019) acknowledge the limitation that their modelling can be seen as very abstract and country unspecific. The authors reason their choice with the high aggregation level of EEMRIOA. However, over the last decade, multiple scholars have started to disaggregate sectorial impact contributions for different sectors and regions.

Chang, Ries, Man, and Wang (2014) provide a very high resolution for the calculation of energy demands of different building types in China. Repeating this disaggregation for the German context would allow for a more accurate estimation of impact reductions resulting from policy implementations. The results of my study further enhance the quantification of impacts by first identifying the relevant target group and second, advancing sufficiency-enabling policies tailored to the German housing sector. Thus, future studies could be performed on the quantification of impact reductions of the key policies investigated.

6.5 Limitations & Future Research

I elaborate here on the four main limitations of my research and their associated quests for future research. Firstly, the size of the population survey "LebensRäume" ("LivingSpaces") can be questioned in its representability (Böltken et al., 2014). Only 3790 observations were available for the analysis and thus, the sample might not be representative of the German population. For the purpose of this study, the depth of the dataset was of more relevance to understanding the socioeconomic characteristics associated with a high floor area per person. Future research could replicate my study with a larger dataset and compare subgroups with more recent census data. In the appendix a detailed critical data science table can be found, discussing further potential biases and limitations of the dataset used and the algorithm applied (Appendix A.8).

Secondly, the historical driver analysis is limited in its scope as the search terms of the literature review, which were used to identify relevant policy developments, stem from the clustering analysis. Therefore, a more comprehensive structured literary review of past policies and demographic developments could be performed to reduce the potential confirmation bias. Here an extensive study of all existing and abolished regulations and subsidies of the German housing sector would be value-adding. To understand regional differences, another dimension could be added by looking at state and municipality-issued policies.

Thirdly, a significant limitation of this study is the excessive focus on policies to reduce energy demand. In his paper on decolonising energy justice, Tornel (2022) exposes the risk of perpetuating epistemic and ontological violence by allowing the "sociology of absences", a concept introduced by Santos (2014). The "sociology of absences" depicts how certain realities, knowledge, and ways of being are systematically rendered invisible, non-existent, or non-credible by dominant social, cultural, and epistemological systems (Santos, 2014). Hence, Tornel (2022, p.51) raises the question whether "modern tools like state policies, human rights, and democratic institutions can solve environmental (or energy) injustices". The results of my analysis align with this critique in calling for a greater societal transformation not merely relying on policy proposals, however, future research should put more emphasis on the development of sufficiency strategies outside the policy sphere.

Lastly, the inequality in residential space is a local challenge. Until 2040 a significant shift from peripheral and less central cities to central cities is expected (Maretzke, Hoymann, Schlömer, & Stelzer, 2021). The clustering analysis showed that we need to redistribute space, especially outside large cities, hence, the projected trend intensified the inequality. The research framework applied in this thesis could be extended by a spatially explicit analysis of the needed redistribution in residential space and a more local historic driver analysis taking into account municipal and state policies.

7 Conclusion

This study addresses the urgent need for more contextualised research on sufficiency in the housing sector. Past literature has largely adopted a global, universalistic approach to sufficiency, often overlooking country-specific enablers and barriers. Identifying the target group for sufficiency measures and understanding the historical context can serve as powerful resources for impact modelling and effective policymaking. My analysis has led to the following key findings:

- The target household group of sufficiency-enabling policies should be: single, currently living without children, older, living outside large cities, residing in (detached) single-family houses, owning their homes, having rather low incomes, and located in West Germany.
- The historical driver analysis reveals that capitalist, market-oriented policies have historically promoted home ownership and single-family houses, thus, actively enabling the materialisation of spacious living, resulting in an unequal distribution of living space.
- Large-scale privatisation and financialisation of the German housing market have shifted the focus to the maximisation of profits of (international) investors instead of providing affordable and sufficient living space for all.
- Current policies hinder a broader societal transformation towards sufficiency by continuing to support the construction of single-family houses, promoting ownership and even discouraging homeowners from subletting part of their property, renting out their house, or moving out.
- Most existing policy proposals inadequately differentiate between household groups regarding their floor area per person and fail to consider the regional historical policy contexts. Effective sufficiency policies, such as moving bonuses, moving advice, and subsidies for splitting single-family houses, should be implemented to address these high-impact households.
- However, the successful implementation of sufficiency measures in the German housing sector is dependent on a broader societal transformation away from a capitalist and market-economy orientation. The necessity of a "societalisation" of the housing sector becomes evident.

By identifying key household characteristics, providing an overview of historical policies and demographic trends, as well as analysing their ties, this study offers a comprehensive understanding of the factors influencing residential space distribution in Germany and therewith, answers the main research question: *How have demographic trends and historical policies influenced the distribution of residential spaces in Germany, and how can the underlying inferences be used to design sufficiency policies that aid in a just housing transition?* My analysis has shown the importance of taking a mixed-method approach, getting a deeper understanding of complex dynamics between policies, demographic trends and household behaviour. My research approach can be transferred to studies on other countries and sectors to gain a contextual understanding. The method should be extended to include an IE perspective to assess concrete environmental impact mitigations. An implication from my study is that it is important not to base policy development solely on the results of data-driven modelling, but to embed the results in the wider context. Integrating sufficiency into the German housing sector to achieve a just transition requires not only a revision of existing policies and the

development of new ones but also a societal shift that prioritises social and ecological values over economic values.

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Appendices

A Cluster Analysis

For the agglomerative hierarchical clustering analysis, the Python SciPy library is used (SciPy, 2024). The code for the cluster analysis can be found on GitHub (see this link `https://github.com/green-caro/master_thesis_living_on_less`).

A.1 Selecting Variables of Interest

To have a meaningful analysis, relevant variables had to be selected. Thus, I first selected all variables that are related to the demographic characteristics of the households, the economic situation, the building type, and the city type. Here I excluded all respondent-related variables as these are not of interest when wanting to understand the household characteristics (e.g. Age of respondent, only household average of relevance). Following, I erased variables that portrayed the "rest" (e.g. east (west/east) or male (male/female)). To decrease the resolution of the income variables to see a clear distinction between clusters and increase the interpretability the income variables were grouped after F. Dorn et al. (2023) (see Table 6 and Table 7).

Table 6: Distribution of Available Yearly Household Income for different groups in 2019 for Germany from F. Dorn et al. (2023)

	Single		Couple without children		Couple with 2 children	
	From	To	From	To	From	To
High income class	€ 46,600.00		€ 69,900.00		€ 97,860.00	
Upper middle class	€ 34,950.00	€ 46,600.00	€ 52,425.00	€ 69,900.00	€ 73,395.00	€ 97,860.00
Middle class	€ 23,300.00	€ 34,950.00	€ 34,950.00	€ 52,425.00	€ 48,930.00	€ 73,395.00
Lower middle class	€ 17,475.00	€ 23,300.00	€ 26,212.00	€ 34,950.00	€ 36,698.00	€ 48,930.00
Lower Income class	€ -	€ 17,475.00	€ -	€ 26,212.00	€ -	€ 36,698.00

Table 7: Distribution of Available Monthly Household Income for different groups in 2019 for Germany (own calculations after F. Dorn et al. (2023))

	Single		Couple without children		Couple with 2 children		Average	
	From	To	From	To	From	To		
High income class	€ 3,883.33	€ -	€ 5,825.00	€ -	€ 8,155.00	€ -	€ 5,954.44	€ -
Upper middle class	€ 2,912.50	€ 3,883.33	€ 4,368.75	€ 5,825.00	€ 6,116.25	€ 8,155.00	€ 4,465.83	€ 5,954.44
Middle class	€ 1,941.67	€ 2,912.50	€ 2,912.50	€ 4,368.75	€ 4,077.50	€ 6,116.25	€ 2,977.22	€ 4,465.83
Lower middle class	€ 1,456.25	€ 1,941.67	€ 2,184.33	€ 2,912.50	€ 3,058.17	€ 4,077.50	€ 2,232.92	€ 2,977.22
Lower Income class	€ -	€ 1,456.25	€ -	€ 2,184.33	€ -	€ 3,058.17	€ -	€ 2,232.92

A.2 Data Cleaning

To be able to cluster the categorical variables I used hot one encoding. There was no observation with missing values. However, for 110 respondents the answer "no information" was selected for at least one variable and thus, these observations were excluded. Due to the low count, I do not expect the results to be affected significantly. Therefore, from the 3900 observations, 3790 could be utilised.

A.3 Multicollinearity

Before interpreting the clustering results one should take a look at the potential of multicolinearity. As portrayed in Figure 7 only a few variables seem to be strongly correlated. The number of persons in the household seems positively correlated to the number of children. As most children still live with their families this link is logical and should not bias the results. Furthermore, there seems to be a negative correlation between the number of over 66-year-olds and the number of persons between the ages of 18 and 65. Furthermore, the housing type multifamily houses and the variable ownership have a negative correlation.

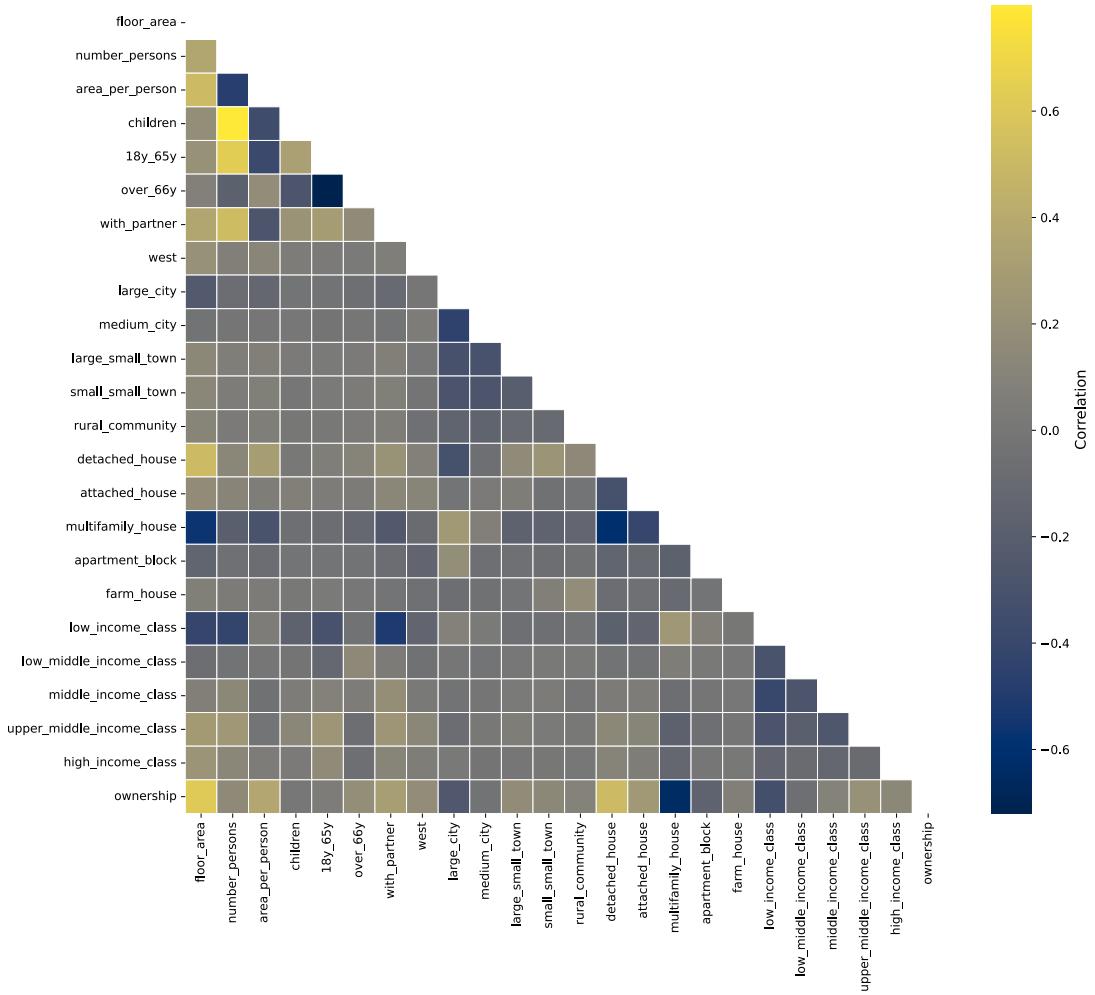

Figure 7: Correlation matrix of all 24 variables

A.4 Descriptives of Variables & Outlier Discussion

The following figures portray the distribution of all variables and other descriptive statistics. One outlier was erased from the dataset as the inserted number of rooms seemed impossibly high for the total floor area stated.

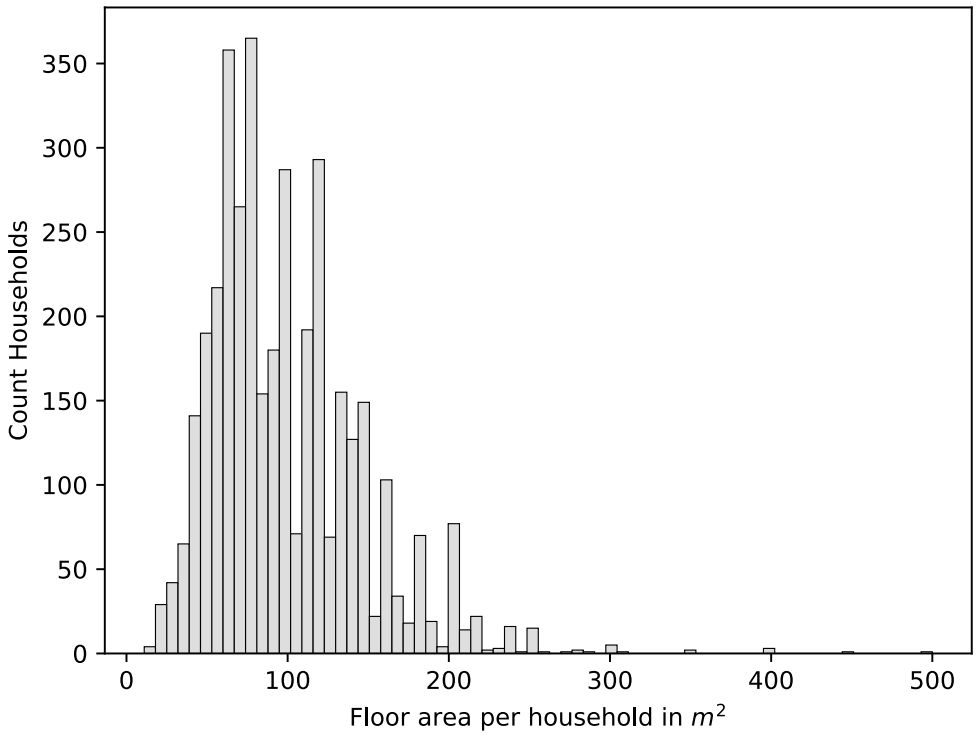

Figure 8: Histogram of the distribution of the variable floor area per household

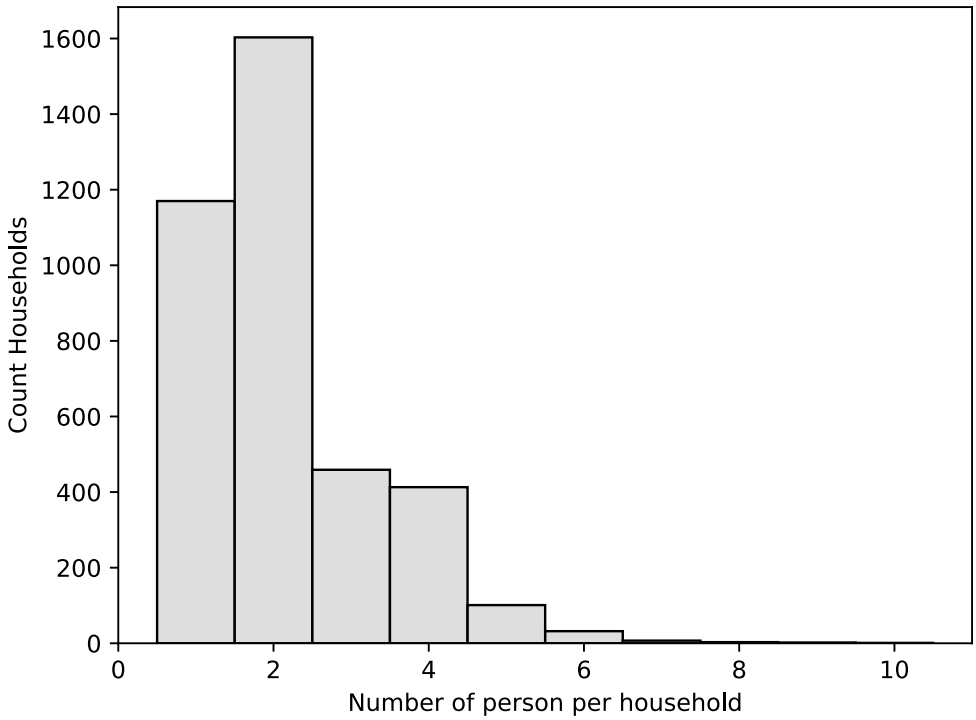

Figure 9: Histogram of the distribution of the variable number of persons per household

