

THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

The effect of resource sustainability interventions on
social sustainable development in the built environment

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Abstract

There are several sustainable development targets for the Swedish housing market. The sector as a whole is expected to contribute to the reduction of greenhouse gases. Housing prices should increase and not inflate. Meanwhile, the development of the built environment should contribute to well being and decrease segregation. Prioritization amongst these targets is often done through policy and by actors in the housing market. This thesis focuses on the trade-offs between environmental and social sustainable development targets. The thesis builds on two studies of development in the built environment. The main study describes an environmental upgrade of housing in a disadvantaged area of Gothenburg, and the second investigates a redevelopment area with high environmental ambitions.

Environmental targets, such as CO₂ reduction, have in some cases been profitably achieved in housing projects in Sweden. The principal study of this thesis describes the implementation of volumetric billing of water at Bredfjällsgatan which successfully reduced water usage and was profitable for the implementing real estate company. However, the system's change also increased the average monthly costs for the households, and the average monthly costs increased even more in households where the inhabitants were unemployed. The lock-in effect of welfare dependency is increased by rising monthly expenses. This group lacks economic incentive to save water since welfare pays for water usage. The analyses of water consumption data show that while economic incentives account for some reduction of water consumption, other parameters such as household size, crowdedness of apartments, and household level of education are also important factors. Households receiving welfare are not economically affected by the implementation of volumetric billing of water but are further socially excluded from society when trapped in welfare dependence. The real estate owner states economic and environmental aspects as motivators for the system's change. Social sustainable development targets on a societal level are not an outspoken priority to the same extent. The real estate owners in disadvantaged housing areas should be recognized as important actors in the development to tackle segregation of the housing market.

The second study presents empirical insights from a housing area that is being built with high environmental ambitions. Perspectives of sustainable development amongst developers in the area differ, but it is apparent that social dimensions of sustainable development receive less attention. The complexity of social dimensions is not fully addressed. Social sustainable development is for example thought of as comfortable outdoor environments in the area, while the larger societal impacts of the housing project were not considered to the same extent. Integration, affordability, and equity were only given indirect focus; instead these targets are often assumed to be reached by varying apartment sizes and mixing tenure in the area.

Keywords: Social Sustainable Development, Housing, Domestic Water

List of papers

- I Mangold, M., Morrison, G., The transformative effect of the introduction of water volumetric billing in a disadvantaged housing area in Sweden. Submitted to *Water policy*
- II Hagbert, P., Mangold M., Femenias P. Paradoxes and Possibilities for a 'Green'Housing Sector: A Swedish Case. *sustainability* 5:2013, page 2018-2035

Papers not included in the thesis:

Bratanova, B., Morrison, G., Fife-Schaw, C., Chenoweth, J., Mangold, M. Restoring drinking water acceptance following a waterborne disease outbreak: the role of trust, risk perception, and communication. *Journal of Applied Social Psychology* 9:2013, page 1761-1770

Harder, R., Yuliya, K., Morrison, G., Feng, F., Mangold, M., Dahlén, L. Quantification of goods purchases and waste generation at the level of individual households. Submitted to *Journal of Industrial Ecology*

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Chapter 1

Background of the thesis

Through the current discourse on sustainable development, the environmental and economic dimensions of sustainability tend to attract more attention than the corresponding social dimensions (Pullman et al. 2009, Geels 2011, Vallance et al. 2011). There is therefore a concern that environmental sustainability is used to motivate investments and changes that might negatively affect equal opportunity, equity and other targets in the sustainable development framework (Luke 2005, Jensen et al. 2012, Bond and Morrison-Saunders 2009, Kommadath et al. 2011, Gasparatos et al. 2008, Gough et al. 2008, Lehtonen 2004).

In many countries, including Sweden, the debate on sustainability and the environment has affected the building industry and the built environment. Certification systems are now a routine procedure for new production and the environmental upgrade of the existing building stock is an important target to be reached. In this process social sustainable development targets risk being negatively impacted (Gough et al. 2008). The purpose of this research has been to analyze the impact of environmental projects on social sustainable development in two case study areas.

The two articles that form the basis of this thesis analyze social sustainable development impacts in an environmental upgrade project of a low profile, 1960s housing area (Bredfjällsgatan case study in Hammarkullen, article I), and social sustainable development targets in a high profile, green new production area (Kvillebäcken case study, article II). Article I is the primary article in this thesis and the focus is the development of the analysis behind Article I. Article II is used to compliment and frame article I with sustainable development perspectives from the building industry.

Article I investigates an example of an environmental upgrade in the introduction of volumetric billing of water in a case study area in Gothenburg, Sweden. Volumetric billing of water is increasingly being introduced in Sweden (Ek and Nilson 2011) to reduce household water usage by providing the households with an economic incentive to save water. Since the volumetric billing of resources with a high marginal cost is seen as a key for achieving sustainable resource management (Wijkman and Rockström 2013), the related social dimensions could be seen as a barrier, as is often the case in ecological modernization theory (Mol and Sonnenfeld 2009), which gives the study its theoretical context by framing volumetric billing in relation to sustainable development. Ecological modernization theory will be described in Introduction chapter.

Article I illustrates how the introduction of volumetric billing was successful in terms of reaching the environmental sustainability target of reduced water usage, while it also led to increased reemployment thresholds and strengthened unequal opportunities. The article did not investigate alternatives to volumetric billing. The focus was rather to evaluate the introduction of water billing at the case study site, to highlight conflicting interests at conceptual and practical levels and to present guidelines and safety measures that avoid negative social effects during a system's change process.

Article II focuses on production of new dwellings in an area with a high environmental ambitions (Kvillebäcken 2013). The study is based on 8 transcribed interviews with real estate developers and focuses on the developers understanding of sustainability and how sustainability demands from residents, building regulations and in their own policy is interpreted. The study shows that there are paradoxes that emerge when sustainability housing projects are planned to be financed by individual residents alone. Furthermore, there is an equivocal understanding of sustainability, primarily social sustainable development, amongst the

developers. The built areas of Kvillebäcken will most likely have a high environmental profile but it will be socio-economically homogenous and thus contribute to segregation in Gothenburg.

The author of this thesis is Mikael Mangold. I have been working as a researcher since 2009 and I have a Swedish master of science in civil engineering and a master in design for sustainable development. I have also been working for Médecins Sans Frontières since 2010 where I am a water and sanitation expert. Further to the two articles that are presented in this thesis I have worked on consumer trust and confidence issues in relation to risk of waterborne disease outbreaks resulting in a publication in the *Journal of Applied Social Psychology* (Bratanova et al. 2013). I have also been working in a group that has been looking at the quantification of household consumer goods resulting in a publication in the *Journal of Industrial Ecology* (Harder et al. 2013). In connection with this work I undertook a study on Household Water Sensitivity (Mangold and Morrison 2012) which was the first step in the Hammarkullen study (Article I).

1.1 Aims and research questions

The aim of this licentiate thesis is to combine insights from these two pieces of work and analyze the challenge of reaching social sustainable development targets in environmental projects in the contemporary Swedish housing industry.

The following research questions will be addressed in this thesis:

- What were the challenges in reaching sustainable development targets in the implementation process studied in Hammarkullen (Article I)?
- What is the focus of developers in the case of Kvillebäcken (Article II) when discussing sustainable development, specifically social sustainable development?

In the research questions there is a distinction between implementing and operationalizing sustainable development. Operationalizing sustainable development signifies formulating policy, guidelines and regulation based on an understanding of sustainable development, this relates more to article II. Implementation refers to the creation of physical infrastructure with impacts on sustainable development targets relating more to article I.

1.2 Structure of the thesis

Chapter 2. Introduction presents resource sustainability and ecological modernization theory specifically focusing on domestic water followed by a brief overview of social sustainable development in contemporary literature and in the local context. The purpose of the chapter is to set a basis for the discussion around conflicts between dimensions in the sustainable development construct.

The bulk of this thesis consists of a description of the Hammarkullen (article I) study. The Kvillebäcken study (Article II) frames the Hammarkullen (article I) study in a context and adds dimensions of redevelopment construction.

Towards the end of the thesis the more unconventional chapter 6. Societal relevance and recommendations has been added. The thesis describes billing systems for domestic water but the analysis of conflicts in the sustainable development construct applies to other societal issues. The intention is to collate conclusions that relate to other areas than just volumetric billing of water in this chapter. Recommendations within the studied areas are given towards the end of this chapter.

1.3 Limitations

The fields of domestic water and the production of housing are the foci. In these contexts the collision between environmental and social sustainable development targets is described. The thesis will not specifically consider neither energy nor greenhouse gas emissions as is often the case in these contexts.

The context of both studies presented is Sweden and Gothenburg during the period 2010-2011. As social sustainable development varies depending on context a consideration of contemporary literature on social sustainable development in Gothenburg has been made.

Article I is the focus of this thesis. A limited analysis of article II will be conducted only to add depth to the analysis of social sustainable development in the Kvillebäcken study (article II).

Chapter 2

Introduction

This thesis analyses aspects of sustainable development and therefore a brief introduction to perspectives on sustainable development is appropriate. A historical perspective on sustainable development allows us to remove some confusion of terminologies. In the Brundtland definition of sustainable development, social and economic indicators were closely linked and attributed to development while environmental indicators were more linked with sustainable (Kates et al. 2005). Indeed, although the documents from the Brundtland Commission and Rio de Janeiro summit clearly stressed a social dimension, through their insistence on intra- and intergenerational justice, gender equity, and calls for participatory decision making, several scholars argue that a more systematic focus on the social dimension has subsequently been secondary to environmental and economic considerations (Boström 2012). Economic development and social development meant raised living standards in emerging regions and countries. Lehtonen (2004) writes about this interesting aspect of sustainable development and analyses the tradeoffs and synergies between the dimensions. Each of the three dimensions has its own characteristics and logic, which are likely to conflict with each other. One key problem is that sustainable development does not give any guidance on how to arbitrate between the unavoidably conflicting objectives of economic rationality (profitability), social justice and ecological equilibrium. For instance, the objectives of improving material well-being and conserving natural ecosystems often conflict with each other. The definition of sustainable development by Kates et al. (2005), see table 1, is useful when understanding social sustainable development in relation to the other dimensions of sustainable development.

Table 1 provides perspective for the understanding of environmental and economic sustainability. The nature of development is a contested subject in the contemporary world where every country has rich and poor segments, almost every country has culturally heterogeneous populations, and growth is seen as a necessity. Social sustainable development covers everything except for environmental and economic sustainability.

Amongst the perspectives on environmental sustainability resource sustainability is of particular interest in this thesis. In the Hammarkullen study (article I) domestic water consumption was studied. Ecosystem services are vital for human health (Assessment Millennium Ecosystem 2005) and an interesting question would be what the water footprint of the water consumption at Bredfjällsgatan is. This has been analyzed by Jenerette et al. (2006) for cities in the US and China, and makes it possible to identify urban scale constraints to the sustainable withdrawal of a particular ecosystem service. Drinking water providers can play a major role in safeguarding the health of these systems because their operations have significant and far-reaching consequences for aquatic ecosystems (Postel 2007).