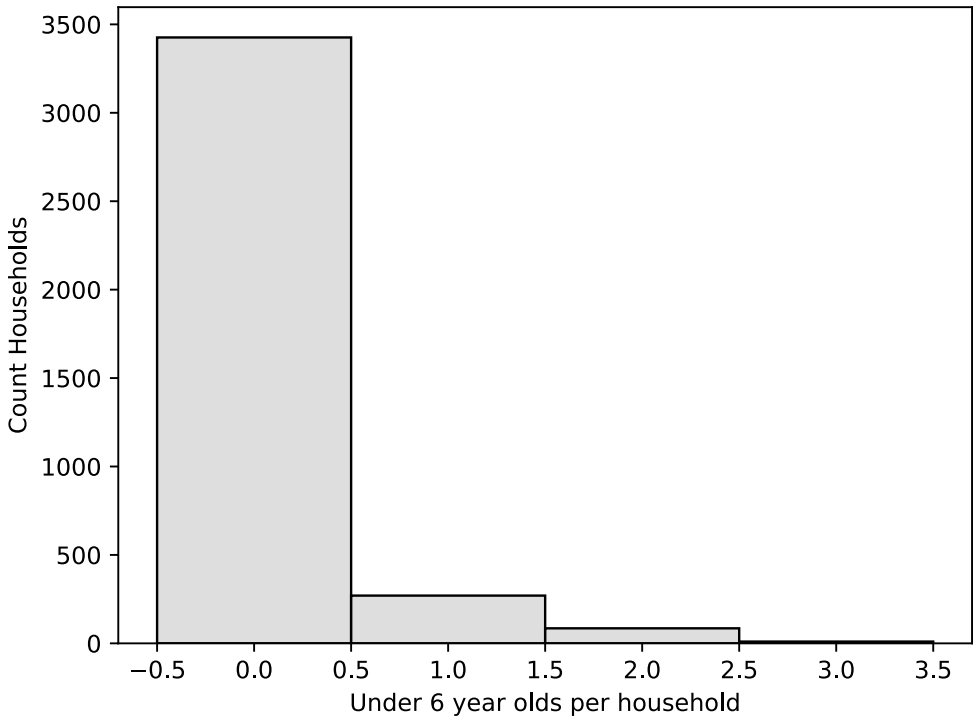

Figure 10: Histogram of the distribution of the variable under 6 year olds

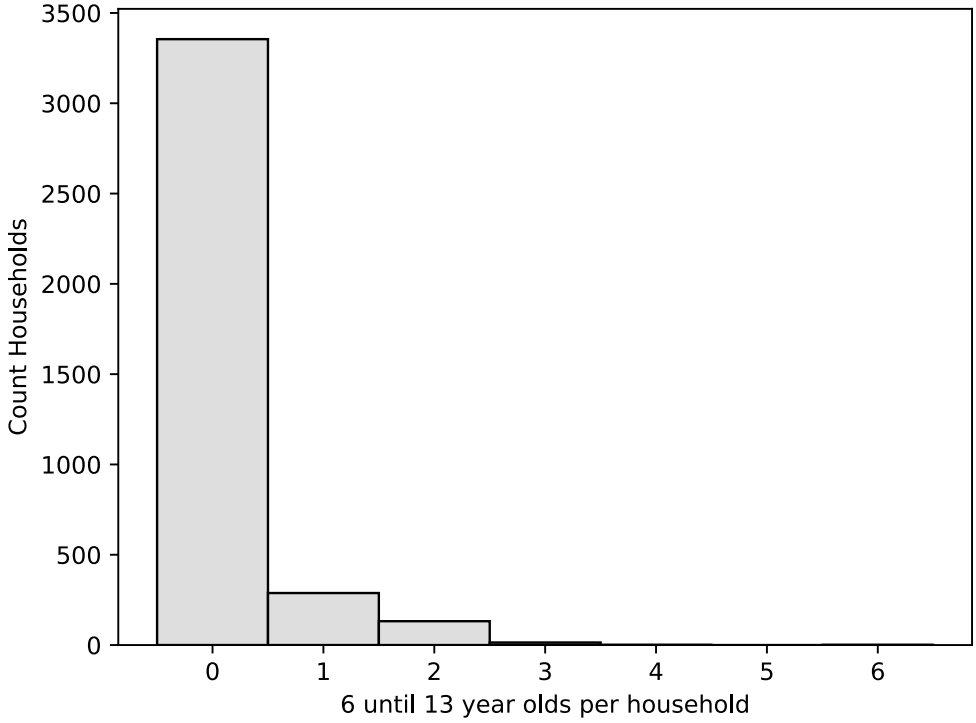

Figure 11: Histogram of the distribution of the variable 6 - 13 year olds

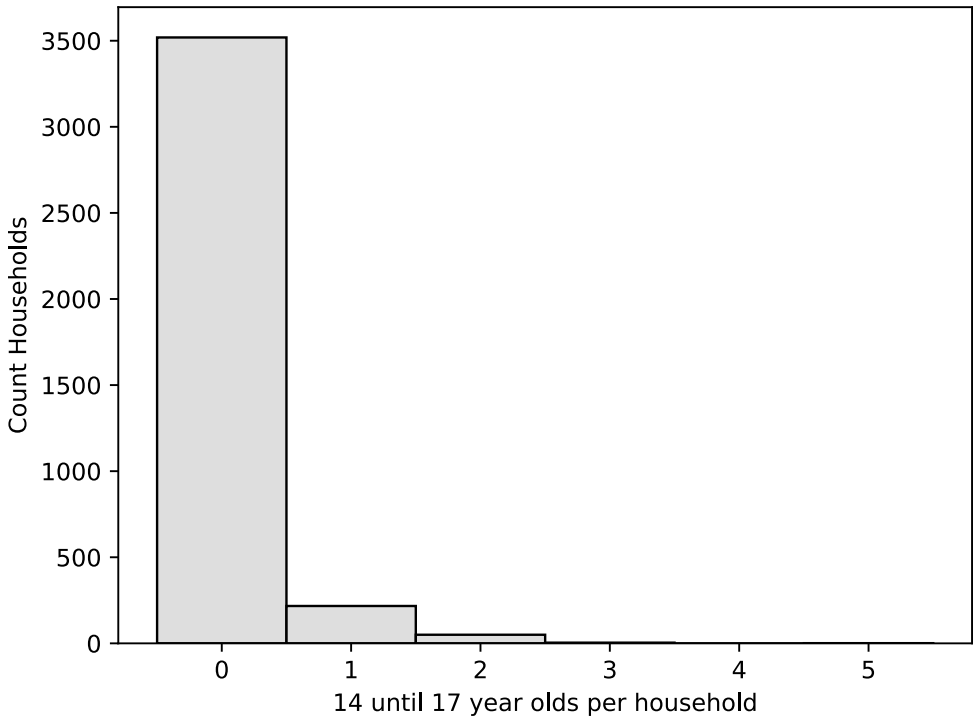

Figure 12: Histogram of the distribution of the variable 14 - 17 year olds

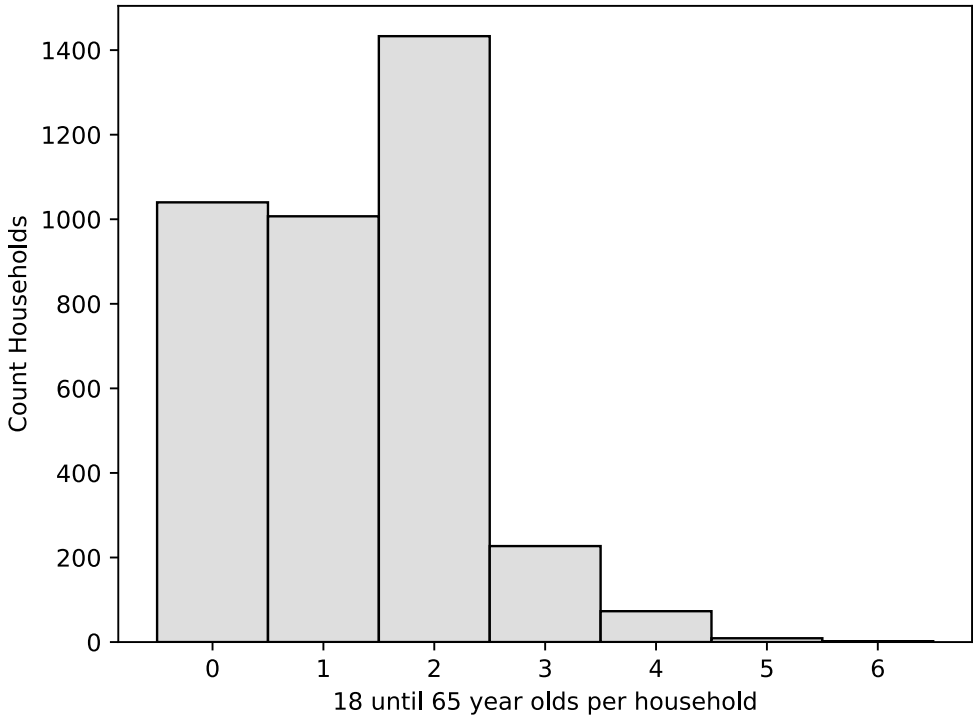

Figure 13: Histogram of the distribution of the variable 18 - 65 year olds including outliers

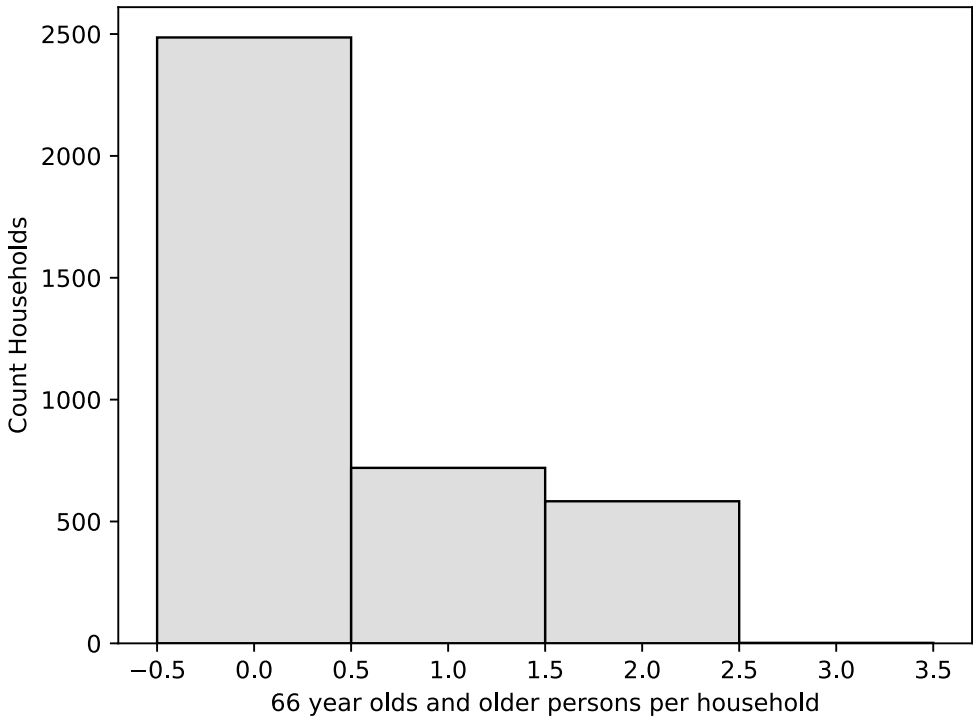

Figure 14: Histogram of the distribution of the variable 66 year olds and older

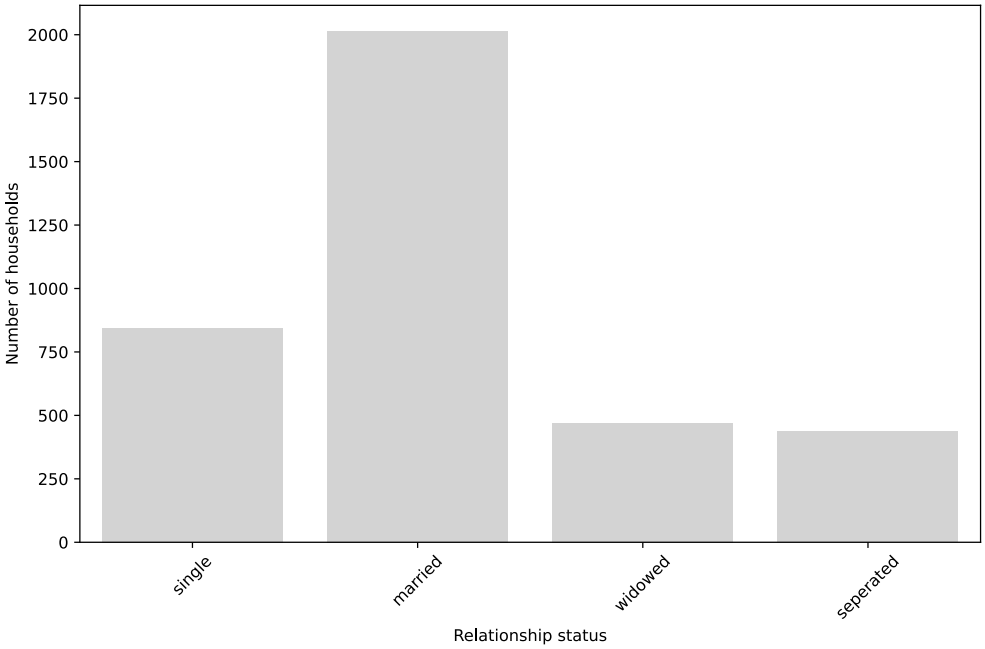

Figure 15: Histogram of the distribution of the variable relationship

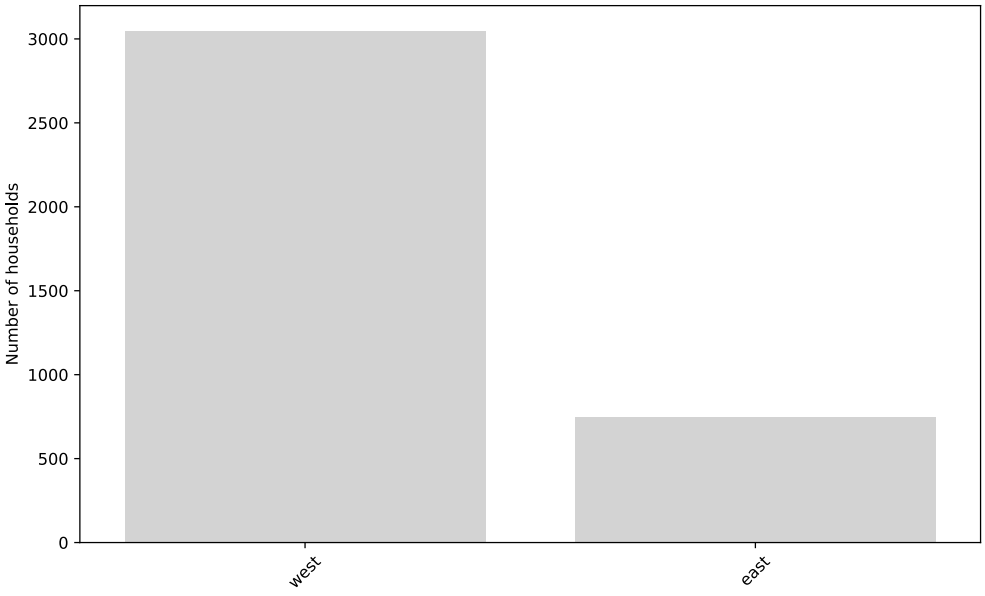

Figure 16: Histogram of the distribution of the variable west east

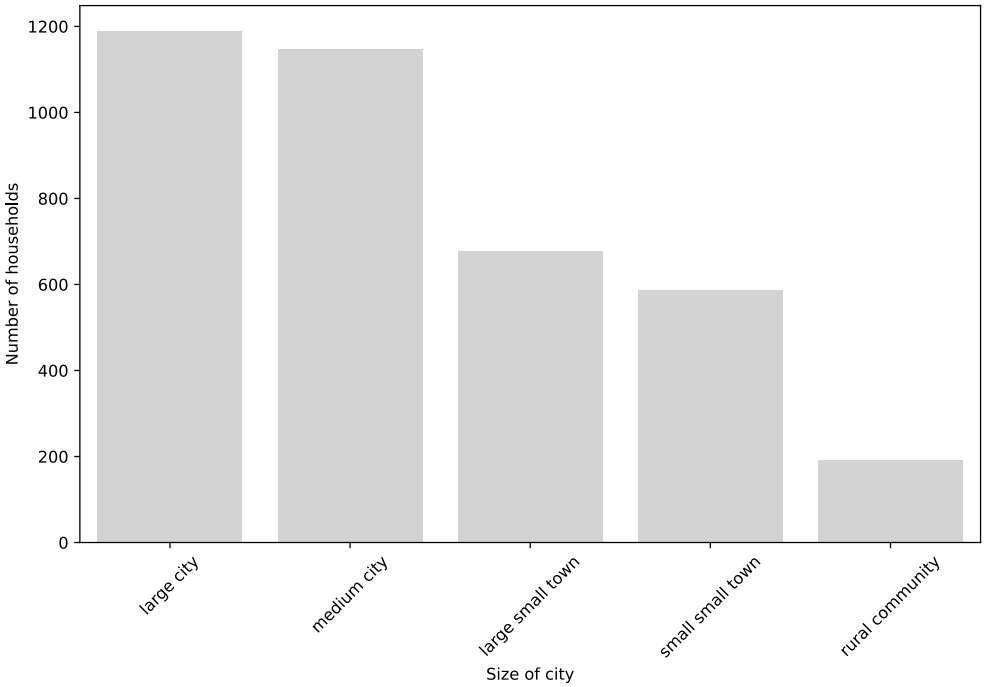

Figure 17: Histogram of the distribution of the variable city type

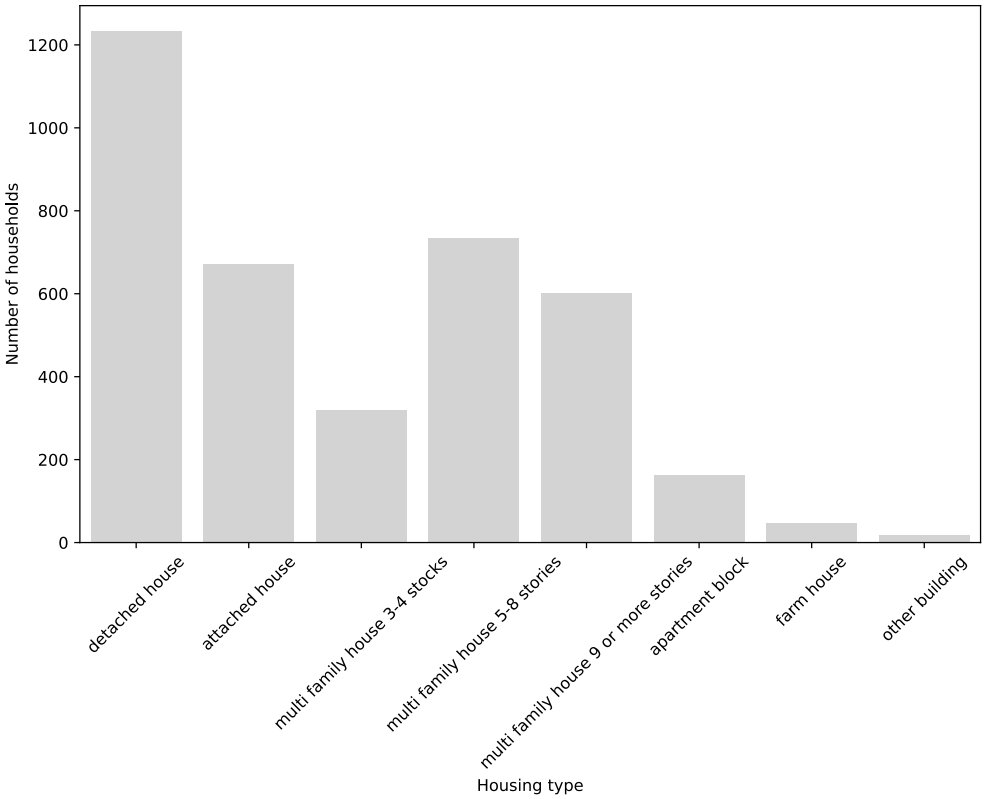

Figure 18: Histogram of the distribution of the variable housing type

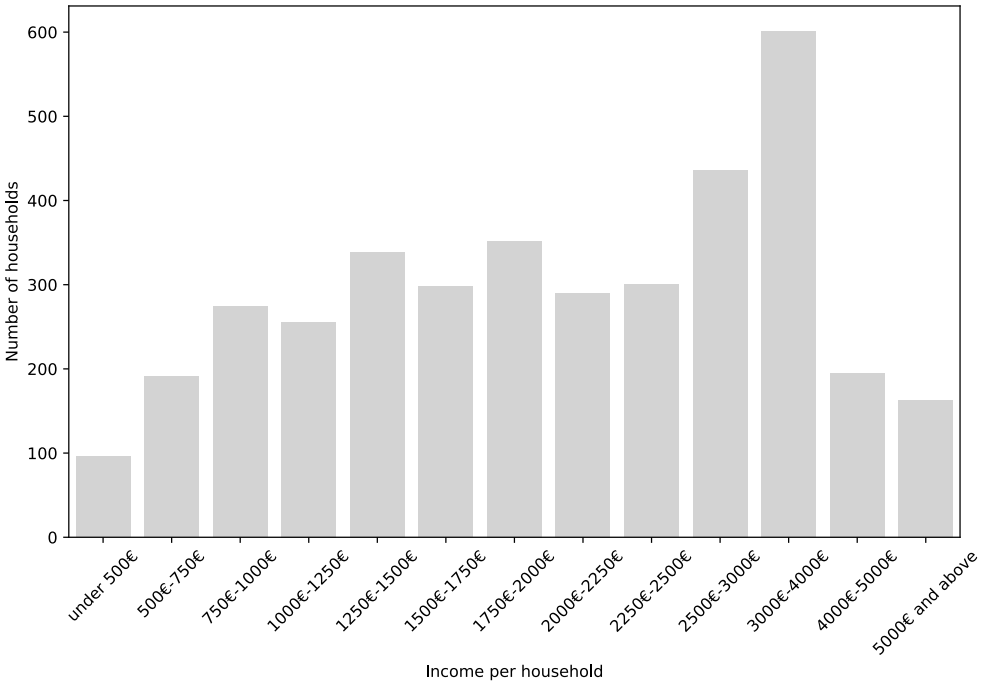

Figure 19: Histogram of the distribution of the variable income class

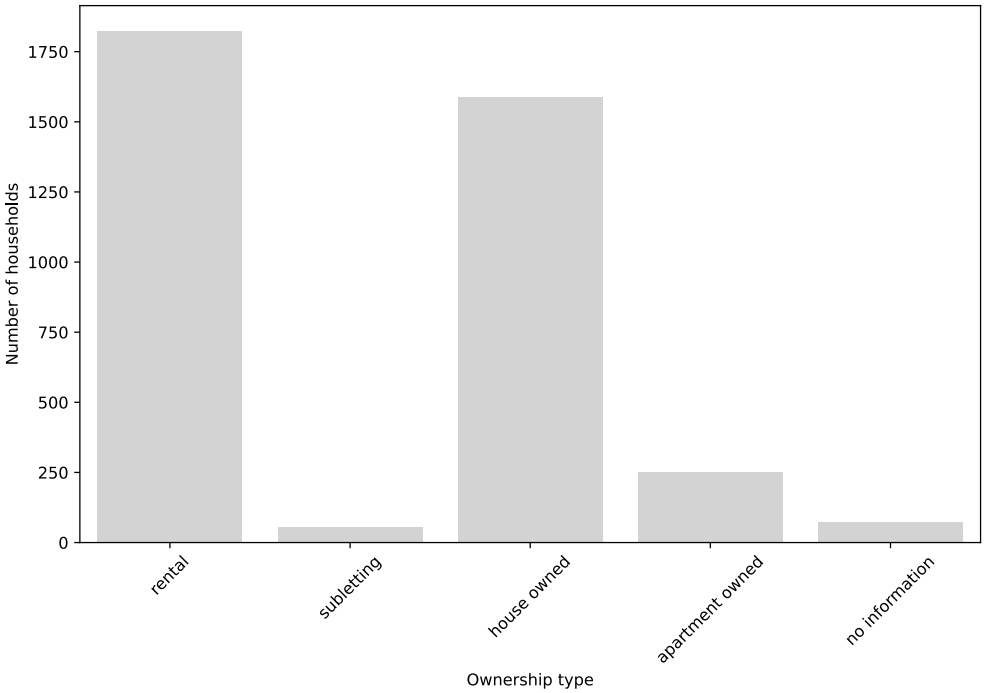

Figure 20: Histogram of the distribution of the variable ownership

A.5 Sensitivity Analysis of Weighting of Floor Area Per Person

The following kernel density estimate (KDE) plots show the distribution of each cluster for the variable floor area per person with different weightings for the variable plotted.

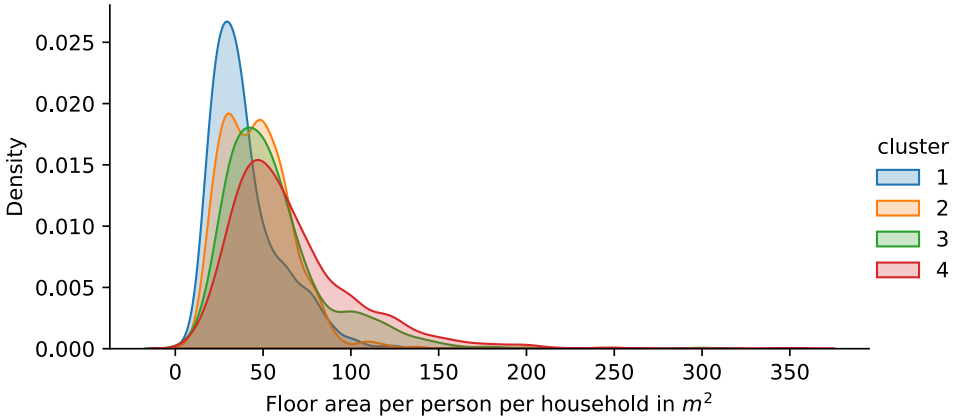

Figure 21: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 1, variance cutoff = 30)

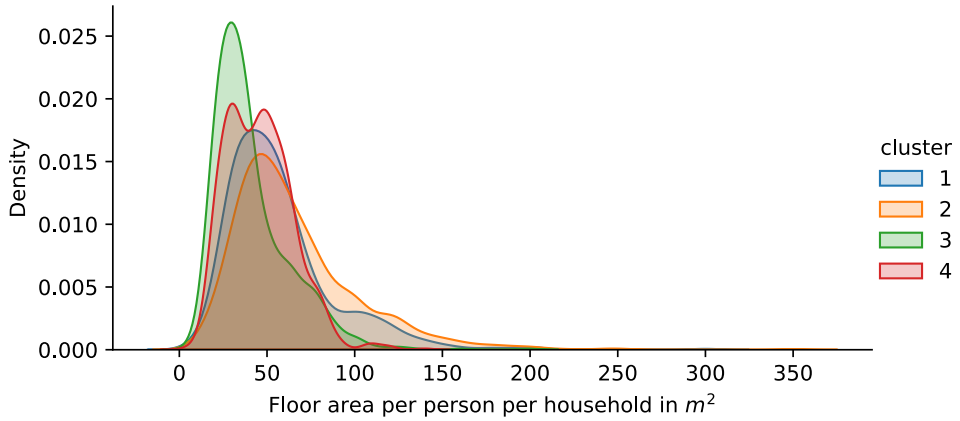

Figure 22: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 2, variance cutoff = 30)

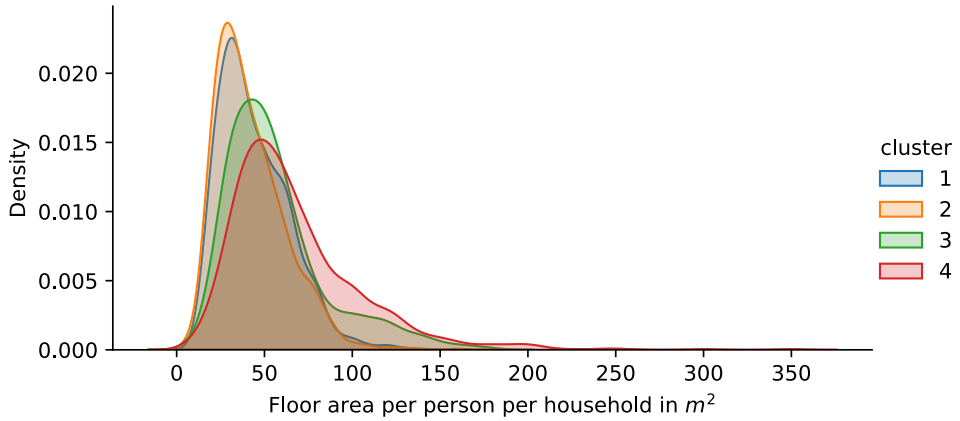

Figure 23: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 5, variance cutoff = 30)

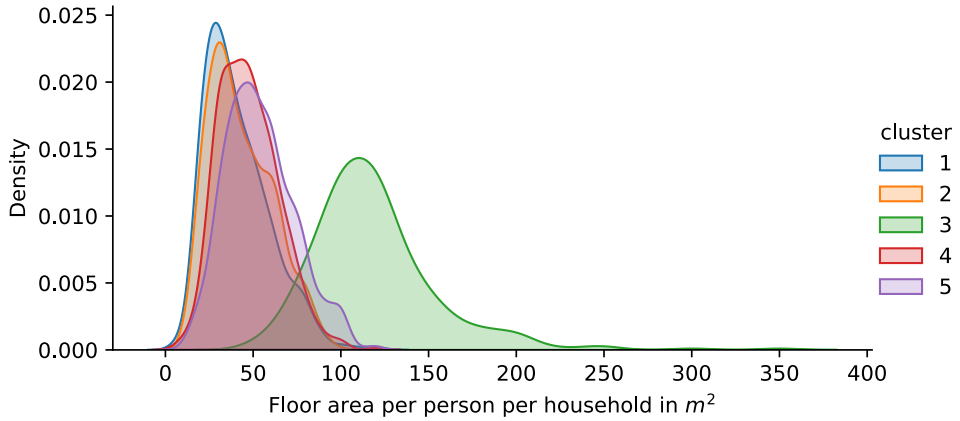

Figure 24: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 10, variance cutoff = 30)

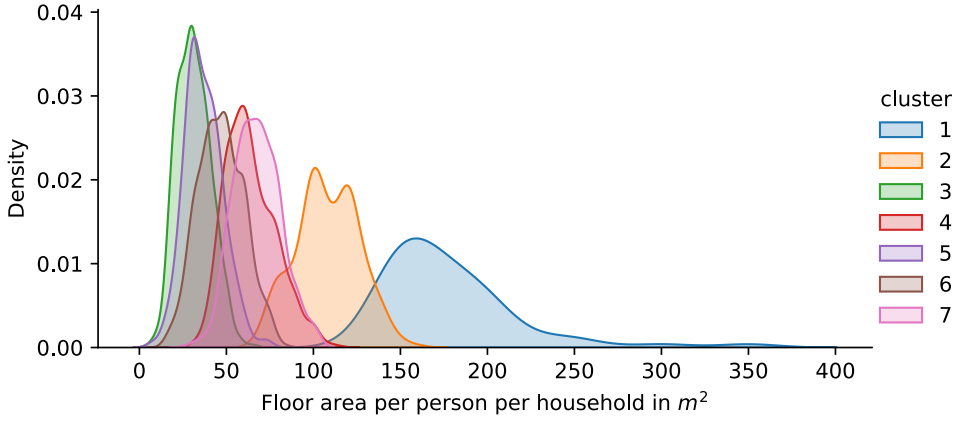

Figure 25: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 20, variance cutoff = 30)