Table 1. Definitions of sustainable development based on Kates et al. (2005).

TO BE SUSTAINED	TO BE DEVELOPED
NATURE	PEOPLE
Earth	Child survival
Biodiversity	Life expectancy
Ecosystems	Education
	Equity
LIFE SUPPORT	Equal opportunity
Ecosystem services	
Resources	ECONOMY
Environment	Wealth
	Productive sectors
COMMUNITY	Consumption
Cultures	
Groups	SOCIETY
Places	Institutions
	Social capital
	States
	Regions

2.1 Natural resource perspective on domestic water

The management and finance structures for domestic water consumption have varied both historically and geographically (Herrington 1999) often depending on how water is perceived. Water has many attributes and can be considered a human right (Meier et al. 2012), a commodity (Loftus 2005, Rogers et al. 2002), a scarce resource, a source of conflict (Sultana 2011), a cultural value or a resource to be taken for granted. The varied perceptions of water impact the way water systems are managed and financed (Salzman 2006, 2012, Perry et al. 1997, Goldman 2007).

Historically, there are points when these perceptions change (Salzman 2006) and as a consequence water management systems shift (Huitema et al. 2011). A well-documented change in perception was the shift toward the management of water as a tradable commodity in order to secure cost recovery, maintenance and service provision in the 1990s (Rogers et al. 2002, Goldman 2007, Savenije and Van Der Zaag 2002), which was internationally recognized through the Dublin statement (UN World Meteorological Organization 1992). The privatization of water utilities around the world sparked reactions amongst activists propagating for water to be seen as a human right (Goldman 2007, Corporate Accountability International 2012). These thoughts were internationally recognized in the General Comment No 15 of the UN Economic and Social Council (2002) after the Water War in Cochabamba 2001, a notorious water privatization conflict (Salzman 2006).

Another such change in perception can occur between environmental concerns for reducing water consumption and the perceived right to water of marginalized groups in society (Ruijs et al. 2008). In ecological modernization theory (Mol and Sonnenfeld 2009) water consumption can be reduced by perceiving water as a commodity and a scarce resource. Ecological modernization theory has had a significant impact on Swedish policy debates, consequently there is a trend of introducing volumetric billing and changing how water is used and paid for (Ek and Nilson 2011). The Hammarkullen study (Article I) analysed the process of the introduction of volumetric billing of water in a disadvantaged community. Since volumetric billing of resources with a high marginal cost is seen as a key for achieving sustainable resource management (Wijkman and Rockström 2013) related social dimensions could be seen as barriers, as is sometimes the case in the practical implementation of ecological modernization theory (Mol and Sonnenfeld 2009).

2.2 Ecological Modernization Theory

In contemporary Sweden, ecological modernization is a key part of the sustainable development discourse in policy, industry, local governance, and other implementing agents for achieving environmental sustainability based on economically profitable means (Spaargaren 2000, Jensen and Gram-Hanssen 2008). Ecological modernization was first introduced as a social theory in the early 1980s as an optimistic school of thought in which economic benefit can be the result of change to environmentalism (Mol and Sonnenfeld 2009, Hajer 1995). An important element in ecological modernization theory is to ascribe environmental loads with a price, i.e. internalizing externalities. Examples include the valuation of ecosystem services (Costanza et al. 1997), environmental taxation (Bovenberg and Goulder 2002), or by tradable certificates of emissions (Rubin 1996), see figure 1. Ecological modernization theory has been criticized for building upon the idea of sustainable growth which in itself is a theoretical paradox (Mol and Sonnenfeld 2009). Ecological modernization theory has also been criticized for its disregard for social justice (Spaargaren 2000, Jensen and Gram-Hanssen 2008, Pataki 2009, Fisher and Freudenburg 2001, Murphy 2012).

Nevertheless, Murphy (2012) states in his comprehensive literature review on social sustainable development that a careful consideration of the relevant literature reveals that ecological modernization theory scholars most often weight equity and participation aspects in the sustainable development discourse. Langhelle (2000) argues that ecological modernization and sustainability should not be conflated at a conceptual level and care is needed when developing policy based on ecological modernization theory that social dimensions of sustainable development are to be included in a satisfactory manner. There is a risk that policy development based on ecological modernization theory alone would disregard the social dimensions of sustainable development since ecological modernization methods are much more adapted to environmental and economic sustainability.

In the implementation phase of environmental sustainability projects that draw on ecological modernization theory there is a greater risk that social sustainable development dimensions are disregarded if projects are profit driven and regulation for social concerns are missing. The Hammarkullen study (Article I) provides an example of the practical implementation of ecological modernization that resulted in changes in measured social sustainable development parameters. It also provides a practical example of the installation of resource and cost saving equipment in a non-emerging economy setting, much like Lettenmeier et al. (2012) but extends the work by adding indicators of social sustainable development .

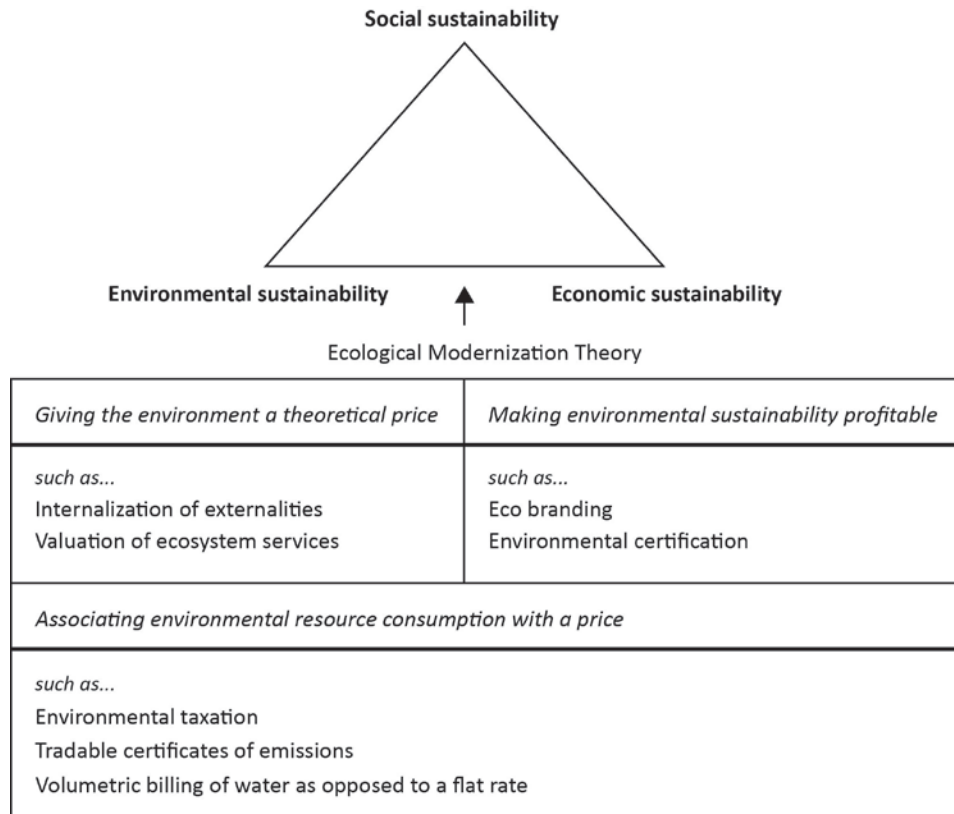


Figure 1. Personal reference diagram of sustainable development and ecological modernization theory. Amongst the three commonly used dimensions of sustainable development, ecological modernization theory includes aspects of economic and environmental sustainability but tends to miss social sustainable development. Three incomplete lists of theories developed in ecological modernization theory literature are also presented.

In the Kvillebäcken study (Article II) a forefront environmental sustainability housing area is being built. Concerns for social sustainable development dimensions are stated but the main focus of the project is environmental issues (Kvillebäcken 2013). Ecological modernization methods that are applied in the Kvillebäcken project are eco branding and certification. Kvillebäcken relies on a conglomerate of medium to large developers that sell or rent unsubsidized apartments to the highest private bidders. The certification used is BREEAM silver and an energy supply of not more than 60 kWh/m² and year. To meet social sustainable development considerations, a requirement was that at least 25% of the apartments should be rental flats. The high environmental ambitions are part of the sales concept for apartments in Kvillebäcken.

The criticism developed by Boström (2012) on profitable means for reaching sustainable development targets applies to the Kvillebäcken project. Boström writes: “Certification cannot make the current model of insatiable demands for goods from all over the world either environmentally sustainable or socially equitable. This reflects the contradiction of using a market-based, consumption-dependent strategy to leverage sustainable development in a world where markets and consumption patterns are fundamentally inequitable.”

2.2.1 Volumetric billing of water and water tariffs

One of the theoretical models presented by proponents of ecological modernization theory is the internalization of externalities, i.e. assigning societal activities with costs of complete environmental restoration. Assigning a cost to the activities demotivates waste and revenues generated can be used for restoration. Volumetric billing of resources demotivates waste even if the cost assigned only contains the resource production cost.

In the case of volumetric billing of water in Sweden, total household water costs include the wastewater treatment cost. The cost of environmental degradation caused by treated wastewater that reaches the final recipient is not included. The implementation of volumetric billing of water thus successfully closes production loops and internalizes externalities in an easily managed manner. However, Gothenburg has a combined sewage network where reaching the minimum sewage flow to avoid blockages is sometimes problematic. The additional cost of metering and systems management should also be considered.

Water tariff structures vary greatly among the OECD countries (table 2). In Sweden where fresh water is abundant and of relatively high quality, resource conservation has not been a major issue. In addition the perception of water as a human right has also led to a limited implementation of volumetric billing of water.

Table 2. Household tariff structures in OECD countries at the beginning of this century

Category	Example countries
'Cutting edge' conservation pricing	Korea (IBR 100%)
Conservation or social pricing	Belgium; Greece; Japan; Italy; Mexico; Spain; Portugal; Turkey (IBR 74–100%)
Price times quantity volumetric	Czech Republic; Hungary; Poland
Traditional volumetric	Austria; Denmark; Finland; France; Germany; Netherlands; Switzerland (CV 80–100%, IBR typically 0–4%)
Mixed volumetric	Australia (CV 68%, IBR 27%, DBR 4%); Luxembourg (IBR 74%, DBR 26%); US (CV 32%, IBR 30%, DBR 34%)
Mixed (general)	Canada (Flat 56%, CV 27%, IBR 4%, DBR 13%)
Predominantly flat-fee	Iceland; New Zealand; Norway; Sweden; UK
Domestic water charges consolidated into general taxation	Ireland

Source: Based on (Herrington 1999)

Notes: CV: Constant volumetric rates; DBR: Decreasing block rates, with higher water charges to low-volume consumption blocks, and successively lower tariffs to higher volume, higher block users. IBR: Increasing block rates, with lower water tariffs to low-volume consumption blocks, and progressively higher rates charged to high consumption blocks.