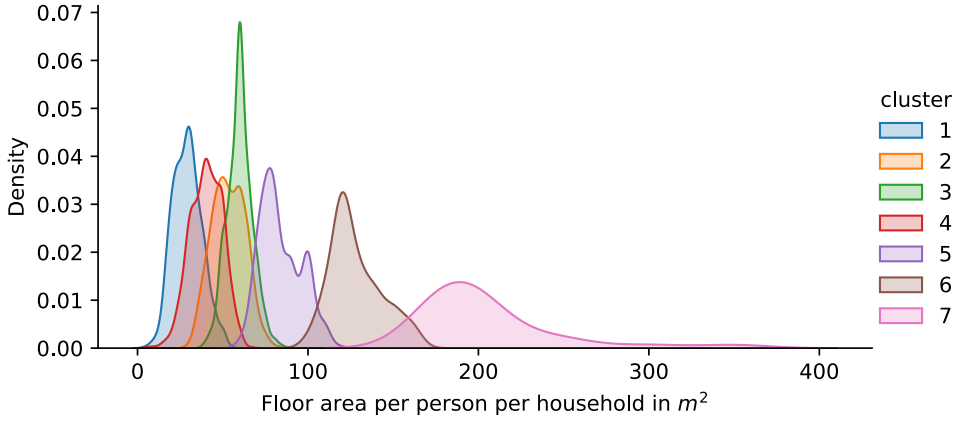

Figure 26: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 30, variance cutoff = 30)

Clearly, one can see that the weighting drastically changes the between-cluster difference of the distribution of the variable when applying a higher weighting. However, only after giving the variable floor area per person a weight of 10, a noticeable difference is visible (see figure 24). For a weight of 30 a clear distinction between the clusters is visible and especially the overlaps of the clusters with a high floor area per person are minimized (see figure 26). Running the cluster analysis, the same variance cutoff of 30 is chosen. This leads to a varying number of clusters for each cluster analysis. Therefore, for the weighting of 30, the cluster analysis is performed with a cutoff of 53, too, to compare the difference in the distribution of each cluster for other variables.

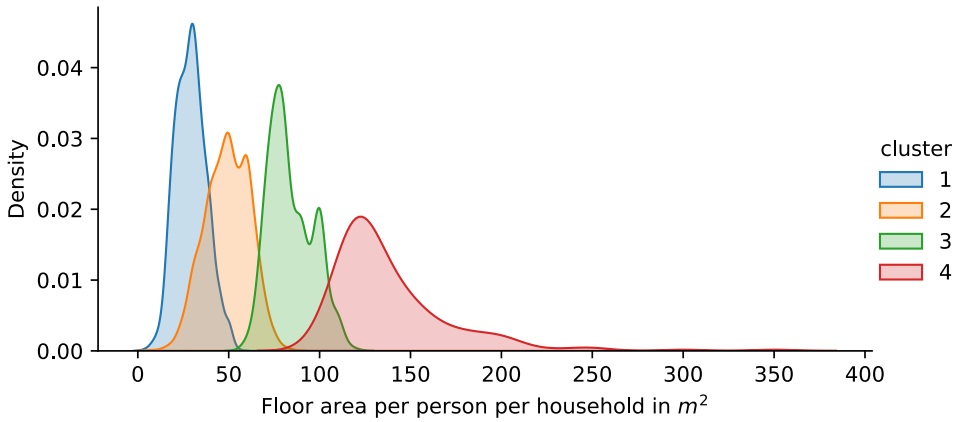

Figure 27: KDE plot showing the distributions of each cluster for the variable floor area per person (weighting = 30, variance cutoff = 53)

Even when choosing a variance cutoff leading to similar amounts of cluster one can see that the weighting drastically changes the between-cluster difference of the distribution of the variable when applying a higher weighting (see figure 27). The following figures describe the distribution for each cluster for all variables for a weighting of 1 and cutoff at 30 and a weighting of 30 and cutoff at 53.

Total Floor Area

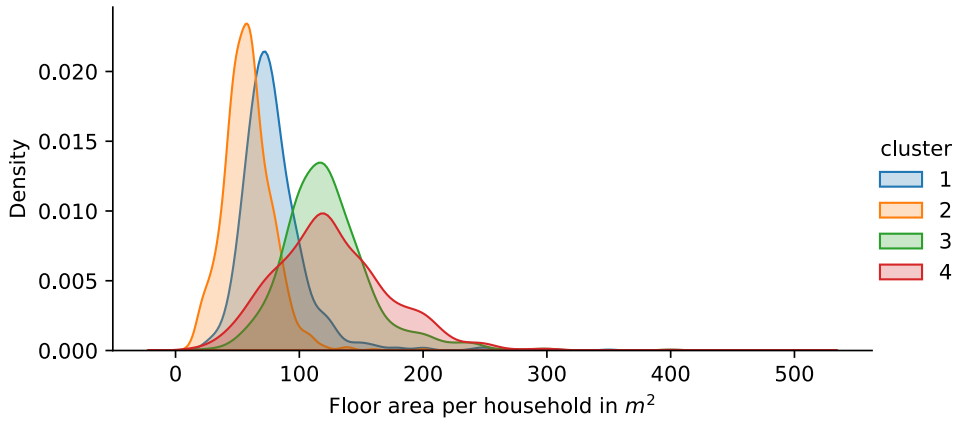

Figure 28: KDE plot showing the distributions of each cluster for the variable floor area (weighting = 1, variance cutoff = 30)

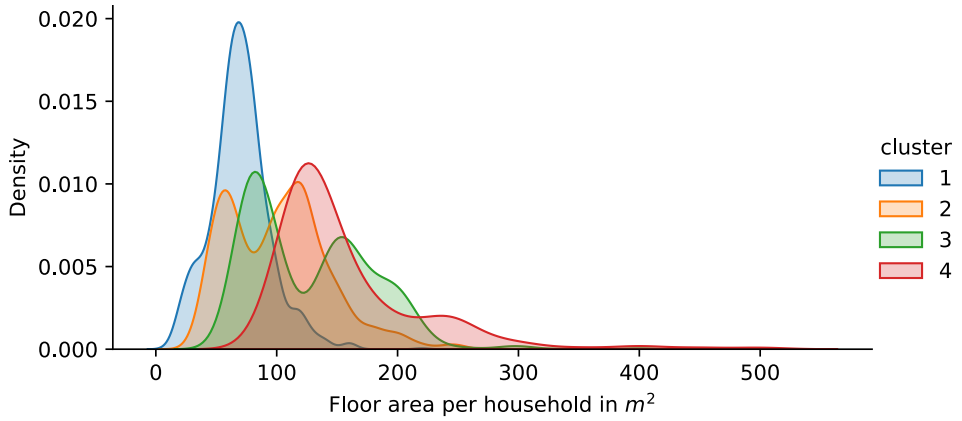

Figure 29: KDE plot showing the distributions of each cluster for the variable floor area (weighting = 30, variance cutoff = 53)

The distributions of each cluster for the variable floor area per person seem a bit less overlapping for the weighting of 1 (see figures 28 and 29). It seems like the two clusters with higher floor areas per person have similar total floor areas and the clusters with lower floor areas per person have as well similar total floor areas. This distinction is reduced when applying the weighting and should be considered when interpreting the results. However, in the analysis, the total floor area of the household is less relevant as for the quest of finding a just solution, the floor area per person is crucial. Nevertheless, the variable does give an insight into the type of housing the person is living in.

Total Number of Persons

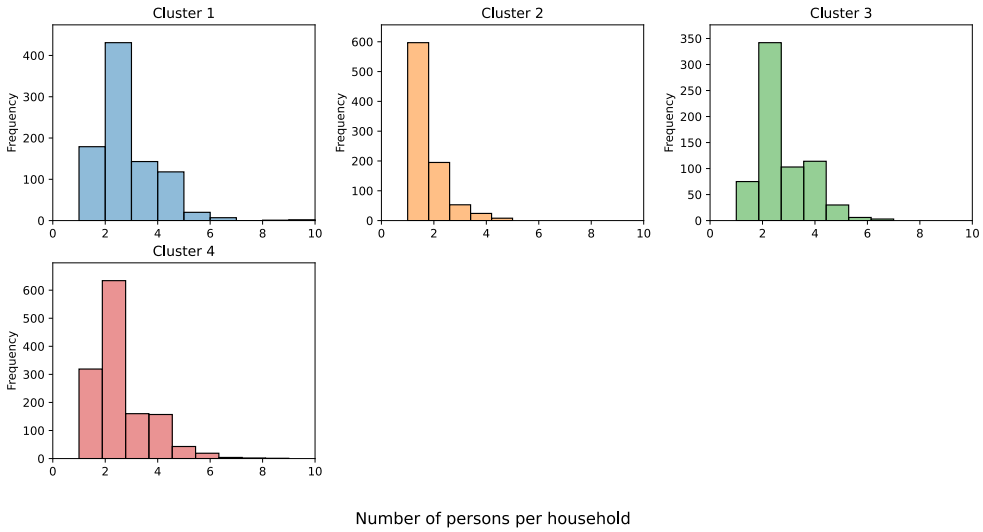

Figure 30: Barplot showing the distributions of each cluster for the variable number of persons (weighting = 1, variance cutoff = 30)

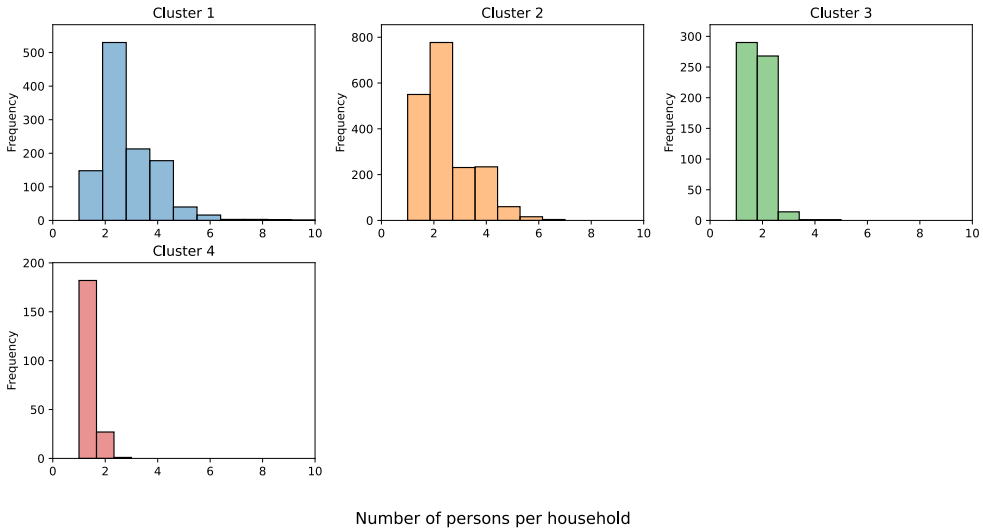

Figure 31: Barplot showing the distributions of each cluster for the variable number of persons (weighting = 30, variance cutoff = 53)

The distributions of each cluster for the variable number of persons per household have changed in different magnitudes for each cluster. The first cluster seems to have a similar distribution with both

weightings. The distribution of cluster 2 is more spread out. However, the two clusters we are more interested in due to the high floor area per person, 3 and 4, have become more defined. One reason could be the connection between the two variables as floor area per person has the variable number of persons per household included.

Age Groups

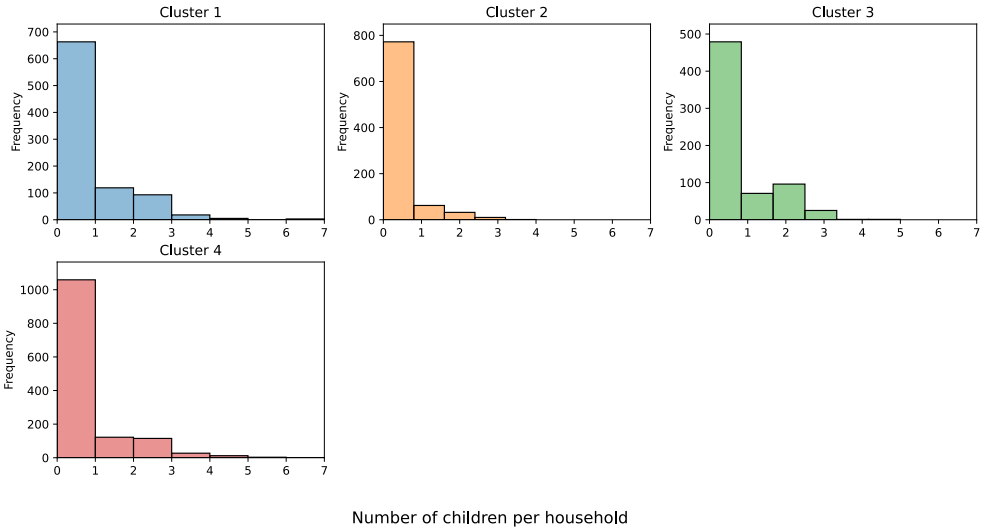

Figure 32: Barplot showing the distributions of each cluster for the variable number of children (weighting = 1, variance cutoff = 30)

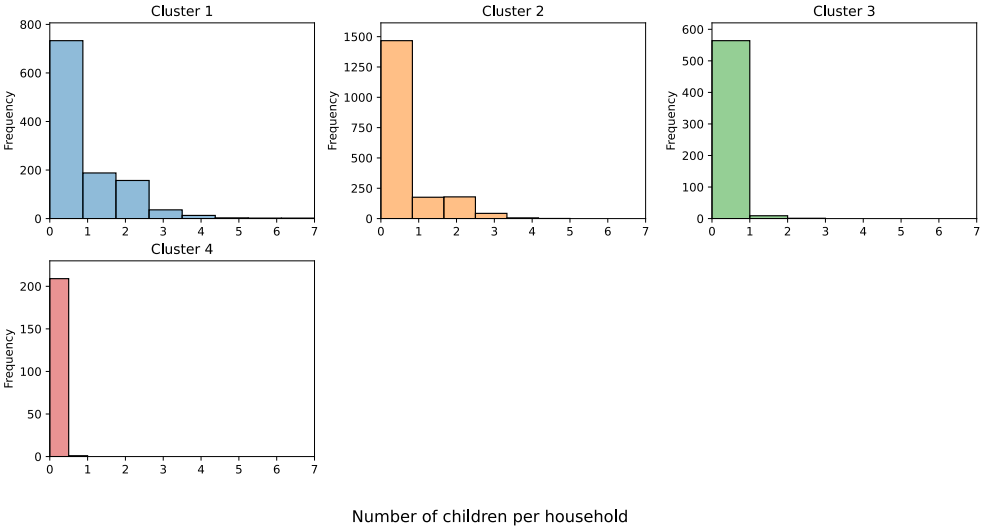

Figure 33: Barplot showing the distributions of each cluster for the variable number of children (weighting = 30, variance cutoff = 53)

The variable number of children per household has become more defined, especially for clusters 3 and 4. Thus, the weighting has improved the clustering outcome.

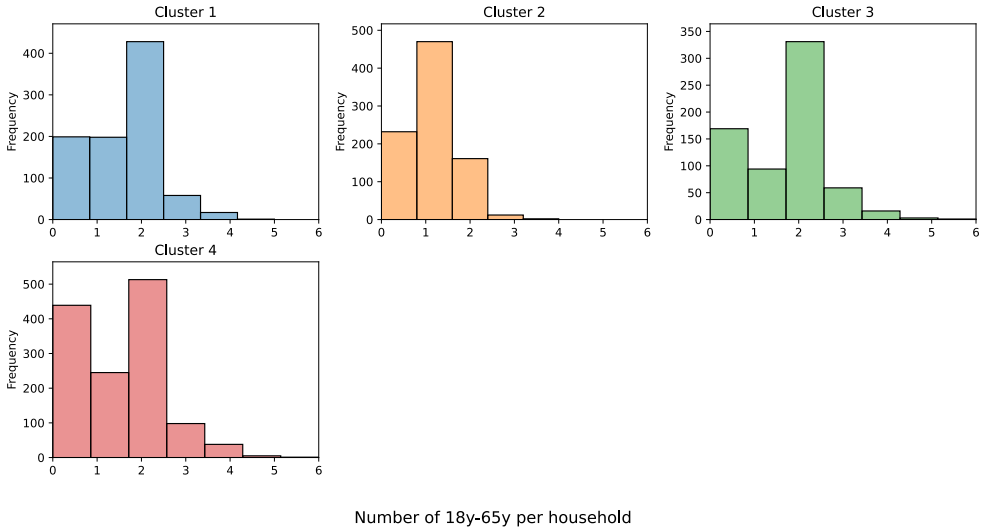

Figure 34: Barplot showing the distributions of each cluster for the variable number of adults between 18 and 65 years (weighting = 1, variance cutoff = 30)

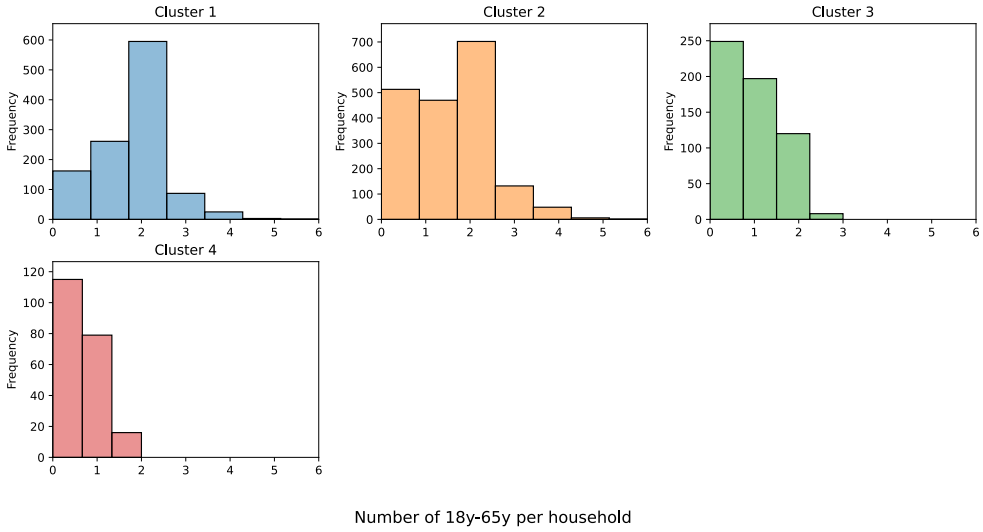

Figure 35: Barplot plot showing the distributions of each cluster for the variable number of adults between 18 and 65 years (weighting = 30, variance cutoff = 53)

The variable number of adults between 18 and 65 per household has become more defined too. Thus, the weighting has improved the clustering outcome.

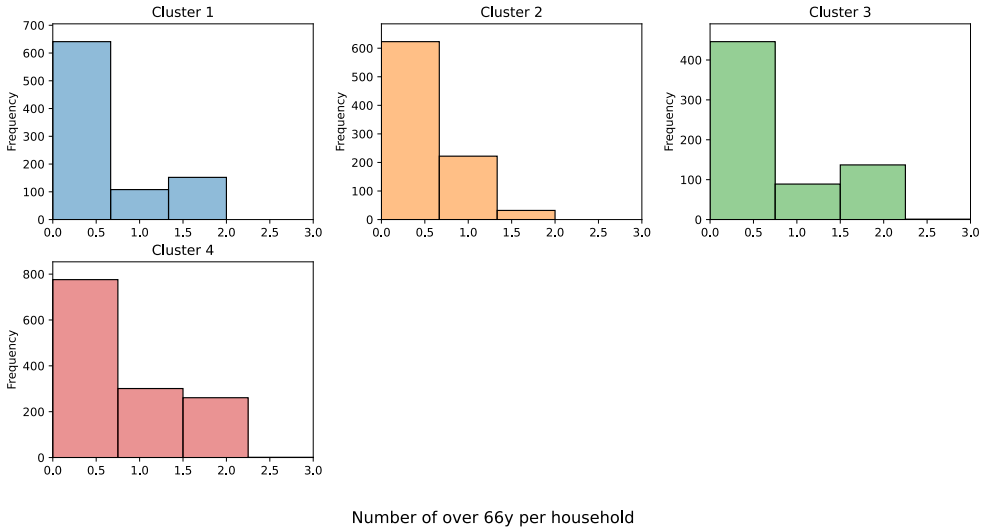

Figure 36: Barplot showing the distributions of each cluster for the variable number of adults over 66 years (weighting = 1, variance cutoff = 30)

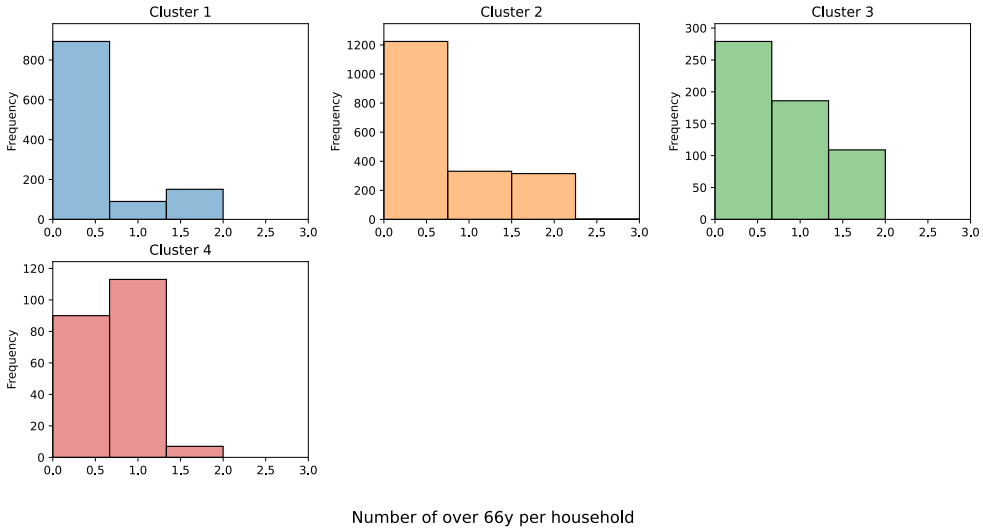

Figure 37: Barplot showing the distributions of each cluster for the variable number of adults over 66 years (weighting = 30, variance cutoff = 53)

The variable number of adults over (and including) 66-year-olds per household has not changed only a little. Here the different weightings seem to have similar clustering outcomes.

Relationship Status

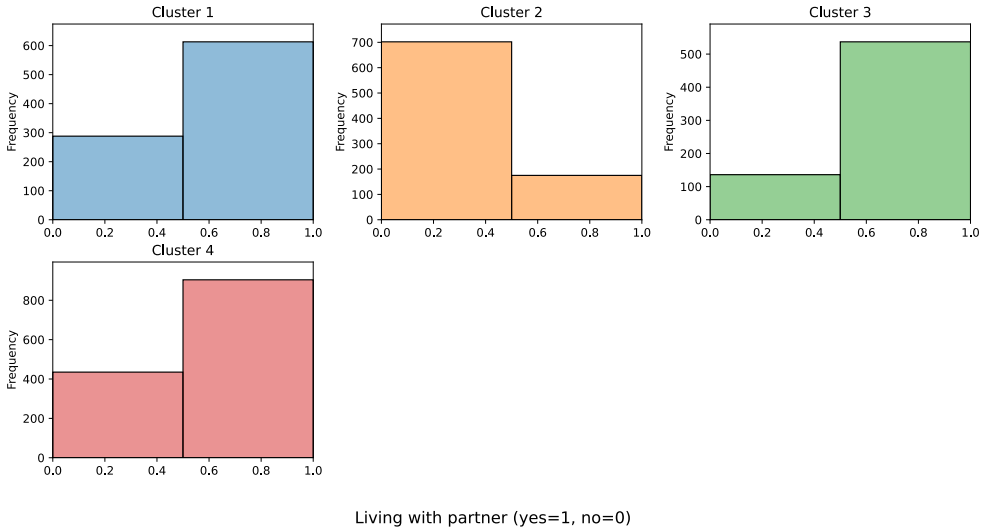

Figure 38: Barplot showing the distributions of each cluster for the variable relationship status (weighting = 1, variance cutoff = 30)

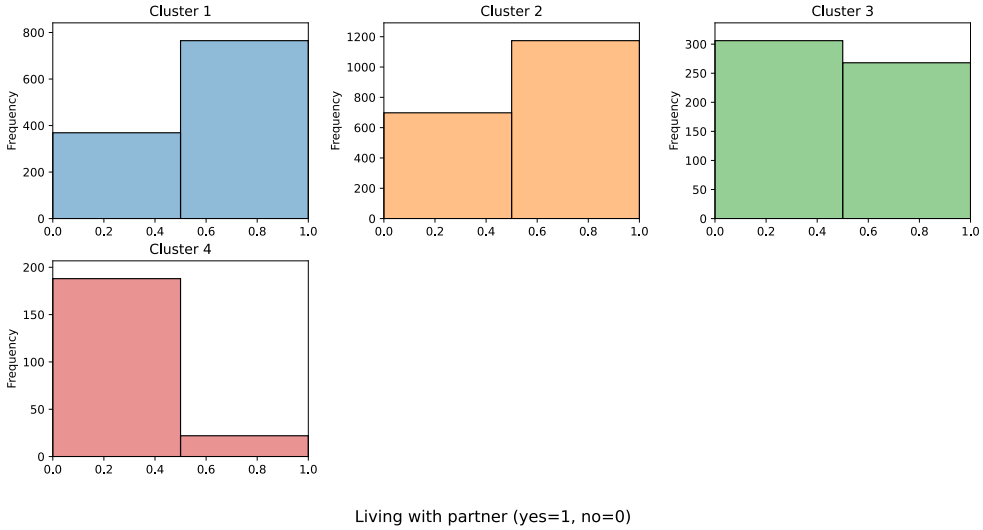

Figure 39: KDE plot showing the distributions of each cluster for the variable relationship status (weighting = 30, variance cutoff = 53)

For the variable relationship status, the weighting seems to have a great effect. For clusters 2, 3 and 4 the average relationship status even is the opposite comparing the weighting of 1 and 30. However, there

the difference in the distribution between cluster 1 and cluster 4 seems to be more distinct after applying the weighting, hence, improving the cluster outcome for the purpose of this study.

City Type

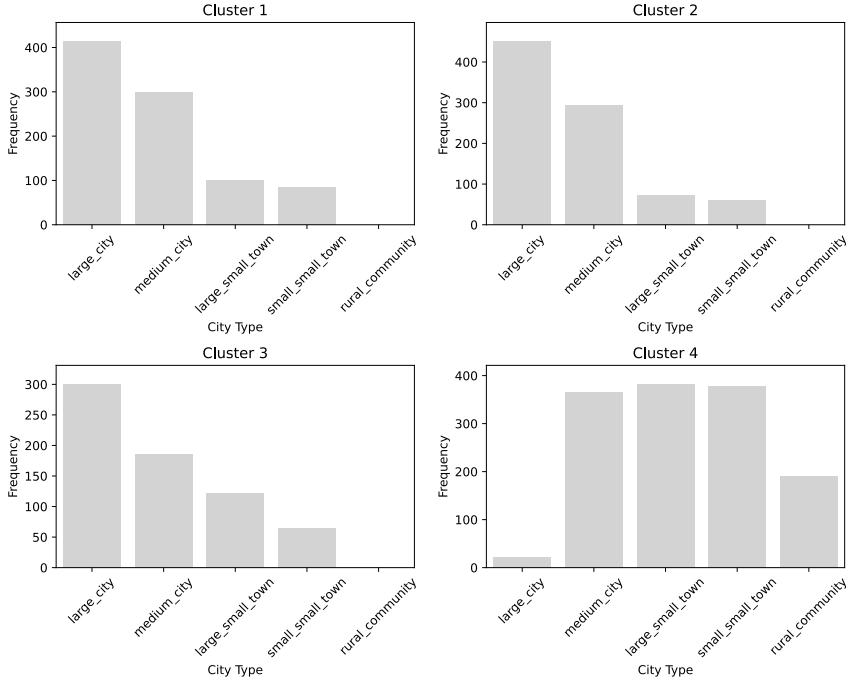

Figure 40: Histogram showing the distributions of each cluster for the variable city type (weighting = 1, variance cutoff = 30)

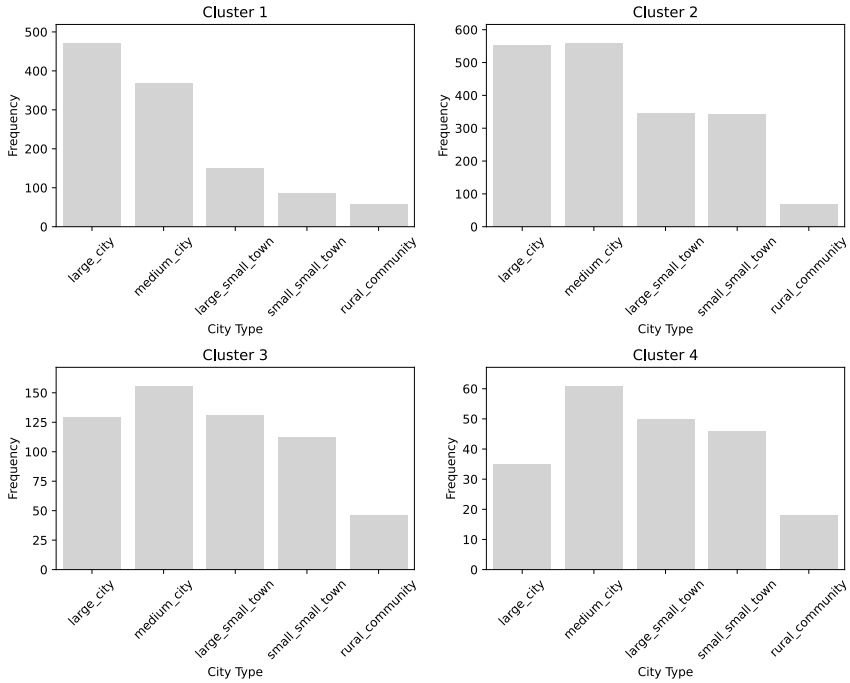

Figure 41: Histogram showing the distributions of each cluster for the variable city type (weighting = 30, variance cutoff = 53)

The distributions for each cluster for the type of city the households reside in have only changed marginally. It seems like the distribution of cluster 4 got a bit spread out and reduced the strength of the cluster outcome.