Since late 2000 environmental concerns have come to have political relevance. Metering costs are lower due to cheaper meters and wireless installations. This has promoted volumetric billing of water and created a trend to install volumetric billing of water in Swedish apartments.

2.3 Brief state of the art on social sustainable development

The purpose of this chapter is to clarify concepts regarding the social dimension of sustainable development. This brief state of the art primarily builds on the related research in table 3.

Table 3. Social sustainable development literature that provide the building block of this chapter.

International literature	Boström (2012), Murphy (2012), Mol and Sonnenfeld (2009), Lehtonen (2004), McKenzie (2004), Dempsey et al. (2011), Dasgupta (2005)
Locally developed reports	Olsson (2012), Andersson (2013), Törnquist et al. (2012), Andersson et al. (2009)
Local policy	Lennander et al. (2013), Kvillebäcken (2013), Stadsbyggnadskontoret (2010)

Social sustainable development has been called the most elusive of the sustainable development dimensions (Boström 2012, Murphy 2012, Dempsey et al. 2011). Social sustainable development is contextual and cultural, demonstrating a greater variability compared to economic and environmental sustainability. There is a variation between north and south, there are variations within countries, and there are variations in how social sustainable development has been perceived at different times.

Another factor contributing to uncertainty that has emerged in the studies that form the basis of this thesis is that institutions and actors claim the term for their own purpose. Projects that have a sustainable development profile are often obliged to fulfill criteria in all three dimensions of sustainable development. Sometimes social sustainable development is claimed in contexts where social sustainable development has little relevance or even defined as to be more easily achievable, e.g. creation of meeting places and increase quality of life as done in Kvillebäcken (2013) and in the maintenance sustainability described by Vallance et al. (2011).

I will not attempt to bring further clarity to the definition of social sustainable development but rather rely on the scientific discourse for definitions. McKenzie (2004) has defined social sustainable development through a conceptual analysis as a condition, a measurement framework, or a number of case studies. Sometimes, different projects or situations are compared to investigate the potential to transfer successful approaches from one project to another.

Definitions of social sustainable development are often described as either a currently existing positive condition, or as a goal that remains to be achieved (McKenzie 2004). Where social sustainable development is considered weak, the community may be deemed at risk or in need of support. Social sustainable development is also sometimes seen as an asset, occurring naturally and to varying degrees within societies. Social sustainable development allows societies to maintain coherence and overcome change and hardship. This is often called social capital in political theory according to McKenzie (2004). However, Dasgupta (2005) provides another perspective of social capital in economics from sociology.

Murphy (2012) has conducted a literature study on social sustainable development and divides the policy concepts of social sustainable development into four categories: Equity, Awareness of sustainability, participation and social cohesion. Equity is described first, given most attention and given the meaning that all citizens, regardless of gender, should have an equal opportunity to both survive and fulfill their development potentials. Awareness of sustainability refers to raising public awareness of sustainability issues with a view to encouraging alternative, sustainable consumption patterns. Participation refers to the goal of including as many social groups as possible in the decision-making processes. Finally social cohesion is found to be an important policy concept but only in certain areas of policy. The Bristol Accord links social cohesion to policy by urging local authorities to “promote a mix of populations, non-segregated areas, accessibility and safety, and the development of opportunity, and facilitate the integration of distressed urban areas” (United Kingdom EU 2005).

Murphy’s own contribution to the debate is to stress the links between the social and environmental dimensions as the key to achieving long term sustainability. Of the ten policy areas outlined by Murphy two apply to the Hammarkullen study (Article I) in a conflicting manner, and one can be applied in the Kvillebäcken study (Article II):

- Commitment to protect vulnerable groups from fiscal measures designed to mitigate climate change (Hammarkullen study, Article I).
- Commitment to decarbonize current welfare provision (Hammarkullen study, Article I).
- Commitment to infrastructural planning which promotes social integration and environmental sustainability simultaneously (Kvillebäcken study, Article II).

Dempsey et al. (2011) has written an article with the purpose of defining social sustainable development in an urban context. They write that social sustainable development is about society but also about people in society. There is a benefit in distinguishing between these two dimensions in an analysis of social sustainable development (Dempsey et al. 2011). These two dimensions are interlinked and key performance indicators of social sustainable development should involve both dimensions. Dempsey et al. (2011) make a clear distinction between equitable access and the sustainability of the community itself. Societies can be socially sustainable and this involves: Social interaction/social networks in the community, participation in collective groups and networks in the community, community stability, pride/sense of place, safety and security. People on the other hand have rights. People in a socially sustainable society are granted rights to a number of different non-physical and predominantly physical factors such as: social inclusion, social capital, mixed tenure, fair distribution of income, employment, residential stability, and decent housing.

Dempsey et al. (2011) also give special attention to social equity. An equitable society is described as one in which there are no exclusionary or discriminatory practices hindering individuals from participating economically, socially and politically in society. Dempsey et al. (2011) focus on accessibility to basic services but recognizes that the debate on inequity often focuses on spatial segregation and domesticity. Equal opportunity and economic freedom relate to living costs as found in the Hammarkullen and Kvillebäcken studies (Article I and II). As Murphy (2012) states: sustainable development is all about equity, equity between generations, countries, and inhabitants.

Many scholars refer to social capital as a way of assessing a society's strength (McKenzie 2004) and setting social sustainable development targets (Kates et al. 2005). When using the term social capital there is need for clarification of reference. The concept of social capital was first developed in relation to economic and natural capital (Lehtonen 2004). However, the contemporary use of the term refers to a multitude of elements, of which one is the much used definition by Putnam (2001) as "the collective value of all social networks and the inclinations that arise from these networks to do things for each other".

The problem of adhering to weak sustainability when considering natural and human capital also exists when social capital is considered (Gowdy and O'Hara 1997). "Weak sustainability is an econocentric concept. In this world view, the universe of discourse is restricted to the market economy. Market exchange values, arising from individual decisions made at a particular point in time, are the basis for weak sustainability."

Dasgupta (2003, 2005) has been recognized for his work on social capital. His writing further stresses the care needed when referring to social capital. "The idea of social capital sits awkwardly in contemporary economic thinking. Although it has a powerful, intuitive appeal, social capital has proven hard to track as an economic good. Among other things, it is difficult to measure; not because of a recognized paucity of data, but because we do not quite know what we should be measuring." Dasgupta (2005) concludes that interpersonal networks can indeed have various strengths and resilience but "There is nothing good or bad about interpersonal networks; other things being equal, it is the use to which a network is put by members, that determines its quality." These conclusions apply to the Kvillebäcken study (Article II) where criticism has been raised for the social segregation created by gathering a homogenous group of dwellers.

2.4 Local theory and policy documents on Social Sustainable Development

Since social sustainable development is context dependent it is relevant to conduct a brief local policy overview which focusses on the built environment (table 3). Andersson (2013) wrote a useful conceptual definition: Social sustainable development is about building a society where basic human rights are respected. This also means creating environments where individuals can acquire knowledge, develop and have good health. If not all individuals in a society have their rights granted then we risk a socially unsustainable situation (my own translation).

In the Kvillebäcken study (Article II) real estate developers had a clear focus on energy when asked about sustainable development. This reflects the past decade's debate about the role of the built environment in relationship to sustainable development. Passive house technology, BREEAM and LEED certification, embodied energy, and kWh/m² have dominated the debate. Other dimensions of sustainable development have certainly been mentioned but the focus has been on environmental sustainability. Economic sustainability has been perceived as reachable since the housing market is increasingly economically independent and deregulated.

I find the local literature on segregation that has been produced during the last five years relevant for the studies presented in this thesis. Recently, segregation has received more attention as a challenge for spatial planning, the construction industry, and social policy. The public financed S2020 project in the Gothenburg region was commenced in 2007 to help policy makers in setting targets for social sustainable development and has played an important role in this process. Andersson et al. (2009) conducted a larger empiric mapping as part of S2020 of the segregation process in Gothenburg. Conclusions from this work have direct parallels with analyses in the Kvillebäcken study (Article II). One of the policy tools developed by S2020 was the Social Consequence Analysis (Stadsbyggnadskontoret 2010) to be applied by policy makers and developers primarily in the planning process. Lennander et al. (2013) and Törnquist et al. (2012) have worked more prescriptively based on the analyses of S2020. Their work is applicable when analyzing the results of the Kvillebäcken construction project.

The Hammarkullen study (Article I) is different since it studies an existing structure where an environmental upgrade is implemented. There are less local policy documents written on this topic, leaving real estate developers more or less free to act based on their own judgment. In the Hammarkullen study (Article I) social sustainable development was not in focus and no strong company specific social sustainable development policy was used. Regulations were followed including consent from the rental organization and signing of new contracts with tenants.

2.4.2 Operationalizing and implementing sustainable development

The vagueness and interpretive flexibility of sustainable development and social sustainable development in particular creates a need for framing and contextualizing (Lehtonen 2004, Boström 2012, Dempsey et al. 2011). In a project such as the environmental upgrading of the Swedish millionprogram, or even at a smaller scale such as the Hammarkullen implementation of volumetric billing of water (article I), sustainable development is operationalized. Figure 2 shows a theoretical process of how sustainable development is developed, operationalized and implemented.

When sustainable development definitions are applied in local contexts then adjustments and simplifications have to be made. The process of defining sustainable development by operationalizing sustainable development has several challenges: it is seldom peer-reviewed and not always done by sustainable development experts, sometimes resulting in sub-optimal solutions being sought.



Figure 2. A theoretical map of a process of sustainable development (SD in figure) theory application. In practice this process might be conducted differently.

In addition definitions of key performance indicators for social sustainable development as part of operationalizing social sustainable development is carried out differently depending on ideology and power structures (Murphy 2012). Sustainable development is a governance tool, when a governance tool is put in

practice priorities are set which often fit in existing political frameworks. Power can be exerted by operationalizing sustainable development and implementing systems based on frameworks claiming sustainable development as a target.

“The selection of social measures in sustainable development indicator sets is often a function of power rather than policy coherence, as influential groups are more likely to have their concerns included. These indicators reflect different sociocultural priorities and as such are often picked for political rather than scientific reasons. For example, preferences for neoliberalism or the European social model will result in different social objectives.” (Murphy 2012)

The practical implementation phase of sustainable development targets also present problems. There is a risk of discrepancies between phrased targets and actual outcome if policy does not take into consideration that implementing agents are guided by short term economic profits. As demonstrated in the Kvillebäcken study (Article II) developers are asked to have a high environmental ambition, but if they are not given economic incentives then competition between developers result in minimum investments towards the sustainable development targets.

An important actor that should be given attention in this chapter is the Social Welfare Services (SWS) that provide protection for marginalized residents in the Hammarkullen area. SWS is administered locally as a part of the municipality. Building on Murphy’s (2012) social/environmental framework it is possible to conclude that one, SWS is subsidizing carbon emissions, and two, SWS is protecting marginalized groups from fiscal policy designed to mitigate climate change. The system deficits are that: SWS has no mandate to reduce carbon emissions, and that SWS has non-utilized knowledge of resident’s socio-economic status that could also be used to design an improved tariff structure. The possibility for SWS to require cooperation with real estate owners should be increased.

There is no formal cooperation between the real estate owner and SWS. SWS contributes with 25% of the monthly revenues of the real estate owner in the study area which further motivates formal cooperation. Thus environmental and social infrastructure investments are paid by public funding through SWS without clear and formal policy directives. On the contrary, SWS has expressed a suspicion against the real estate owners’ intentions to require funding for building upgrades.

Chapter 3

Methods

The theoretical frames for the studies in this thesis were developed over the period of one year often in collaboration with Pernilla Hagbert PhD student at the Chalmers faculty of Architecture. The two studies that form the basis for this thesis were conducted in parallel during this period.

The research process has been abductive, transcending iteratively between theoretical analysis and empirical studies as in the Hammarkullen study (article I). The benefit of the abductive research process is that it is explorative and requires a broad perspective. The challenges of the abductive research process are to reach depth and focus the studies. Depth was achieved by spending a lot of time at the case study site and by gathering many perspectives from various stakeholders.

Both studies presented in this thesis used a mix of qualitative and quantitative methods. In the Kvillebäcken study (Article II) in-depth interviews were the basis for a quantitative text analysis. First a conceptual text analysis was conducted in order to identify thematic groups and patterns. After that the quantitative text analysis was conducted to enable the determination of observed patterns.

3.1 Hammarkullen

In the Hammarkullen study (Article I) and based on Bryman and Bell (2007) both qualitative and quantitative methods were employed in order to more accurately describe and evaluate the introduction of volumetric billing of water at the case study site, and to highlight conflicting interests at conceptual and practical levels. Informant and semi-standardized interviews were used to highlight conflicting interests. Water usage data and data on socio-economic status from SWS were used to describe and evaluate the economic impact of the introduction of volumetric billing. A questionnaire study was conducted to describe the households in terms of detailed socio-economic status and water usage practices. Data was selected based on research focus, relevance to the issue, and availability. A diary was kept in order to document an increased understanding of the system's change process (Creswell et al. 2003). Research questions were phrased for the Hammarkullen study (article I) as shown in table 4.

Table 4. Hammarkullen research questions with associated appropriate research design.

Index	Research question	Data needed	Appropriate research design
RQ1	What are the environmental implications of the introduction of volumetric billing of water?	Hot and cold water measurements	Water meter readings
RQ2	How did the implementation of volumetric billing of water affect different households economically?	<ul style="list-style-type: none"> • Socio economic data on inhabitants combined with water billing changes • Statements from inhabitants. 	<ul style="list-style-type: none"> • Collection of data from SWS and the water billing company • Semi-standardized interviews
RQ3	How was implementation of volumetric billing of water thought of and motivated by stakeholders?	<ul style="list-style-type: none"> • Informant interviews • Water billing economic total cost impact 	Triangulation: Semi-standardized interviews with stakeholders, contrasting summary of economic incentives
RQ4	How was the implementation of volumetric billing of water received among inhabitants?	Statements from residents	Semi-standardized interviews with residents: Interview guide, data recording, data processing

3.1.1 Appropriate research designs

The data needed to answer the research questions required both quantitative and qualitative methods found in table 5 and as used in article I. Especially RQ1 required both quantitative and qualitative data. The impact on household economies can be described by comparing data on income from the questionnaire and from SWS with payments for water. But to fully understand the economic situation of people in the area they had to be talked to. Interviews were a manner of formalizing conversation and making them presentable in the article and the thesis.

Table 5. Table of data used in the Hammakullen study (article I).

Quantitative data	Sample size	Response rate
• Water metering readings	571	100%
• SWS information on socio-economic status	149	90%
• Questionnaire study	85	56%
Qualitative data	Interviewees	Interview type
• Inhabitant interviews	85 Households	Semi-standardized interviews
• Stakeholders interviews	SWS, real estate manager, water company, resident organization, water metering company	Semi-standardized informant interviews

3.1.2 Quantitative data

In order to assess the economic impact on the households (RQ1) and make an economic summary of stakeholder incentives (RQ4) several datasets were collected and merged. Hourly readings of hot and cold water usage during one year were provided by the real estate company for their flats (N=571, Response Rate, RR, 100%). SWS provided data on family structure and the financial situation of the most underprivileged inhabitants at Bredfjällsgatan (N=255, RR=90%). These two datasets were merged as illustrated in figure 3. The sampling for questionnaire and interview subjects (N=85, RR=56%, for details see table 6), was designed through two criteria: The household should be among the 571 households with volumetric billing, and the household should be among the households that first had meters installed (to reduce metering errors). On this basis 152 households were selected where water meters had been installed for two months. Of the 152 households, 51 households refused participation and in 16 cases language barriers prevented participation (see table 6). Enumeration was a lottery ticket, worth 20 SEK, received after participation. Statistical analyses were conducted on the merged dataset (N=149) illustrated in figure 1 and the questionnaire material (N=85).

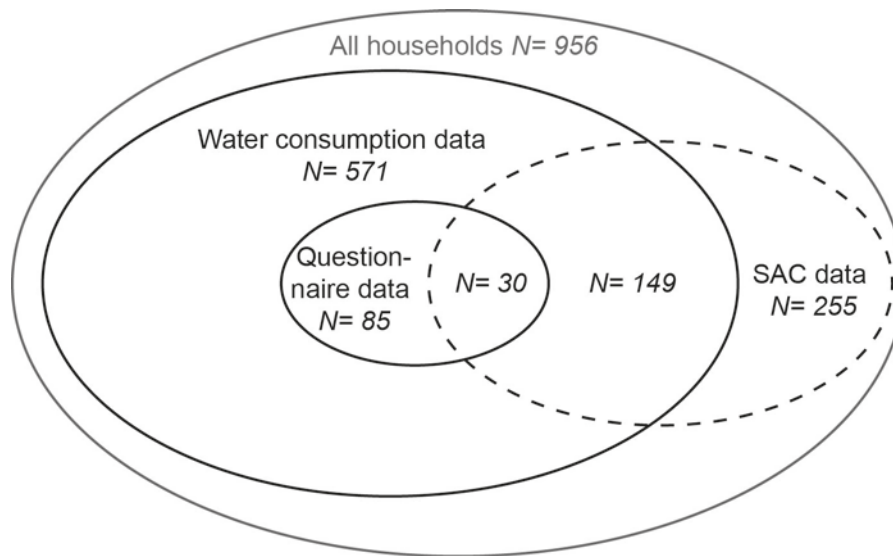


Figure 3. Illustration of the overlaps of the three data sets gathered in the case study area.

The data was organized with addresses as the index joining the three databases. Excel was used for quick calculations and to produce data points for statistical analysis in SPSS. Excel was also used for the creation of summaries for figures.

The statistical analysis in SPSS was conducted in an explorative manner as data was gathered. A more thorough analysis was conducted when writing article I and in parallel with the writing of this thesis. Correlation analyses were often the starting point for understanding the data. After that regression analyses were conducted, and general linear modelling of variables divided in tertiles to better understand observed correlations.

MySQL was used to extract data for SPSS from the 17 000 000+ measurements of water consumption, see figure 4 for an illustration of the measurements. Several multiple regression analyses were conducted in steps to explore correlations. The purpose of the statistical analysis was to identify predictors of an increased water bill. A special focus was given to the group of households getting their water bill paid by SWS. Unfortunately, the quality of water usage data disaggregated to the household level was found to be poor in the period between meter installation and initiation of volumetric billing (figure 4). However, aggregated data at the building level has been recorded for many years and the difference in usage before and after was calculated on an aggregated level.

Making a questionnaire study combined with the interviews assured a better insight into how the questionnaire was answered as well as raising the response rate. The risk of being perceived as too demanding and intrusive by conducting the studies jointly existed. However, trust can also be established by spending more time together with the interviewee (Flick 2009).

Working in a suburban multicultural low income area was a challenge, it was time consuming and presence was required at all hours of the day to assure a high response rate (table 6). Households refused to be part of the study for various reasons: some women did not want to part because the researcher was a man and some people thought the researcher was checking if they had paid the TV licence. One approach utilized was to dress appropriately. Wearing a Fattah scarf at times was mentioned as being a reason for participation on

three occasions. In order to increase the response rate and to remove sample bias the area was visited at various times of the day. On 5 occasions the area was visited until after midnight.

Table 6. Detailed description of response rate in the Hammarkullen study (article I).

Status of household participation	Apartments
Exclusion (apartments are not used as dwellings)	18
Language barrier prevented participation	16
Someone was home but door was not opened	26
No response after 10 visits	23
Rejection	51
Completed interview and questionnaire	85
Total amount of apartments	219

Short comings

The aim was to study the process of introduction of volumetric billing of water where the implementing agent was part of the study itself. Hence, the implementing agent had little interest in apartment specific data before the actual billing was initiated, and thus there are few measurements before the initiation of volumetric billing making it difficult to make water saving predictions on a household specific level. Furthermore the initial measurements are of poor quality where the first reduction in water consumption is not discernible (figure 4).