West-East

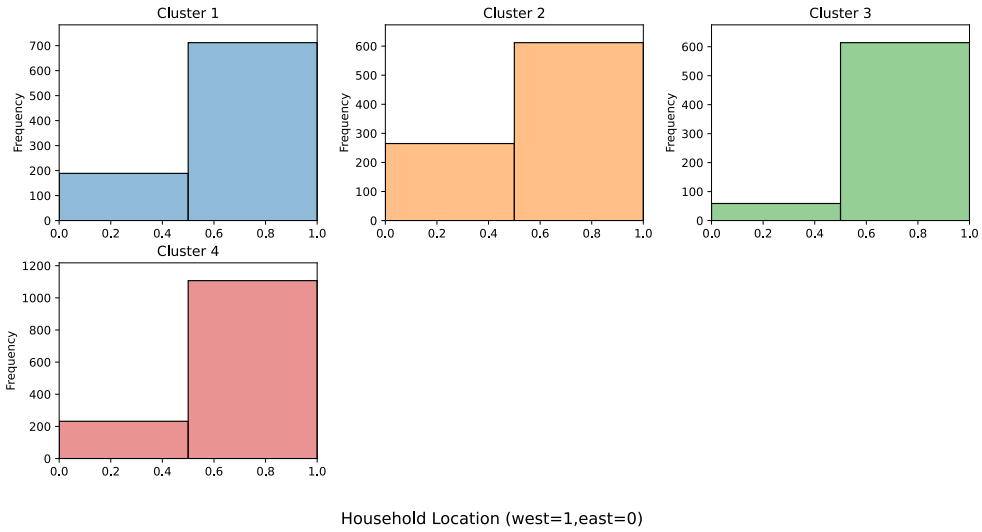

Figure 42: Barplot showing the distributions of each cluster for the variable west-east (weighting = 1, variance cutoff = 30)

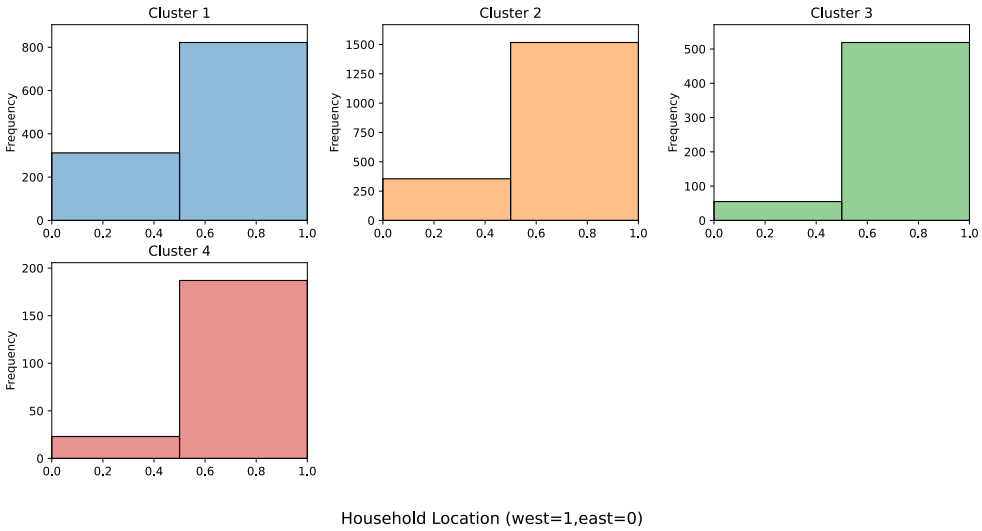

Figure 43: Barplot showing the distributions of each cluster for the variable west-east (weighting = 30, variance cutoff = 53)

The distribution for each cluster for the variable west-east has only changed marginally and increased the difference between the distributions of the different clusters.

Housing Type

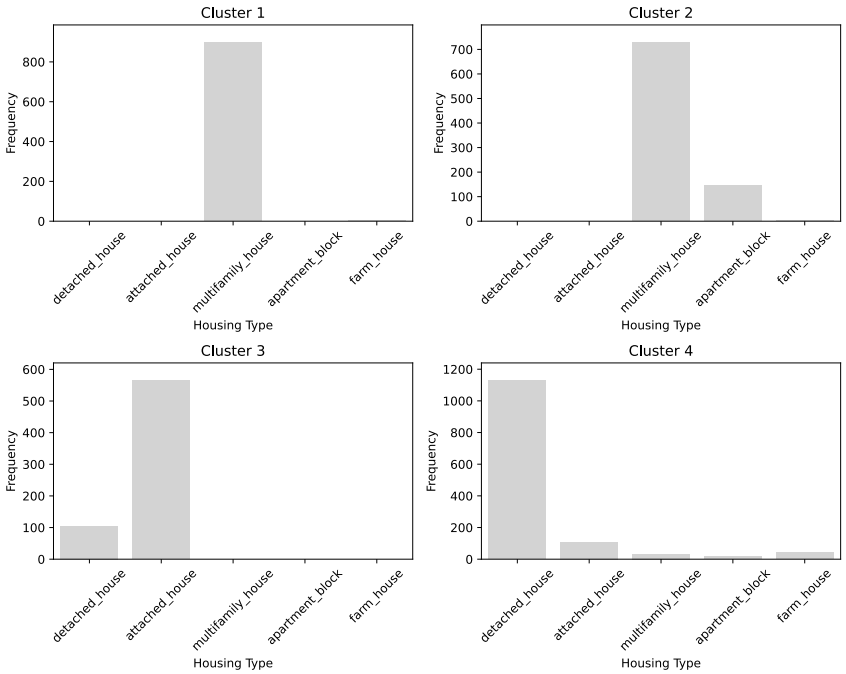

Figure 44: Histogram showing the distributions of each cluster for the variable housing type (weighting = 1, variance cutoff = 30)

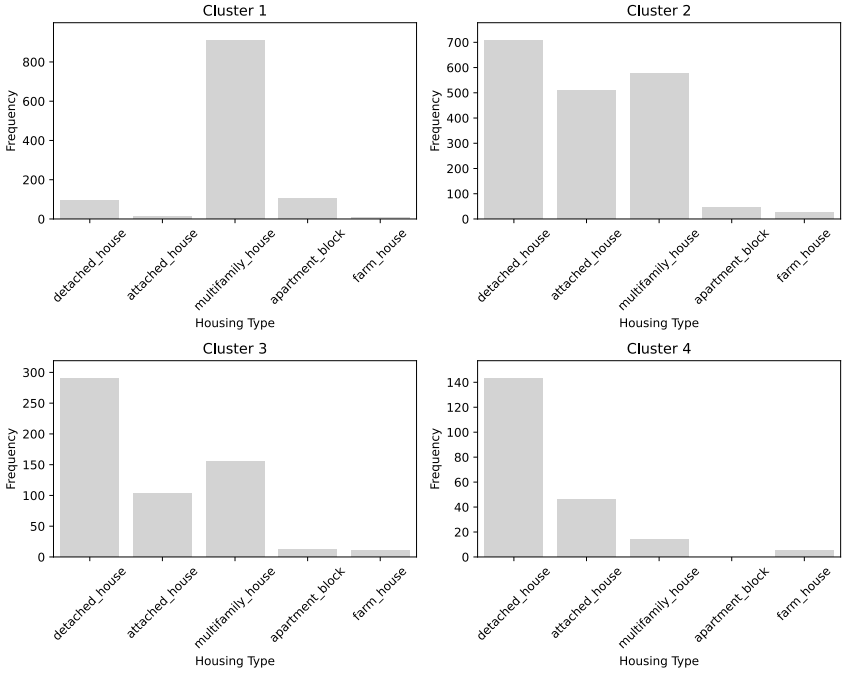

Figure 45: Histogram showing the distributions of each cluster for the variable housing type (weighting = 30, variance cutoff = 53)

The distribution for each cluster for the housing types has changed most drastically for clusters 2 and 3.

Here households from more different housing types have been grouped in the cluster with the new weighting. However, the distribution for clusters 1 and 4 has stayed almost the same.

Income Class

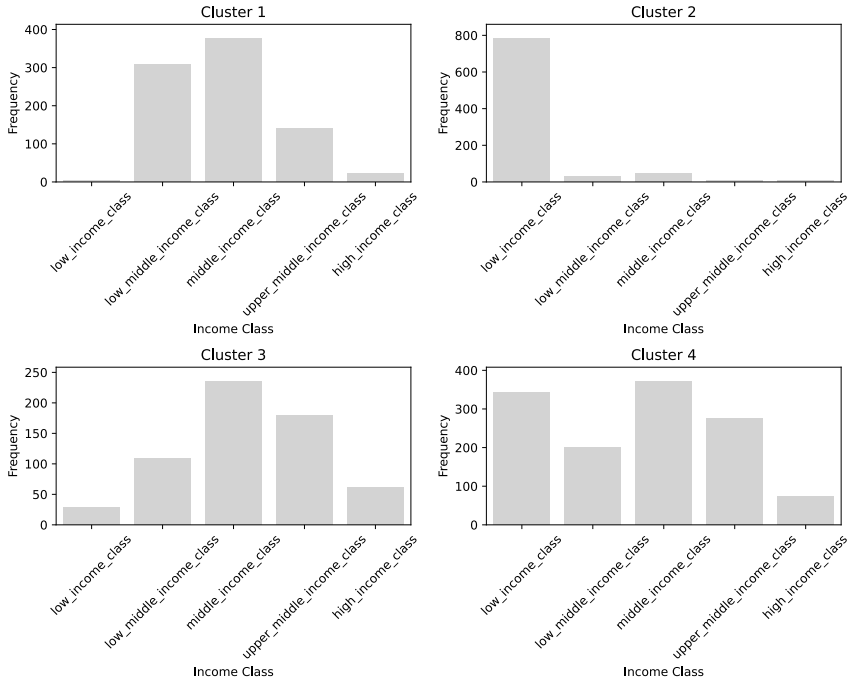

Figure 46: Histogram showing the distributions of each cluster for the variable income class (weighting = 1, variance cutoff = 30)

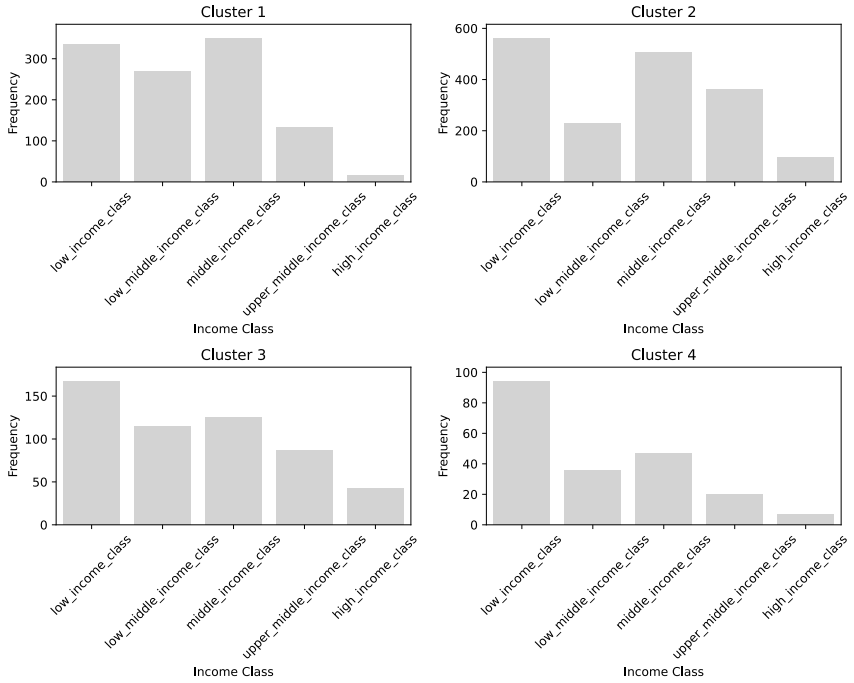

Figure 47: Histogram showing the distributions of each cluster for the variable income class (weighting = 30, variance cutoff = 53)

The distribution for each cluster for the income classes has become less distinct and more overlapping. All clusters seem to have households included with all types of income classes. However, this variable might also not be representative for the purpose of the study as it only accounts for current income underestimating the income accumulation from retired persons who have a very different lifestyle than someone with the same pension who had no chance of saving or investing their earnings. In general, no wealth related variable was available in the dataset besides the following variable of ownership int he furthest sense.

Ownership

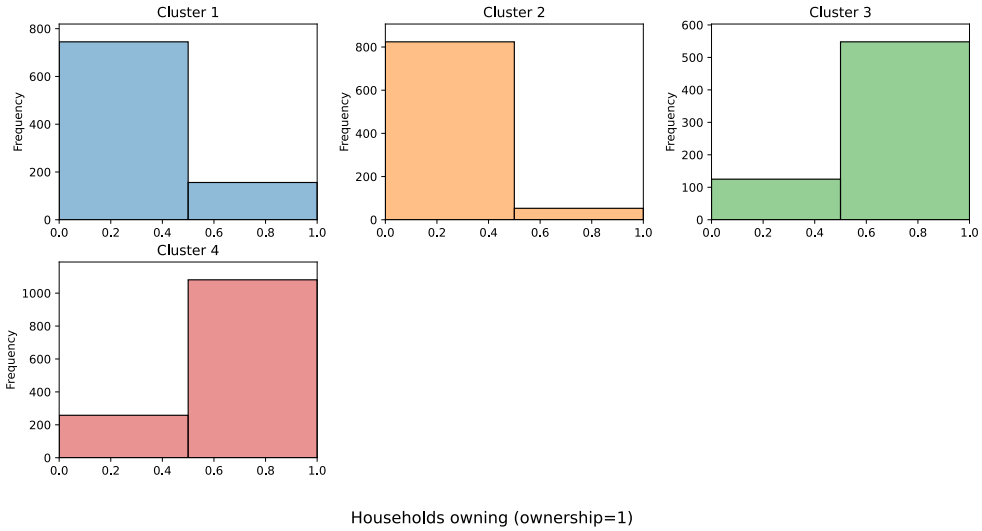

Figure 48: Barplot showing the distributions of each cluster for the variable ownership (weighting = 1, variance cutoff = 30)

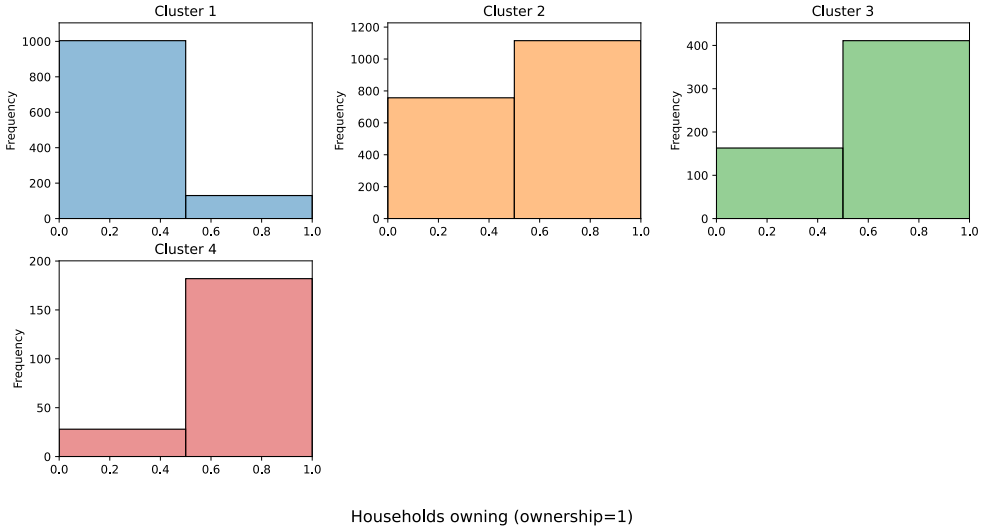

Figure 49: Barplot showing the distributions of each cluster for the variable ownership (weighting = 30, variance cutoff = 53)

For the variable ownership, the distribution for each cluster has become more distinct. Interesting to note is the switch in cluster 2 which with the weighting of 1 grouped people that did not own their home.

However, with a weighting of 30, the majority seemed to own their homes. In general, it seems like the weighting improved here again the between cluster variance.

As portrayed in the figures 28 until 49, it is visible that although one might expect that the variance for the other variables decreases when giving a weight of 30 to the variable floor area per person, the distribution for each cluster seems to be still distinct in the between-cluster comparison. To conclude, a weighting of 30 seems appropriate and might enhance the clustering outcomes.