571 Households

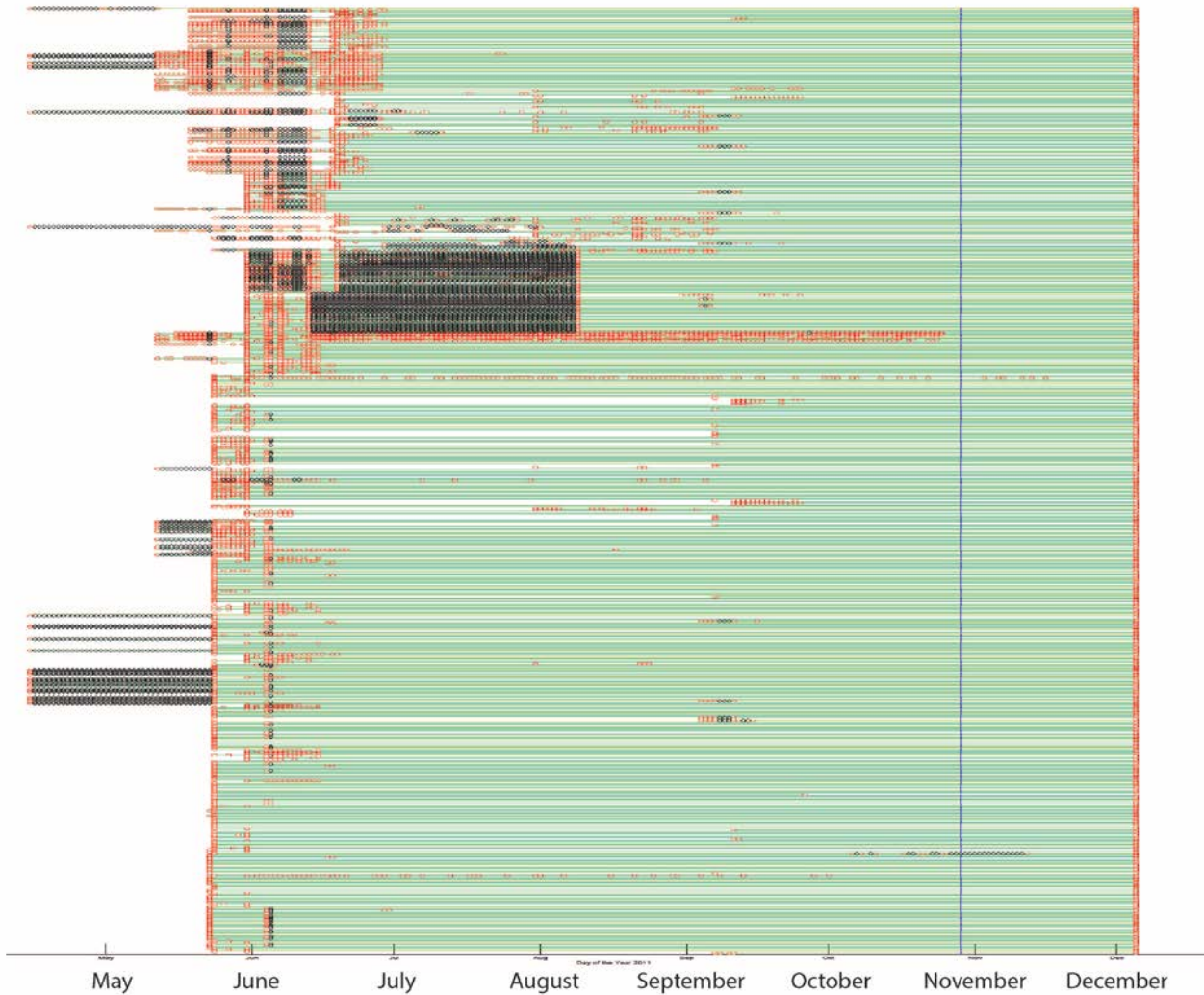


Figure. 4 Visualization of hot water consumption data in the beginning of the metering campaign in 2010. On the Y axis are the 750 hot water meters (some apartments have more than one meter). On the X axis are the daily availabilities of hourly readings: A green dot indicates 24 readings, a red dot indicates between 1 and 23 readings and a black dot indicates no readings. This visualization was used in order to create reliable variables of monthly consumption.

3.1.3 Qualitative data

Interview techniques, questionnaire design and approaches to studying society have been applied in these studies primarily based on Esaiasson et al. (2012) and Flick (2009).

3.1.3.1 Case Studies

Case studies were the basis of both the Hammarkullen and the Kvillebäcken studies (article I and II). Studying a case in detail has several advantages which have been exploited in this study: One, providing a historical account of the system's change process; two, making it possible to alternate between deductive and inductive perspectives; three, reach perspectives commonly not explored in drinking water research in a non-emerging economy setting; four, being able to picture socio-economic impacts on a disaggregated level (Ragin and Becker 1992, Yin 2008).

A problem in the research design was the abductive nature of the research process (Dubois and Gadde 2002) which is generally not promoted in civil engineering as a discipline and certainly not when summarizing results in articles. Furthermore, since the study area can be considered an opinionated issue, another challenge was being free from opinions. The discourse studied has an ethical dimension which made refraining from taking sides more difficult, and indeed, a lot of the references used are opinionated in different ways.

3.1.3.2 Triangulation

Since the studied issue is opinionated, triangulation was used to describe the steps in the decision making process of implementing volumetric billing of water using both quantitative and qualitative methods and supported by Flick (2009 p. 26-27) who has stated that “the different methodological perspectives complement each other in the study of an issue and this is conceived as the complementary compensation of the weakness and blind spots of each single method”.

For the triangulation, informant interviews were carried out separately with the water company, SWS, the residents' association, and the real-estate owner and manager, to map the various interests. Field notes were taken and used to describe the case study and to reflect the stakeholders' positions. Furthermore, an economic summary of the system's change provided insight into the incentives of each stakeholder.

Triangulation using qualitative methods helped avoid overlooking parts of an opinionated and complex issue. By presenting qualitative data the readers understanding of the complexity can be deepened. However, even in quantitative research good science aims at increasing the understanding of the complex, also by adding new ways of interpretation.

A general weakness in triangulation is the lack of assured comprehensiveness. How does one assure saturation of perspectives that are added in the triangulation? The term triangulation is furthermore misleading due to the use of triangulation in geometry. In geometry only three signals / vectors are needed to identify a specific location. Using triangulation as a term in methods gives the association of being able to assure validity, not just improve validity.

3.1.3.3 Resident interviews

In the Hammarkullen study (Article I) semi-standardized interviews were conducted in the same 85 households that participated in the questionnaire study to reveal residents' experiences and opinions on volumetric billing. The interviewees were asked one initial question: “what do you think about the new system for water payments?” This question was chosen in order to answer a direct research question, as suggested by Flick (2009). Thereafter, confrontational questions were asked to affirm the interviewee's position, and the interviews continued until the interviewee was content with the answers given. Interviews

were recorded with a handheld device. These interviews were used qualitatively to provide insight into the respective interests of residents and actors. After completion the interviewees' statements were grouped thematically and characteristic quotes were translated into English (Esaïasson et al. 2012).

By doing many shorter interviews it was possible to give a comprehensive account of how the residents perceive the implementation of volumetric billing of water. By counting the number of interviewees in each thematic group and checking how each interviewee is consuming water it is possible to compare personal perception more in depth.

Furthermore, unstructured and informal meetings occurred without recording. These informal meetings included 7 occasions when the researcher was invited for dinner or coffee for longer periods of time. During these times issues other than the water system were discussed but an understanding of life in the areas was created.

It would be interesting to conduct more interviews at a later date for a longitudinal study. Quantitative data is available for a long period of time while the interviews represent a snapshot two months after the initiation of volumetric billing.

Shortcomings

A bias was the language barrier that sometimes existed in communication with native Kurdish, Vietnamese, and Arabic speakers. Interviews were conducted in Swedish, English, German, Spanish and Persian. Flick (2009) mentions interpretation as a shortcoming of semi-standardized interviews. The selection of quotes and the translation are connected biases. The selection of quotes is addressed firstly by having a comprehensive account of statements by the research question directly corresponding to the initial question asked and the affirming confrontational questions, secondly by a subjective measure of exhausting the thematic groups. The translation was addressed by cross confirmation with fellow researchers.

3.2 Kvillebäcken

The basis of the Kvillebäcken study (Article II) was an in-depth interview study with eight real estate developers. The interviews lasted approximately one hour and were recorded and transcribed. By applying a snapshot in the Kvillebäcken case study development process perspectives among the seven developers could be identified (Ragin and Becker 1992, Yin 2008), in an area where sustainable development issues are proposed to be at the forefront. These perspectives are used to illustrate what key practitioners expect, foresee, and overlook in the contemporary sustainable development targets for the housing sector.

An interview guide was followed containing questions of: innovation within the company, housing concepts offered, perceived changes in standards during the past decade, and identified drivers for housing development. The interviewer kept to the interview guide as far as possible, following the same sequence of questions and progression of questions throughout the interviews. However, minor variations naturally occurred due to the length and focus of the respective interviewee's response (Kvale and Brinkmann 2008).

As part of the inductive process the material was then coded using markers on three levels; content relating to the company/industry in general or specifically to Kvillebäcken; content belonging to identified reoccurring main themes of the interview; and content specific to subthemes that might or might not be reoccurring throughout the interviews. The coding was hence done partly with the interview guide in mind, complemented by observing the patterns of themes that emerged when reviewing the processed material as a whole.

In order to visualize observed patterns, a text analysis was conducted according to the themes revealed in the inductive process (Thompson 2001). The bias emerging from the interviewer's wording and the varying total word usage in each theme was mitigated by adding the words most frequently used by interviewees as well as interviewer in each theme and subsequently comparing the ratio of the words in each theme. To be noted is also that the words 'people' and 'common' were given extra attention to differentiate usage in a context outside of the thematic group.

In this thesis the analysis was taken one step further by separating social sustainable development conceptually into categories and analysing how developers were speaking of social sustainable development. Because the interviews were not initially intended to be used in this way the analysis took a step outside of the interview guide when identifying words to be used. Words were taken from: the interview guide, the Kvillebäcken program for sustainable development (Kvillebäcken 2013), and international literature on social sustainable development. Some words were thus found to be used neither by interviewer nor interviewee. Furthermore it is relevant to investigate how other elements of social sustainable development are thought of by the developers that fall outside of the program. In the results chapter the following categories are described in more detail:

- Awareness of sustainability
- Tenure and apartment size
- Outdoor environments
- Affordability
- Community

Relatively little room was given to social sustainable development during the interviews resulting in fewer total word counts and increased granularity. Furthermore the purpose of the interviews was not primarily directed to social sustainable development. As an example, no questions were asked regarding resident awareness of sustainability even though this was a stated policy in the Kvillebäcken program for sustainable development.

Chapter 4

Results and Discussion

4.2 Hammarkullen

In the Hammarkullen study (Article I) the consequences of the implementation of volumetric billing of water was studied. A special focus was given to the group of households where inhabitants are unemployed and receive welfare from SWS. The figure in Article I that best describes the reduction of water consumption is figure 5 below. After the implementation of volumetric billing of water it is possible to describe water consumption at Bredfjällsgatan in high detail.

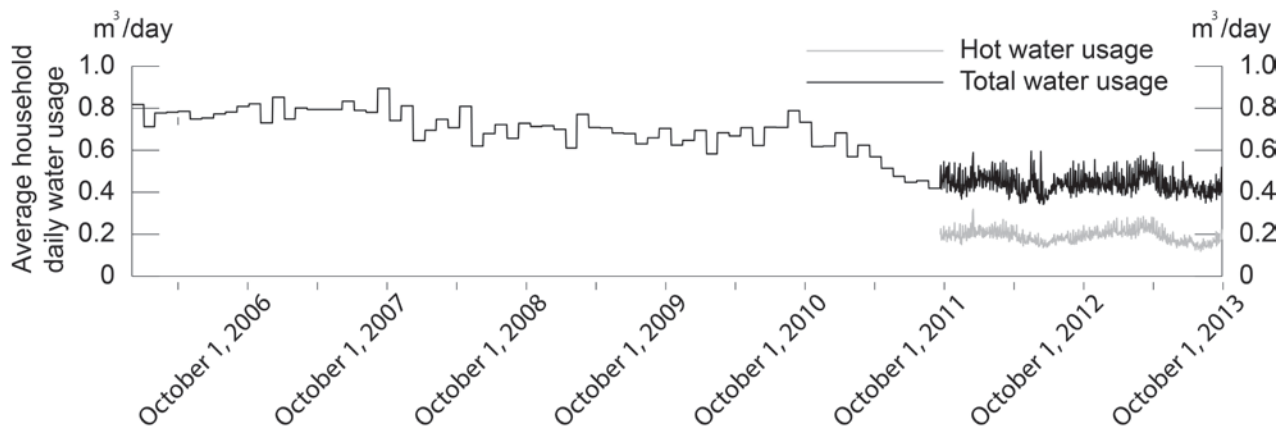


Figure 5. Average water consumption of the households' in the case study area. For the first six years, only monthly readings of water consumption on a building level are available. After October 1, 2011, the readings of individual household consumption had stabilized.

The information that water would be billed volumetrically was disseminated already in the end of 2010. The process of implementing volumetric billing was done one building of approximately 30 households at a time. From October 1 2011 the readings had stabilized for the entire case study area enough to allow accurate analysis, see figure 4 in the chapter 3.2.2 Quantitative data. This explains why water usage decreases before October 1, 2011. In figure 5 we can also see that less hot water is used during the summer months. The difference between the first and the second year after the implementation of volumetric billing of water is an increase of 2%.

This provides some insight into research question 1 (RQ1) phrased in the methods chapter and also provided in table 7. The environmental impact of decreased water consumption (RQ1) in CO₂ equivalents was calculated based on averages provided by Gothenburg water and Gothenburg energy. The total yearly decreased hot and cold water consumption of the 571 apartments amounts to 19381 and 22189 m³/year. The equivalent CO₂ emission is 80.0 and 0.1 ton CO₂ equivalents / year. This is the equivalent of the 571 households driving 680 km in the average CO₂ emitting Swedish car.

Table 7. The research questions phrased in the methods chapter

Index	Research question
RQ1	What are the environmental implications of the introduction of volumetric billing of water?
RQ2	How did the implementation of volumetric billing of water affect different households economically?
RQ3	How was implementation of volumetric billing of water thought of and motivated by stakeholders?
RQ4	How was the implementation of volumetric billing of water received among inhabitants?

One of the more central figures in Article I that can answer RQ2 is figure 6. In the positive integral it is observable that households pay more after the introduction of volumetric billing of water than before. Furthermore households that have their rent and water bill paid by SWS have a slightly different consumption composition. The statistical analysis also revealed which households characteristics were significantly correlated with elevated monthly costs. The following chapter describes the statistical analysis of the result.

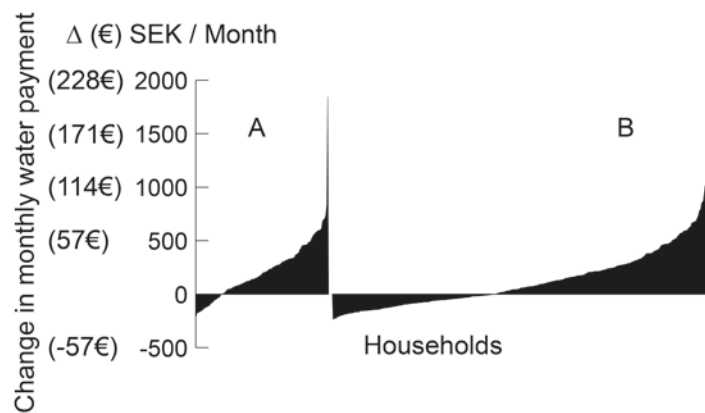


Figure 6. Average change in monthly costs in households after the introduction of volumetric billing of water. A represents those receiving welfare from SWS (N=149). B represent the remaining households (N=422).

Furthermore the argumentation around the lock-in effect of welfare dependency was central in explaining negative impacts on social sustainability targets of social inclusion. A table that was used when explaining the impacts of the implementation of volumetric billing of water was table 8. This table illustrates the economic impact on household economies. Even though the variation in water consumption is great amongst the households as seen in figure 6 it is useful to use the averages to explain economic impact.

Table 8. Water costs for families based on average Swedish water consumption which is similar to the consumption levels at Bredfjällsgatan.

	Price [(€) SEK/m ³]	Apartment with 4 Room and kitchen and 4 residents Additional cost [(€) SEK/year]	Apartment with 4 Rooms and kitchen and 8 residents Additional cost [(€) SEK/year]
Cold water	(1.55) 13,78	(119) 1058	(408) 3633
Hot water	(4.83) 43	(168) 1496	(577) 5137
Total Yearly costs		(287) 2554	(986) 8770

RQ3 was primarily addressed in the Hammarkullen study (article 1) with table 1, summarizing benefits and disadvantages of stakeholders in the implementation of volumetric billing of water. Table 9 is central in explaining the economic aspects of the decision to implement volumetric billing of water.

Table 9. The change from paying a flat rate to paying volumetrically with a specific water tariff had several consequences. These benefits and disadvantages for different stakeholders are summarized in table 4. Monetary values and water consumption in italics have been calculated from the database of 571 households.

Benefactors / Benefits	Benefactors / Benefits
Smaller households are given the possibility to save water and reduce costs <i>82 SEK (9.35€) increased monthly cost on average for single households</i>	Smaller households are given the possibility to save water and reduce costs <i>82 SEK (9.35€) increased monthly cost on average for single households</i>
Real-estate company has decreased the yearly water costs <i>2 350 000 SEK (268 000€) / year</i>	Real-estate company has decreased the yearly water costs <i>2 350 000 SEK (268 000€) / year</i>
Environmental benefits by reduced resource consumption <i>73 l/apartment/day for hot water</i> <i>84 l/apartment/day for cold water</i>	Environmental benefits by reduced resource consumption <i>73 l/apartment/day for hot water</i> <i>84 l/apartment/day for cold water</i>
Environmental benefit in system flexibility and possibility for temporally adjusted water and heat prices	Environmental benefit in system flexibility and possibility for temporally adjusted water and heat prices

When table 9 was presented for SWS the response was that the costs were not high enough to motivate a deeper investigation of an alternative system. The cost of adding bureaucracy for detailed management would quickly surpass the potential savings. SWS were more concerned about the lock-in effect of dependency on welfare, but they did not speak of any action to be taken in regards to the specific case of water payments in this respect.

When the results were presented to Gothenburg Water questions were raised why volumetric metering of cold water had been installed. From their perspective there is little point in reducing cold water consumption with any costly interventions. If the water consumption of Gothenburg is reduced then the marginal price of water will increase since the marginal cost of producing water is low in comparison to fixed costs. Furthermore it was mentioned that the environmental impact of reducing cold water consumption is limited. It was considered better for the environment if more water is consumed as this would increase the flow in the pipes reducing settled solids and clogging.

When these results were presented to the real estate manager it was maintained that environmental aspects are one reason for implementing volumetric billing of water and that water usage in their stock of low-income multi-family buildings was at a level above the national average. Reduced resource consumption and improved environmental sustainability were considered positive outcomes.

By focusing on the decreased annual profit of the real estate company the analysis can be deepened by separating new and old costs. Figure 7 presents a breakdown of the costs of the real estate company. What is interesting to notice is that all costs in figure 7 were known to the real estate owner before the implementation of volumetric billing of water. This reduced the financial risk of the investment substantially. The tariff rate and the assumed occupancy were derived from, Gothenburg energy, Gothenburg water and Gårdstenbostäder, all publically owned companies, which made it easy to motivate the system's change.

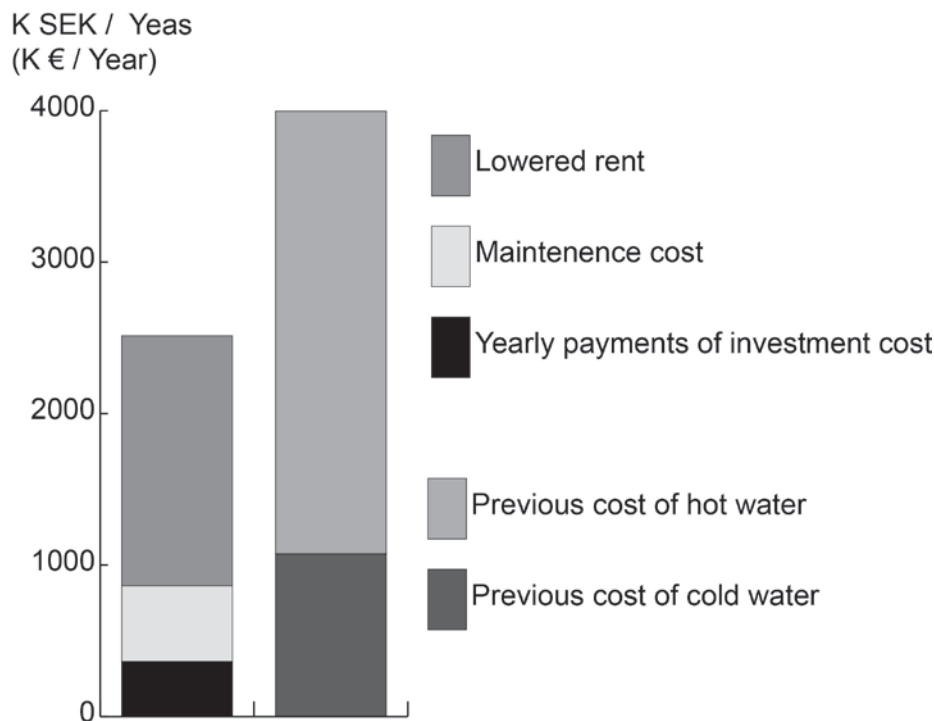


Figure 7. Yearly costs and savings by the real estate company related to the installation of volumetric billing of water from the first year of stable measurements.

In figure 7., the yearly investment cost is calculated with a 5% effective interest rate and a payment plan of ten years, which is the warranty of the water meters installed. Maintenance costs were estimated based on the cost of having one employee working constantly with system maintenance. Profit is certainly needed for a system's change to take place when managed by a private investor. However, it is a risk that equity and equal opportunity are sacrificed for increased profit (Chomsky 1999).

4.1.1 Water consumption patterns and hypotheses behind the statistical analysis

When the study in Hammarkullen started the statistical analysis was going to be the centre of the analysis. However, as the work progressed it became apparent that the socio economic impacts of the implementation of volumetric billing in itself was interesting. The statistical analysis was thus remade to fit the purpose of describing patterns of household water costs. Domestic water consumption is complex and a multitude of pattern studies have been conducted. Pullinger et al. (2013) finds that attempts to categorize consumers in groups is generally complicated and explains the consumption to a lesser extent than when looking at the actual behaviours of consumers. Yet the group of people that receive welfare from SWS get their water bill paid and thus lack direct economic incentive to decrease consumption. Teenagers have also been found to use more water than other age groups (Ek and Nilson 2011). Based on this reasoning the following hypotheses were initially made, see table 10.