A.6 Choosing a Within-cluster Variance Cutoff Value

Table 8: Last 10 clustering steps of agglomerative hierarchical clustering, using the ward distance metrics, describing the numbers of clusters after the merging step, the maximum within-variance of the clusters and the difference in the variance to the clustering in the step before (weighting=30)

Number of clusters	Within variance	Difference
10	22.33	0.06
9	24.50	2.17
8	28.99	4.49
7	29.80	0.81
6	40.98	11.18
5	47.40	6.42
4	52.08	4.68
3	72.72	20.64
2	83.89	11.17
1	175.64	91.75

Table 9: Mean values for all variables for each cluster (weighting = 30, variance cutoff = 23)

cluster	1	2	3	4	5	6	7	8	9	10
floor area in m^2	65.03	72.44	64.35	123.81	112.34	121.51	152.22	116.76	146.39	225.83
number persons	2.52	2.62	1.23	2.07	3.33	2.92	1.55	1.52	1.14	1.10
area per person in m^2	27.58	30.13	53.46	59.98	35.92	42.97	98.28	77.42	128.02	204.17
children	0.59	0.63	0.04	0.07	1.03	0.64	0.01	0.03	0.01	0.00
18y 65y	1.57	1.64	0.76	1.21	2.00	1.77	0.72	0.84	0.54	0.43
over 66y	0.35	0.34	0.43	0.79	0.30	0.51	0.82	0.65	0.59	0.67
with partner	0.67	0.68	0.16	0.88	0.87	0.84	0.50	0.45	0.11	0.07
west	0.81	0.67	0.72	0.89	0.90	0.80	0.92	0.90	0.89	0.90
large city	0.94	0.12	0.51	0.14	0.40	0.11	0.20	0.24	0.17	0.17
medium city	0.04	0.49	0.36	0.26	0.31	0.25	0.22	0.30	0.28	0.37
large small town	0.01	0.20	0.02	0.29	0.20	0.29	0.30	0.19	0.24	0.23
small small town	0.01	0.11	0.09	0.27	0.09	0.28	0.24	0.18	0.23	0.13
rural community	0.00	0.08	0.01	0.05	0.01	0.08	0.04	0.10	0.08	0.10
detached house	0.00	0.13	0.00	0.60	0.00	0.88	0.66	0.43	0.65	0.87
attached house	0.00	0.02	0.03	0.38	0.99	0.05	0.23	0.16	0.24	0.07
multifamily house	1.00	0.69	0.90	0.00	0.00	0.02	0.04	0.38	0.07	0.03
apartment block	0.00	0.14	0.07	0.00	0.00	0.01	0.03	0.02	0.00	0.00
farm house	0.00	0.01	0.00	0.00	0.01	0.04	0.03	0.01	0.02	0.03
low income class	0.29	0.30	0.68	0.11	0.07	0.12	0.23	0.32	0.48	0.27
low middle income class	0.26	0.22	0.12	0.11	0.09	0.16	0.17	0.21	0.17	0.20
middle income class	0.26	0.33	0.11	0.39	0.31	0.34	0.28	0.19	0.23	0.20
upper middle income class	0.16	0.09	0.04	0.30	0.33	0.21	0.17	0.15	0.08	0.17
high income class	0.00	0.02	0.01	0.04	0.10	0.08	0.10	0.06	0.02	0.10
ownership	0.07	0.14	0.12	0.91	0.73	0.83	0.91	0.63	0.87	0.87

Table 10: Median values for all variables for each cluster (weighting = 30, variance cutoff = 23)

cluster	1	2	3	4	5	6	7	8	9	10
floor area in m^2	66.00	70.00	59.00	120.00	110.00	115.00	176.00	90.00	130.00	198.00
number persons	2.00	2.00	1.00	2.00	3.00	3.00	2.00	1.00	1.00	1.00
area per person in m^2	27.00	30.00	53.00	60.00	35.00	43.00	100.00	77.00	123.00	198.00
children	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
18y 65y	2.00	2.00	1.00	2.00	2.00	2.00	0.00	1.00	0.00	0.00
over 66y	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00
with partner	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
west	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
large city	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
medium city	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
large small town	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
small small town	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rural community	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detached house	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00
attached house	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
multifamily house	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
apartment block	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
farm house	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
low income class	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
low middle income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
middle income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
upper middle income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
high income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ownership	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 11: Mean values for all variables for each cluster (weighting = 30, variance cutoff = 30)

cluster	1	2	3	4	5	6	7
floor area in m^2	69.75	64.35	123.81	118.13	127.94	146.39	225.83
number persons	2.58	1.23	2.07	3.07	1.53	1.14	1.10
area per person in m^2	29.20	53.46	59.98	40.38	84.00	128.02	204.17
children	0.62	0.04	0.07	0.79	0.02	0.01	0.00
18y 65y	1.62	0.76	1.21	1.85	0.80	0.54	0.43
over 66y	0.35	0.43	0.79	0.43	0.70	0.59	0.67
with partner	0.67	0.16	0.88	0.85	0.47	0.11	0.07
west	0.72	0.72	0.89	0.83	0.90	0.89	0.90
large city	0.42	0.51	0.14	0.21	0.22	0.17	0.17
medium city	0.33	0.36	0.26	0.27	0.27	0.28	0.37
large small town	0.13	0.02	0.29	0.25	0.23	0.24	0.23
small small town	0.08	0.09	0.27	0.21	0.20	0.23	0.13
rural community	0.05	0.01	0.05	0.05	0.08	0.08	0.10
detached house	0.08	0.00	0.60	0.55	0.51	0.65	0.87
attached house	0.01	0.03	0.38	0.39	0.18	0.24	0.07
multifamily house	0.80	0.90	0.00	0.01	0.27	0.07	0.03
apartment block	0.09	0.07	0.00	0.01	0.02	0.00	0.00
farm house	0.01	0.00	0.00	0.03	0.02	0.02	0.03
low income class	0.30	0.68	0.11	0.10	0.29	0.48	0.27
low middle income class	0.24	0.12	0.11	0.13	0.20	0.17	0.20
middle income class	0.31	0.11	0.39	0.33	0.22	0.23	0.20
upper middle income class	0.12	0.04	0.30	0.25	0.15	0.08	0.17
high income class	0.01	0.01	0.04	0.09	0.07	0.02	0.10
ownership	0.11	0.12	0.91	0.79	0.72	0.87	0.87

Table 12: Median values for all variables for each cluster (weighting = 30, variance cutoff = 30)

cluster	1	2	3	4	5	6	7
floor area in m^2	70.00	59.00	120.00	115.00	112.50	130.00	198.00
number persons	2.00	1.00	2.00	3.00	1.00	1.00	1.00
area per person in m^2	29.00	53.00	60.00	40.00	80.00	123.00	198.00
children	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18y 65y	2.00	1.00	2.00	2.00	1.00	0.00	0.00
over 66y	0.00	0.00	0.00	0.00	1.00	1.00	1.00
with partner	1.00	0.00	1.00	1.00	0.00	0.00	0.00
west	1.00	1.00	1.00	1.00	1.00	1.00	1.00
large city	0.00	1.00	0.00	0.00	0.00	0.00	0.00
medium city	0.00	0.00	0.00	0.00	0.00	0.00	0.00
large small town	0.00	0.00	0.00	0.00	0.00	0.00	0.00
small small town	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rural community	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detached house	0.00	0.00	1.00	1.00	1.00	1.00	1.00
attached house	0.00	0.00	0.00	0.00	0.00	0.00	0.00
multifamily house	1.00	1.00	0.00	0.00	0.00	0.00	0.00
apartment block	0.00	0.00	0.00	0.00	0.00	0.00	0.00
farm house	0.00	0.00	0.00	0.00	0.00	0.00	0.00
low income class	0.00	1.00	0.00	0.00	0.00	0.00	0.00
low middle income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00
middle income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00
upper middle income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00
high income class	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ownership	0.00	0.00	1.00	1.00	1.00	1.00	1.00

Table 13: Mean values for all variables for each cluster (weighting = 30, variance cutoff = 53)

cluster	1	2	3	4
floor area in m^2	69.75	101.38	127.94	157.74
number persons	2.58	2.22	1.53	1.14
area per person in m^2	29.20	49.32	84.00	138.90
children	0.62	0.37	0.02	0.00
18y 65y	1.62	1.33	0.80	0.53
over 66y	0.35	0.52	0.70	0.60
with partner	0.67	0.63	0.47	0.10
west	0.72	0.81	0.90	0.89
large city	0.42	0.30	0.22	0.17
medium city	0.33	0.30	0.27	0.29
large small town	0.13	0.19	0.23	0.24
small small town	0.08	0.18	0.20	0.22
rural community	0.05	0.04	0.08	0.09
detached house	0.08	0.38	0.51	0.68
attached house	0.01	0.27	0.18	0.22
multifamily house	0.80	0.31	0.27	0.07
apartment block	0.09	0.02	0.02	0.00
farm house	0.01	0.01	0.02	0.02
low income class	0.30	0.30	0.29	0.45
low middle income class	0.24	0.12	0.20	0.17
middle income class	0.31	0.27	0.22	0.22
upper middle income class	0.12	0.19	0.15	0.10
high income class	0.01	0.05	0.07	0.03
ownership	0.11	0.60	0.72	0.87

Table 14: Median values for all variables for each cluster (weighting = 30, variance cutoff = 53)

cluster	1	2	3	4
floor area in m^2	70.00	100.00	112.50	132.00
number persons	2.00	2.00	1.00	1.00
area per person in m^2	29.00	50.00	80.00	130.00
children	0.00	0.00	0.00	0.00
18y 65y	2.00	1.00	1.00	0.00
over 66y	0.00	0.00	1.00	1.00
with partner	1.00	1.00	0.00	0.00
west	1.00	1.00	1.00	1.00
large city	0.00	0.00	0.00	0.00
medium city	0.00	0.00	0.00	0.00
large small town	0.00	0.00	0.00	0.00
small small town	0.00	0.00	0.00	0.00
rural community	0.00	0.00	0.00	0.00
detached house	0.00	0.00	1.00	1.00
attached house	0.00	0.00	0.00	0.00
multifamily house	1.00	0.00	0.00	0.00
apartment block	0.00	0.00	0.00	0.00
farm house	0.00	0.00	0.00	0.00
low income class	0.00	0.00	0.00	0.00
low middle income class	0.00	0.00	0.00	0.00
middle income class	0.00	0.00	0.00	0.00
upper middle income class	0.00	0.00	0.00	0.00
high income class	0.00	0.00	0.00	0.00
ownership	0.00	1.00	1.00	1.00

Table 15: Mean values for all variables for each cluster (weighting = 30, variance cutoff = 84)

cluster	1	2
floor area in m^2	89.45	135.92
number persons	2.36	1.42
area per person in m^2	41.73	98.71
children	0.46	0.02
18y 65y	1.44	0.73
over 66y	0.45	0.68
with partner	0.65	0.37
west	0.78	0.90
large city	0.34	0.21
medium city	0.31	0.28
large small town	0.17	0.23
small small town	0.14	0.20
rural community	0.04	0.08
detached house	0.27	0.55
attached house	0.17	0.19
multifamily house	0.49	0.22
apartment block	0.05	0.02
farm house	0.01	0.02
low income class	0.30	0.33
low middle income class	0.17	0.19
middle income class	0.28	0.22
upper middle income class	0.16	0.14
high income class	0.04	0.06
ownership	0.41	0.76

Table 16: Median values for all variables for each cluster (weighting = 30, variance cutoff = 84)

cluster	1	2
floor area in m^2	80.00	130.00
number persons	2.00	1.00
area per person in m^2	40.00	90.00
children	0.00	0.00
18y 65y	2.00	1.00
over 66y	0.00	1.00
with partner	1.00	0.00
west	1.00	1.00
large city	0.00	0.00
medium city	0.00	0.00
large small town	0.00	0.00
small small town	0.00	0.00
rural community	0.00	0.00
detached house	0.00	1.00
attached house	0.00	0.00
multifamily house	0.00	0.00
apartment block	0.00	0.00
farm house	0.00	0.00
low income class	0.00	0.00
low middle income class	0.00	0.00
middle income class	0.00	0.00
upper middle income class	0.00	0.00
high income class	0.00	0.00
ownership	0.00	1.00

A.7 Count of Observations for Each Cluster

In table 50, the counts of households falling into each cluster are portayed.

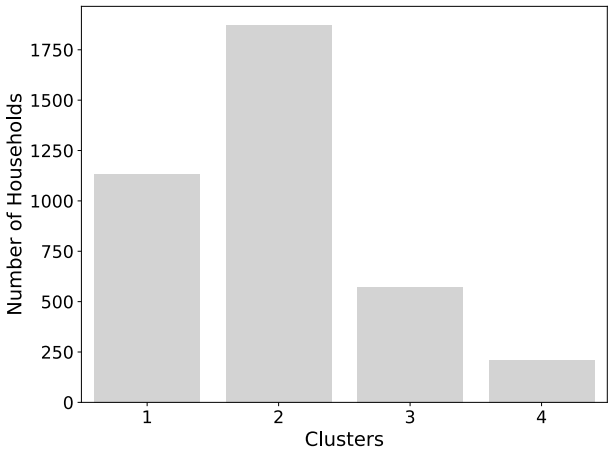

Figure 50: Counts of households in each cluster

A.8 Reflection on Critical Data Science

Table 17: Critical Data Science table after Laura van Geene (2023) for the agglomerative clustering analysis of the "Lebensräume" population survey (Böltken et al., 2014)

Data Science Process	**Inclusion** Who is (not) included in the data?	**Inequality** What role does inequality play in data science methods?	**Participation** Who is (not) involved in the data science process?	**Power** How does the data reflect existing power dynamics?	**Positionality** What is your own positionality with the research?
Focus of Analysis Theories, processes & stakeholders that drive the analysis	The population survey provided by the BBSR is driven by the interests of the federal institute, thus, individuals outside the state's vision are not captured in the dataset.	Individuals with very high wealth might be reluctant to give more information than necessary about their living situation to the state, decreasing their visibility in the dataset. The question about income grouped income above 5000€ in one category, thus, the super-rich cannot be identified in the study.	The design of the study was performed by the BBSR, thus, questions about the satisfaction of living and the choice of variables might be heavily biased by Western norms and state focus. The inclusion of knowledge of Global South Scholars or Indigenous communities could have shed a different light on the living situation. For example, the neglect of community influence on the living situation might have been captured.	The state collects information from the individual and is seen as true knowledge, whereas other knowledge systems that would not be captured in a population survey are neglected.	Born and raised in Germany, I have been exposed to the democratic structures and the power of the state my whole life and might be biased towards the observed "objectivity" of the survey.

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Table 17 – continued from previous page

Data Science Process	Inclusion	Inequality	Participation	Power	Positionality
Collect & Combine Data Contexts and power relations that lie beneath data collection & creation of data sets	People without a registered address are not captured in the dataset, thus, inequalities are underestimated as some people live in even less space. Furthermore, respondents needed phone access and information on all the questions asked.	Only people who were available at home when being called or surveyed at the door are included in the dataset. People who have a low income and need to work most of the day, might not be represented in the study.	The respondents could not decide on the processing of their data.	Again the state can collect data from the individual whereas the individual has no access to census lists to contact enough people.	My Global North perspective might have biased my choice of the data set as I put emphasis on the availability of socio-economic information.
Transform Data Completeness, Missing data, Consistency, Pluralism & Accuracy of collected data	I had to erase a few households that did not provide information for certain questions. This might exclude people who didn't have access to all this information like the household's income.	The data set is rather small and might therefore not represent extremely wealthy or extremely poor households very well.	No other definitions of living space were included in the survey and I also did not compare the dataset to other sources looking at different dimensions.	I had no possibility to contact the household with missing data similarly I could not ask the respondents for their approval to use their data for my cause.	The variables I selected might have been biased by my Western understanding of important factors influencing the living situation. Other factors could have been of importance, too.
Analyse Data Representation of all, what is dominant, what is uncertain	The households with missing data are not included in the clustering. Additionally, extremely wealthy individuals cannot be differentiated as explained before, hence, they cannot be represented in a cluster.	By clustering the data, the data is summarised for 4 groups and therewith, the unequal distribution between the two extremes becomes less visible.	I did not include anyone in my analysis process and thus there might be a bias in the method I chose for the investigation.	The analysis puts Western households living in too much space in focus and thus, might not recognise the struggle of the underprivileged.	I am analysing the data with the background of my Westen knowledge I have gained from mostly Western scholars, and therefore, might not have included relevant analyses from other parts of the world.

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Table 17 – continued from previous page

Data Science Process	Inclusion	Inequality	Participation	Power	Positionality
Interpret & Visualise Data Consideration of all the above to formulate answers to the research question	None of the affected household target groups was involved in the interpretation process and thus important factors shaping their individual trajectory might be missing.	The interpretations were limited to the development of the housing sector. However, in our complex society, many factors influence inequalities that materialised and thus, not all drivers for the unequal distribution of floor area per person might be captured.	Again I was the only party included in the interpretation process. However, I discussed with my peers the optimal visualisation to understand what other people might need to understand the results.	Having gained an interest in justice, I applied this lens to the interpretation of my results and thus, the outcome is focused on the inequalities that have emerged.	My interpretations are again influenced by my knowledge system and upbringing. The focus on capitalism critique is grounded in my Western experience. Individuals from other backgrounds might have included a stronger decolonial perspective.
Communicate Findings Transparency and accessibility of the results	The results are only available to individuals with internet access and being able to read. I have presented my findings already in a public online debate about sufficiency in the housing sector, however, the event was in German and thus, only useful to German-speaking individuals.	Future research on the quantification of the impacts and the uptake from policymakers could increase the impact of this study. The combination of historic drivers and current characteristics could allow more people to understand the necessity of a societal transformation as single measures seem to be not enough.	I think the visualisations of my research are understandable and can be agreed upon. They are in line with past research on sufficiency.	This study challenges the current focus of sustainability measures on efficiency and criticises the narrow fairness definition that ignores the risks of green colonialism.	This research aims to challenge current dominant power structures and the focus on profits over justice. However, this study adds to the numerous literature that investigate the lifestyles of the Global North and lacks a Global South perspective.