Table 10. Hypotheses for statistical analysis based on populations N=85 and N=149 in figure 3.

Index	Hypothesis
H1	Households with more inhabitants use more water
H2	Households with more inhabitants use less water per person
H3	When at home people use water (for cleaning, personal hygiene, flushing, and cooking). More time home should increase water consumption.
H4	Unemployed people consume more water since they lack direct economic incentive, they are home more time during the day, and they live in larger households
H5	People that have water saving appliances use less water
H6	An understanding of the system's change and its economic implication promotes water saving.
H7	The new economic incentives makes people consume less water
H8	People with a concern for environmental issues consume less water
H9	Teenagers use more water than other age groups
H10	Water saving behaviours help people cut water costs

In article I the statistical analysis revealed the four most significant factors of water consumption amongst the 85 households to be: number of inhabitants, presence of teenagers in the households, level of educational qualification, and receiving welfare from SWS; see table 11.

Table 11. Example table from multivariate regression analyses of predictors of average monthly water bill during the first year after the implementation of volumetric billing of water.

Dependent: Average water cost during the first year after the system's change	Model 1	Model 2	Model 3	Model 4	Model 5
Number of people in household	0.481**	0.316**	0.307**	0.309**	0.295**
Teenagers in household		0.369**	0.34**	0.341**	0.373**
Level of educational qualification			-0.222*	-0.234*	-0.219*
Receives welfare from SWS				0.266**	0.253*
Hours spent home per day per inhabitant					0.112
Adjusted R square	.219	.319	.358	.422	.425
R Square Change	.231	.109	.048	.071	.011

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

It was more difficult to find support for the other hypotheses in the data. Confounding between variables, lack of detail in questions, and low response rate made it difficult to assign correlations. For example, water saving strategies show little significant correlation with water consumption (only turning the tap off while brushing teeth explained decreased water consumption). Possibly there is a deficiency in the questionnaire length and structure that lead to this uncertainty. The questions on water saving behaviours were towards the end of the questionnaire.

A strong predictor of water consumption is level of education, see table 11 and Figure 8. This predictor deserves a deeper explanation. It was also observed that the level of education is not linked with cultural belonging, nor receiving welfare SWS. It is tempting to interpret education to be a predictor of an understanding of cost associated with water consuming activities (H6). Since people had not received their first water bill at the time the questionnaire was sent out education might matter for the ability to predict a future cost for water.

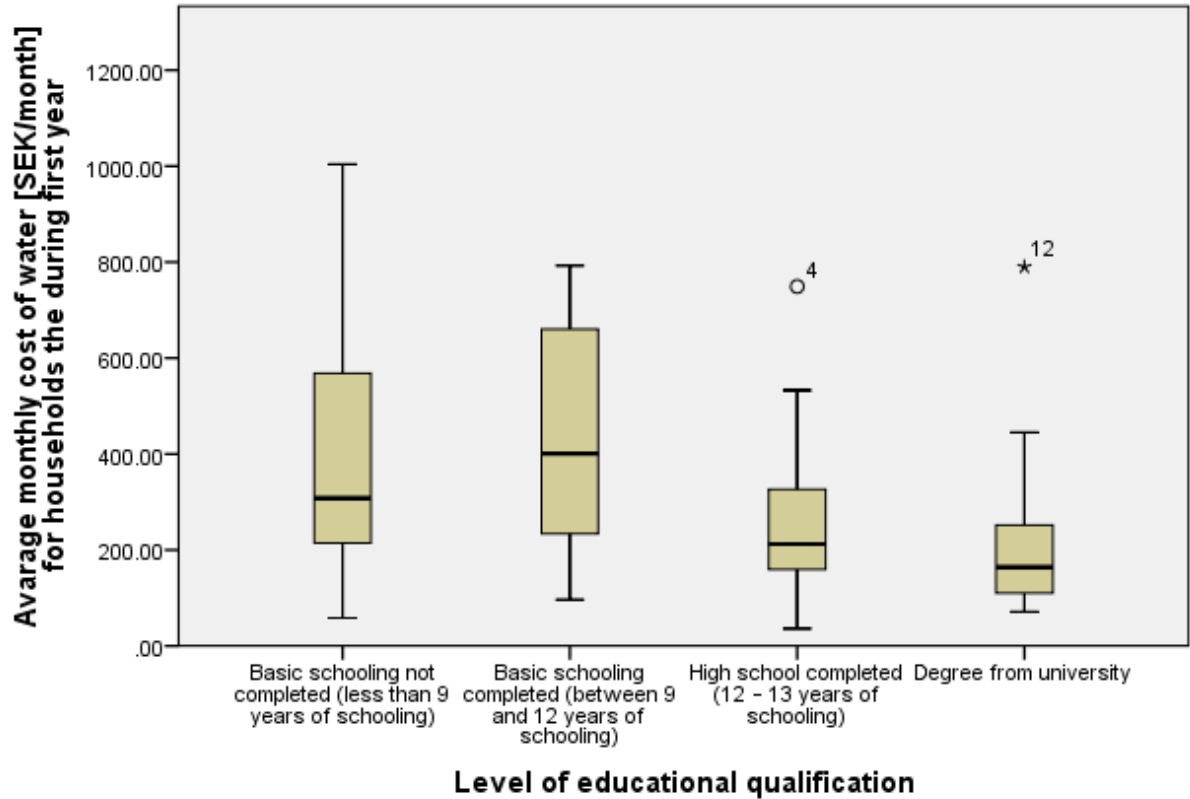



Figure 8. Boxplot of household water costs divided into categories of highest educational qualification in the household.


It is tempting to conclude that there is a link between the findings in the previous chapter about lack of information amongst some of the inhabitants. Many in the area are not aware how their water consumption impacts their monthly costs. This lack of awareness has a general component uncertainty of how much water domestic activities consume that exists amongst water consumers (Pullinger et al. 2013). Potentially this could be linked with level of education. Language spoken at home could have an impact since all information from the real estate company has been in Swedish. It is important to add here that there is no correlation between language spoken at home and level of education in the area.


After the interview studies in Hammarkullen were completed several residents requested information about how much money domestic activities were costing. A leaflet was produced, see Figure 9, and given to the residents who had requested information as well as the real estate maintainer and SWS. However, any reduced water consumption cannot be observed in data with certainty.

hur mycket kostar vatten?





1 bad / bath







6 min dusch / shower







10 min dusch / shower






30 min dusch / shower







per dag för toalett som står och rinner
per day for a toilet that is leaking




how much does water cost?





diska med proppen i
using sink plug while doing dishes

spara  per månad
save per month





vattensnått duschmunstycke
water saving shower head

spara  per månad
save per month





badbalja till små barn
using separate baby bath tub

spara  per månad
save per month




börsta tänderna med avstängd kran
brushing teeth with water turned off

spara  per månad
save per month

20 öre  10 öre

har du ett snålspolande handfatmunstycke?
do you have a water saving faucet head?




spara pengar!  save money!

Figure 9. The produced leaflet showing water costs.

4.2 Kvillebäcken

In the Kvillebäcken study (Article II) it is demonstrated that developers have an unclear and sometimes ambiguous understanding of sustainable development. Furthermore the analysis of the usage of words showed how the different pillars of sustainable development are prioritized in comparison with other constraints and drivers in the building industry (figure 10). For a more detailed description of the steps of the analysis, see chapter 3.1 Methods and Article II.

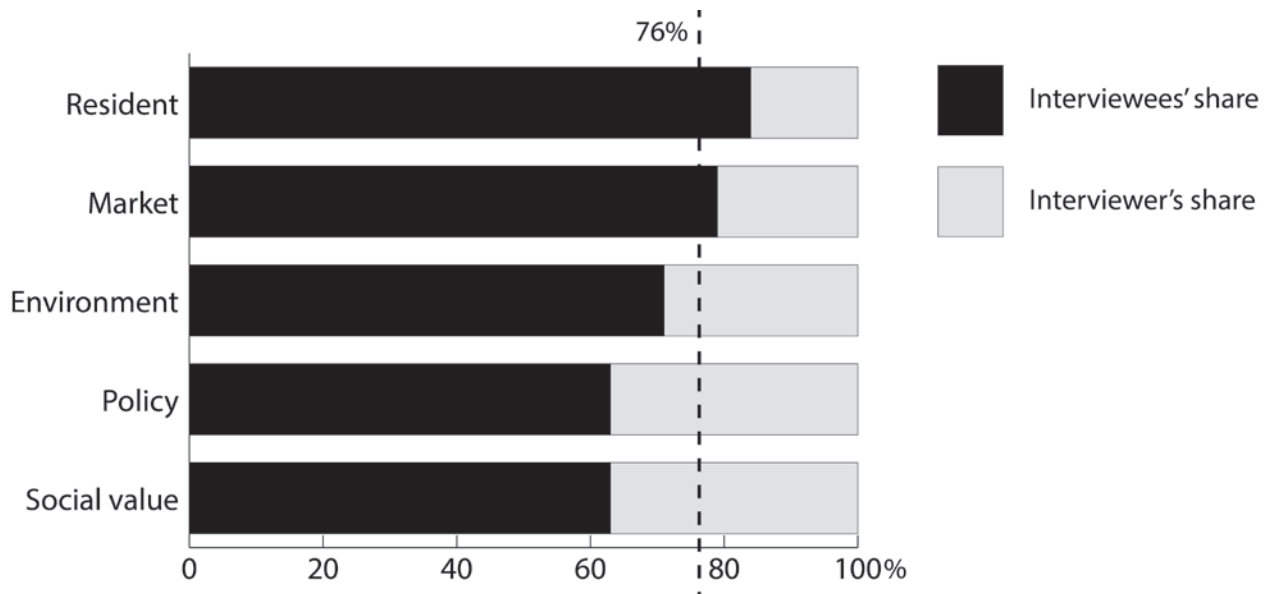


Figure 10. Interviewees' and the interviewer's usage of words in thematic groups. A total of 37 719 words were said during the 7 interviews, of which 28 601 by the interviewees; i.e. 76%.

From the interviews it became clear that social issues and social sustainable development were not the most central concerns of the developers in Kvillebäcken. The developers are more focused and aware of the environmental impacts and targets of Kvillebäcken. Residents were certainly a focus but much more in terms of customers than inhabitants in an area. Even though social sustainable development is not the focus amongst the developers it is still interesting to consider how social sustainable development is considered. There is potentially some overlap between the thematic groups *Social value* and *Residents* when trying to analyse for social sustainable development. This overlap can be studied in more detail by subdividing social sustainable development into categories.

In the Kvillebäcken programme for sustainable development the targets that relate to social sustainable development are:

- Attractive and alive outdoor environments
- Connections between Kvillebäcken with the surrounding city
- Possibility for individual initiatives
- The trademark of the area should be social life quality with safety and diversity

These different targets were separated conceptually based on the literature study. The transcribed interviews were analysed again to see how the developers divide their interest amongst social sustainable development issues.