B Policy Analysis

Table 18: Events in the German Housing Market, 1945-2022. Table of all policies analysed from 1945 until 2024. Housing states are added when found in the literature to enrich the timeline. In the description, a longer explanation of the policy can be found. When applicable, the characteristics of the clustering results that are driven by the policy are mentioned in the column "Characteristics influenced".

Time	Name	Type	Description	Characteristics influenced	Source
1950	Shortage in Housing	Housing state	Due to war destruction, Germany had a drastic shortage in housing. In 1950, more than 4.5 million houses were missing to cover the demand. The average per-person floor area per capita was only 15m^2.		Voigtländer (2009); Richter (2023)
1950	First Housing Act "Erste Wohnungsbaugesetz"	Policy	The first housing act was aimed at solving the housing crisis and offering affordable practical homes to the German citizens. To provide sufficient housing for the broader population, especially social housing projects were favoured. Income limits and small living areas defined the constructed dwellings of this time.		Staub (2017); Hinz-Wessels et al. (2013)
1951	Economic Cooperation Administration (ECA) programme	Policy	Under the Marshall Plan, the US government issued two programmes to support the construction of housing in Germany. The Economic Cooperation Administration (ECA) programme was the first in 1951. 3,300 homes were financed. This rather symbolic support had a greater influence on the German ideals of living than actually providing for a large share of housing. In contrast to the goals of the housing act, this programme was aimed at building single-family houses.	Ownership, Single-family houses, older age	Staub (2017)

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Time	Name	Type	Description	Characteristics influenced	Source
1952	Housing Construction Premium Act	Policy	The Housing Construction Premium Act was aimed at supporting citizens to save to build and buy their own homes to live a "bourgeois" life. As this subsidy could only be used one or a maximum of two times, people waited with the acquisition until they found the perfect fit. Thus, households were encouraged to only live in one dwelling over the rest of their lifetime.	Ownership, Single-family houses, older age	Petsch (1983); Richter (2023)
1953	Amendment to the Housing Construction Act	Policy	The Christian Democratic Union of Germany (CDU) called for a greater focus on owner-occupied housing. Thus, the Amendment to the Housing Construction Act put an even greater emphasis on the support of construction buying. The consequence was a 10 percent higher financial support on owner-occupied buildings compared with similar objects rented out.	Ownership, Single-family houses, older age	Petsch (1983)
1953	Mutual Security Agency (MSA) programme	Policy	The second housing programme initiated by the USA in 1953 was covered under the Mutual Security Agency (MSA) programme. It provided 4500 single-family houses to miners and other important industrial sectors. The influence was not merely set on economic upturn but also on affecting the housing ideal of Germans and establishing the ownership of single-family houses instead of the provision of practical and sufficient social housing.	Ownership, Single-family houses, older age	Staub (2017)

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Time	Name	Type	Description	Characteristics influenced	Source
1955	Commuter allowance	Policy	The commuter allowance is a policy instrument that was already established pre-war in Germany. In 1955 it was renewed and has since then often been updated, increasing the value subtractable from the income tax. It is regardless of the mode of transport chosen and does not require a proof of necessity. This supported the construction and acquisitions of houses outside the city in cheaper suburban neighbourhoods.	Single-family houses, outside of large cities	Richter (2023); Bach et al. (2007); Bundesregierung (2023)
1956	Second Housing Act "Zweite Wohnungsbaugesetz"	Policy	The second housing act put again focus on the support of owner-occupied houses. Building societies, banks and insurance companies started to offer lucrative financing models for house acquisitions. The housing economy and rent control stayed in place until the 1960s.	Ownership, Single-family houses, older age	Hinz-Wessels et al. (2013)
1957	Law on community housing "Wohnungsgemeinnützigkeitsrechts"	Policy	Policy focusing on the support of community housing with criteria limiting the freedom of the building development. It existed already pre-war, however, was adapted in 1957. Criteria for the community housing projects were the following: There was no profit maximization, with profits being limited and distribution restricted. Business activities were confined to constructing small flats of up to approximately 120 m^2. Funds and assets were legally earmarked and restricted. Any surplus generated had to be reinvested in new construction, ensuring an obligation to build. Additionally, there were no ties to the profit-oriented construction industry. This regulation remained unchanged in the new version of the law in 1969.		Bundesministerium der Justiz (1969); Bundesministerium der Justiz (1969);Bundesministerium der Justiz; Bündnis 90/Die Grünen (2015)

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Time	Name	Type	Description	Characteristics influenced	Source
1959	Stock of detached and semi-detached houses	Housing state	By the late 1950s, nearly 60 percent of all apartments were constructed in either detached or semi-detached houses.	Single-family houses, high floor area	Petsch (1983)
1960	Housing stock	Housing state	By 1960, over 5 million homes had been constructed with the aid of state subsidies, with approximately 60 percent of these being state-subsidized social housing.		Hinz-Wessels et al. (2013)
1961	Liberation of 'White Districts'	Policy	Paul Lücke, then Minister of Housing, deregulated the housing markets in "white districts", areas where the housing shortage was below 3 percent. His goal was to liberalize the housing market. First, only in 52 districts the policy applied, by the end of the 1960s almost all regions in Germany felt subject to the initiative.	Less social housing (not focused on reduced size, social needs)	Voigtländer (2009)
1965	Housing benefit "Wohngeld"		The housing benefit is designed to support low-income households in paying their rent. In 2019 the housing benefit was totalling to 153 euros per month per person. In case the tenant has almost no income and receives the citizen money ("Bürgergeld"), the state pays heating and housing expenses completely if the size of the apartment and the rent are considered reasonable.		Haustein (2007); Richter (2023)

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Time	Name	Type	Description	Characteristics influenced	Source
1980	Social housing development	Housing state	In the 1980s, social housing constituted about 20 percent of all dwellings, but by the early 2000s, this had dropped to six percent. The number of social housing units in Germany decreased from 3.9 million in 1987 to 1.14 million in 2019. Annually, approximately 100,000 social housing units lose their status, while only around 30,000 new ones are built.	Social housing reduction, privatization, deregulation	Richter (2023)
1990	Average living space area	Housing state	In 1990, the average living space per person was about $30m^2$ in the east of Germany and $45m^2$ in the west of Germany.	West-east difference, increase in floor area per person	Richter (2023)
1990	Abolition of the law on community housing	Policy	On January 1, 1990, the CDU, CSU, and FDP abolished the public housing law, which had previously provided tax benefits to cooperative housing associations in exchange for rent control and profit distribution limits. Political decisions made since the 1980s, shifted housing policy towards private investors. The law on community housing had established next to rent controls a limit on the floor area of the apartments.	Social housing reduction, privatization, deregulation	Butterwegge (2021); Bundesministerium der Justiz (1969); Bündnis 90/Die Grünen (2015)

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Time	Name	Type	Description	Characteristics influenced	Source
1993	Old Debt Assistance Act "Altschulden-hilfe-Gesetz"	Policy	The Old Debt Assistance Act targeted the housing industry, including municipal housing companies, local authorities, housing cooperatives, and private landlords in the new federal states and East Berlin, to improve their credit and investment capacity. It also aimed to enhance conditions for individual home ownership. Approved applicants received interest relief and/or partial relief. From January 1, 1994, to June 30, 1995, the federal government and states covered the interest on housing loans. Partial relief involved assuming old liabilities from housing loans exceeding EUR 76.69/sqm as of July 1, 1995.	privatisation of eastern houses, ownership	Wissenschaftliche Dienste des Deutschen Bundestages (2013); KfW (n.d.)
1996	Homeowner's allowance "Eigen-heimzulage"	Policy	Introduced in 1996, the homeowner's allowance aimed to support individuals purchasing homes. Eligible applicants, including couples with incomes up to €70,000 (or €140,000 for couples with children, plus €30,000 per child), could receive an annual state subsidy. This subsidy amounted to 5% of construction costs for new buildings (up to €2,556 per year) or 2.5% of acquisition costs for old buildings (up to €1,278 per year), with an additional €767 per child. This support lasted for up to ten years. However, the homeowner's allowance was discontinued in 2005.	owning, single-family houses, old age	Richter (2023); Bundesministerium der Justiz (2019)
2002	target-30-ha	Target	In 2002, the German government agreed on the 30-ha target. The aim was to limit the area used for new construction and building development. The target was extended multiple times but nevertheless not reached by 2024.		Berndgen-Kaiser et al. (2018)

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Time	Name	Type	Description	Characteristics influenced	Source
2004	German Investment Act	Policy	Permission of Hedge Funds in Germany, allowing foreign investors to enter the german hosuing market.	increased floor area, less social housing, increase in rents multiplying the remanence effect	Butterwegge (2021)
2004	Housing as a Commodity	Housing State	The commodification of housing has become increasingly apparent with the acquisition of public housing companies by international financial investors since 2004. Over the past decade, federal, state, and local governments have sold several hundred thousand flats from public housing stocks to private companies. Notable examples include the sale of GAGFAH, the housing association of the former Federal Insurance Institution for Salaried Employees, to Fortress Investment Group, the sale of Berlin's GSW to Cerberus/Goldman Sachs fund companies, and the sale of Dresden's WOBA to Fortress. These sales have sparked widespread debate and had significant consequences, such as the citizens of Freiburg preventing the planned sale of the municipal housing company in a 2006 referendum.	increased floor area, less social housing, increase in rents multiplying the remanence effect	Kemper (2007)
2007	Act for the Creation of German Real Estate Stock Corporations with Publicly Listed Shares	Policy	Permission of Real Estate Investment Trusts to the German market. REITs are listed corporations that invest in real estate while being exempt from corporate taxes. These entities are required to distribute the majority of their income each year. Consequently, rather than the G-REIT itself paying corporate taxes, investors are responsible for paying taxes on the dividends they receive.	increased floor area, less social housing, increase in rents multiplying the remanence effect	Busching (2007); Butterwegge (2021)

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Table 18 – continued from previous page

Time	Name	Type	Description	Characteristics influenced	Source
2007	Second wave of international investments	Housing state	Since 2006, there has been a recorded second wave of commercialization through subsequent sales.	increased floor area, less social housing, increase in rents multiplying the remanence effect	Wissenschaftliche Dienste des Deutschen Bundestages (2013)
2008	Residential Riester "Wohnriester"	Policy	Support is provided for lower-income individuals and retirement planning through measures like allowing Riester contract holders to allocate saved capital towards purchasing residential properties. However, restrictions on moving out or selling houses mean people may stay in their homes longer than necessary. Tax deductions are available for expenses related to old-age provision contracts, but Riester-contracted capital used for housing incurs retrospective taxation at retirement. This tax is calculated based on a housing subsidy account and can be spread over 25 years or subject to one-off taxation, with only 70% of the amount taxed in the latter case.	ownership, single-family houses	BMWSB (n.d.-b)

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Table 18 – continued from previous page

Time	Name	Type	Description	Characteristics influenced	Source
2015	Rent Amendment Act "Mietnovellierungsgesetz"	Policy	Since June 1, 2015, the nationwide Rent Amendment Act (Mietnovellierungsgesetz or MietNovG) has been regulating permissible rent increases for existing flats and the assumption of estate agent costs. While previous tenant protection measures primarily addressed existing rents, the introduction of the Mietpreisbremse (rent brake) now restricts rents for new leases. However, its implementation varies across federal states, applying mainly in tight housing markets and initially for a five-year period. Generally, the Mietpreisbremse mandates that the new rent for affected flats cannot exceed the local comparative rent by more than 10%, typically suggested by the local rent index.		bpb (2015); Eurosystem Household Finance and Consumption Network (2013)
2018	Average living space area	Housing state	The living space per capita had increased to 44.2m^2 in the East and 48.5m^2 in the West.	west- east difference, increase in floor area per person	Richter (2023)

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Time	Name	Type	Description	Characteristics influenced	Source
2018	Child building benefit "Baukindergeld"	Policy	Since 2018, certain families aiming to become homeowners have had the opportunity to apply for a capital subsidy known as Child building benefit, assisting with their down-payment. Eligible families, with a taxable household income of up to €90,000 annually and €15,000 for each additional child, could receive €1200 per child annually for a maximum of 10 years, but this option was only available in 2021. However, one study revealed that this subsidy not only makes homeownership less attainable for lower-income households but also contributes to the escalation of prices for more expensive homes that are already out of reach for such households. This unintended consequence undermines the subsidy's initial intentions, potentially exacerbating the issue of rising house prices.	owning, single family houses	Richter (2023); KfW (2021b); Schmidt (2019)
2022	Federal promotion of co-operative housing	Policy	The federal government, in collaboration with KfW, introduced a funding program for acquiring cooperative shares. This program is available for both new cooperative ventures and for joining existing housing cooperatives. It operates as a loan subsidy, with the interest rate subsidized from federal funds during the initial fixed-interest period. Additionally, a significant portion of the loan debt is forgiven, amounting to a 7.5% repayment subsidy. To qualify for the subsidy, it's necessary that the acquired cooperative shares are intended for owner-occupancy of the cooperative flat and that the flat is utilized by the owner.		BMWSB (n.d.-a)

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Table 18 – continued from previous page

Time	Name	Type	Description	Characteristics influenced	Source
2024	Home ownership for families "Wohneigentum für Familien"	Policy	The subsidy assists low to medium-income families with children in Germany in constructing or purchasing new, owner-occupied, and environmentally friendly residential properties. Key points include a promotional loan with an effective annual interest rate as low as 0.01% for climate-friendly new builds, applicable to both house construction and initial purchases of houses and condominiums. The maximum loan amount ranges from 170,000 to 270,000 euros for families with children and single parents, with subsidy amounts varying based on income levels.	ownership, single-family houses	KfW (2024)

C Sufficiency Policy Proposals of the European Sufficiency Policy Database

Table 19: Description of Policy Proposals to reduce floor area per capita after Zell-Ziegler et al. (2024)

Policy	Policy Description
Right to exchange flats	Right to exchange flats between the tenants of two different flats without rise of rent (except flats where the landlord lives in the same house with not more than two flats)
Moving bonus	Moving bonus in case of switching from a bigger to a smaller flat (size/living space must be regional average or below)
Moving advice	Municipal advisory offices for moving, sublease and home exchange (main target group: elderly people living on more than 80m2)
Advice for change of use	Advice from municipal advisory offices regarding building regulations for switching usage or adapting houses
Fiscal relief for subleasing	Fiscal relief for long-term subleasing room in the own household (not for touristic subleasing)
Subsidies for small flats	Subsidy for municipalities when building small flats (e.g. <40 m^2 or regional average).
Subsidy for splitting Single-Family-Houses	Financial subsidy for structural partitioning of single family houses under the condition of subleasing (or sale) of part of it

Table 19: Description of Policy Proposals to reduce floor area per capita after Zell-Ziegler et al. (2024) (continued)

Policy	**Policy Description**
Investment grants for housing co-operatives	Housing cooperatives do not profit from depreciation rates like the commercial housing construction. Therefore, grants should be given at a similar level. In addition, housing cooperatives that provide significantly smaller living spaces per person compared to the regional or municipal average should receive additional grants (EnSu complement).
Financial support for buying shares of housing cooperatives	(Increase) subsidy/premia for buying housing coop shares.
Bonus payment for living on small space	Bonus for having less living space (at primary residence) than regional or municipal average (also for shared living concepts)
Design of development plans with diverse and mixed use	To support redensification and the city of short distances, the conversion of e.g. office space to residential space is facilitated.
Training offensive for existing buildings (offers by chambers of crafts)	With declining new construction activity, more craftsmen can be recruited for energy-efficient refurbishment and construction in existing buildings. The chambers of crafts should therefore offer appropriate training and retraining measures, including courses on building with renewable and natural building materials.
Training offensive for existing buildings (training content)	Training content must be changed away from new construction and towards the preservation, renovation and conversion of existing buildings. In particular, conversion measures for sufficent housing should be taught (EnSu complement).
Permit and promote alternative housing	Alternative housing, such as tinyhouses, ecovillages, prefabricated houses or shared flats, should be permitted and promoted by law and provided for in the PAGs of the municipalities.
Tax free home-sharing	Enable a tax free home-sharing (law-proposal: § 3 Nr. 49 EStG-E)