Attractive and alive outdoor environments implies unique meeting places, and safe environments with little traffic and possibility for an active life (Outdoor environments in figure 11). These elements of social sustainable development are described by Vallance et al. (2011) as maintenance social sustainable development.

Connections between Kvillebäcken and the surrounding city is mentioned as integrating Kvillebäcken into the existing community. Lehtonen (2004) and Murphy (2012) mentions participation and creation of community engagement as a part of social sustainable development which constitutes the Community category in the analysis (figure 11).

Diversity which Murphy (2012), and Dempsey et al. (2011) link with equity is thought of as a diversity of tenures and apartment sizes in the area. However, Törnquist et al. (2012) and Buys et al. (2007) question this will actually have the intended consequence. There is thus a point in separating between aspects of mixed tenure and apartment sizes from issues of affordability which was also part of the interview guide.

Possibility for individual initiatives is mentioned by Murphy (2012) and Lehtonen (2004) as linked with social sustainable development in awareness of sustainability. Even though this is a *Possibility for individual initiatives* it does not require awareness, it is thought of as the basis for creating a social environment where environmental initiatives can arise. Unfortunately it was not possible to separate *Possibility for individual initiatives* in a useful way since the questions asked interfered too much with the individual initiatives for innovation within the company and that no questions were asked on the topic of resident awareness of social sustainable development.

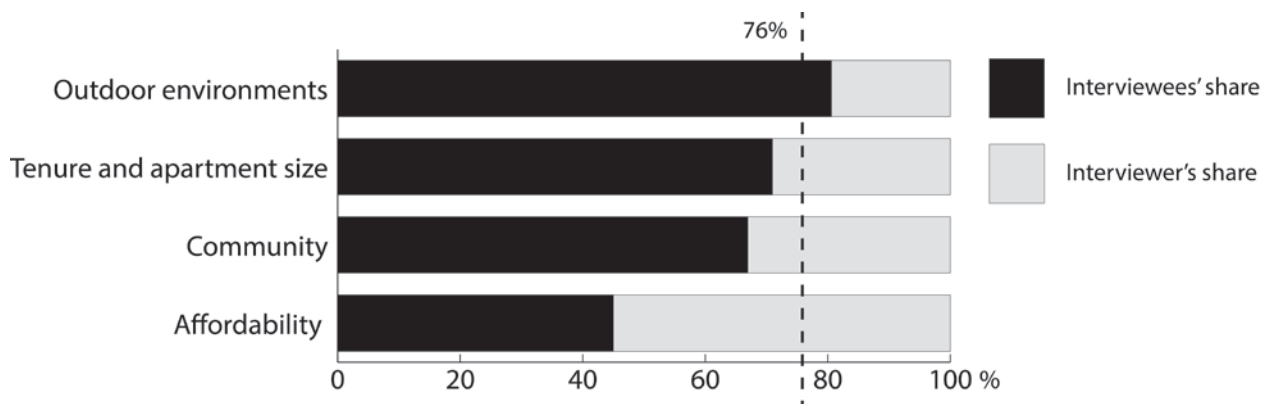


Figure 11. Interviewees' and the interviewer's usage of words in social sustainable development categories. A total of 37 719 words were said during the 7 interviews, of which 28 601 by the interviewees; i.e. 76%.

As expected social sustainable development receives relatively less attention compared to the other thematic groups (figure 11). However, there is a clear tendency that developers focus on accessibility, life quality and safety in the area when they are talking about social sustainable development. Segregation, affordability, diversity, equity were not mentioned and developed any further in the interviews. However, it is clear that the manner in which these targets are thought to be reached is through varying apartment sizes and mixing tenure in the area. (Törnquist et al. 2012, Buys et al. 2007).

Chapter 5

Conclusions

Based on the Kvillebäcken article II study it is possible to say that developers focus on residents as customers and economy when discussing the Kvillebäcken development. Social dimensions of sustainable development receive less attention in comparison with the economic and environmental dimensions. Some of the companies requested policy to regulate construction to safe guard desired values of the built environment.

The project of implementing volumetric billing of water at Bredfjällsgatan was not focused on reaching sustainable development targets specifically. However, environmental and economic aspects were explicitly mentioned as motivators behind the project. The social issue of income distribution was not in focus when implementing volumetric billing. When the payment system for water changed, household economies of marginalized groups of society were affected. Households were given help to reduce water consumption but the monthly costs increased in the area on average. It is important to recognize the key function the real estate manager of such areas as Bredfjällsgatan can fill in reaching social sustainable developments targets.

Chapter 6

Societal relevance and recommendations

When presenting the Hammarkullen study (Article I) questions are often asked about the inequality of the high consumers being subsidized by the small consumers when flat rates are applied. It is important to keep in mind that the focus is not an alternative to volumetric billing of water. Volumetric billing is a powerful tool in reducing resource consumption and decreasing the tragedy of the commons (Mol and Sonnenfeld 2009). However, for solving the problems of segregation and inequity there is a need for larger societal measures (Olsson 2012, Törnquist et al. 2012, Lennander et al. 2013, Werne 2013).

What the analysis of the Hammarkullen data demonstrates is how it is possible for implementing agents, knowingly or not, to exploit the conflict between social and environmental sustainability. The ecological modernization paradigm builds on appreciating the environmental resources with a cost within the modern economic system, where profit is included as a bottom line. When the implementing agent of a system's change is more concerned with making profit than with the fate of the people affected by the system's change, decreased equity and less equal opportunities are often the consequences (Chomsky 1999). The data also show the societal cost of socially excluding marginalized groups by trapping families in permanent unemployment. This societal cost should be recognized and addressed by other regulatory tools in the employment process.

The introduction of the thesis started with the definition of parts of social sustainable development to build a basis for arguments made from data. Numerous attempts to operationalize social sustainable development by defining key performance indicators is done for the purpose of increasing applicability in governance and monitoring. There are many reasons for setting indicators for social sustainable development: easing governance, measuring progress, as well as comparing different dimensions of sustainable development. Part of the problem of joining social sustainable development in an ecological modernization theory framework is that it is complicated to set indicators for social sustainable development in a useful way.

One such example is the usage of the theoretical concept of social capital as something accountable through monetary value. On a theoretical level there is something very appealing in thinking about social capital in relation to natural and economic capital (Dasgupta 2005). McKenzie (2004) writes that a lot of authors refer to social capital as part of social sustainable development. Strong social networks however, are not always positive for a society (Dasgupta 2005). This is one example of a way social sustainable development is oversimplified. When reducing the complexity of social sustainable development and deriving real policy from simplified theoretical constructs then real people may suffer. For example in the Kvillebäcken study (Article II) where the focus is reaching social sustainable development by building meeting places in a homogenous and segregated district, there is a risk that some marginalized groups are further sidelined and that the development of Gothenburg as a whole is forgotten. Furthermore as pointed out by Dasgupta (2005) there are dark sides to social capital which makes it possible for one group of society to benefit at the expense of another due to strong social networks i.e. social capital. In the Kvillebäcken area there is a place where homeless people are spending time. These people will most likely not feel more included in society by the current changes taking place in their area.

Based on observation it is possible to argue that the positive impacts of ecological modernization methods such as the volumetric billing of water lies in their simplicity and accountability in a market based economy. Social dimensions of sustainable development are however complex. When trying to set indicators for social

sustainable development, in order to merge it into ecological modernization theory, many difficulties arise. These include value laden prioritizations, assumptions regarding what people want, and paternalistic generalization regarding behaviour. Regulating policy and subsidies are important when working for social sustainable development targets. Examples of this are the existing subsidies from SWS for water, and different forms of social housing. To be noted is also the mechanical routine with which sustainable development is often implemented. Not all implementation processes are informed or even rational, such as the Hammarkullen case. This further calls for strict and easily followed regulation.

When profitability is expected to drive environmental sustainability the need to protect people and marginalized groups must be acknowledged. To some extent this can be done in legislation or policy, but sometimes the state needs to pay to assure the existence of desired values in society, whatever they may be. It is claimed that there is no conflict between the environmental agenda and social sustainable development. In theory this might be true but when having to make tradeoffs and choose how to spend a limited budget then the conflict becomes clear (Boström 2012). In the case of housing and environmental upgrades these conflicts emerge more clearly (Gough et al. 2008). If there is to be no conflict between the environmental agenda and social sustainable development then marginalized groups should not be forced to pick up the bill for environmental improvements.

As phrased by Lehtonen (2004) “While developing countries are likely to be the most vulnerable, it is reasonable to assume that irreversible social developments may also arise in developed economies. Social precautionary principle should therefore be applied when designing policies. Policy design and studies on the potential effects of policies should be carried out in a dialogue and public deliberation between all affected parties and involve a consideration of various scenarios.”

In the Swedish case this is not simply a problem that has emerged with the environmental agenda. Comparatively little governmental funding is invested in the housing sector and social housing is not seen as a societal need (Törnquist et al. 2012, Werne 2013). The Hammarkullen case study is able to show how a profitable environmental project can lead to increased monthly costs for marginalized groups. Many times it is easier to make marginalized groups pay for environmental upgrades simply because they are economically exposed and lack alternatives and power to make their voice heard.

The part of Bredfjällsgatan that has been presented in the thesis is owned by a private investment company. The underlying company, the real estate maintainer, is responsible for maintenance of the buildings. The staff of the real estate maintainer is perhaps in the best position to facilitate improvement of the area. The staff has long term experience of working in the area and know people well. The real estate maintainer is understaffed compared with the other real estate managers in terms of employee per served flat, and the real estate maintainer is not recognized for the key function the real estate maintainer serve in working against segregation in society. When economic savings is a target given by the private investment company to the real estate maintainer then there is a risk that marginalized groups come under increased economic stress. The real estate maintainer initiated and implemented volumetric billing of water. The real estate maintainer is in a position to positively impact a marginalized group in society if given resources and directives to do so.

An interesting and perhaps idealistic way forward is the cooperation between real estate owners and SWS. The potential areas for cooperation are information sharing and ownership utilization. SWS has information about inhabitants that could be used to safeguard residents from exploitation when environmental projects are implemented. If the real estate owner could be trusted to manage this type of data then fair rents could be achievable. There are several hinders to be overcome: the system of private ownership is built on limited trust, and the high sensitivity of the data. SWS actually pays the rent of a substantial number of the residents

in the area. SWS has power and invested interests in the area. An upgrade of the area is in the interest of SWS. These factors could be utilized in a formal cooperation between SWS and a real estate owner. The problems with this are that: the formal tenant should still be the inhabitants, reducing the negotiating power of SWS; contracts of rental flats have a limited value and raising their value might further worsen segregation.

Kvillebäcken was granted 35 million SEK for environmental upgrades (Kvillebäcken 2013). The idea was to incentivize and promote environmental housing. In a similar manner the inhabitants of the Swedish millionprogram cannot be expected to carry the cost of environmental upgrades. The Brogården project in Alingsås has been wrestling with these issues in their upgrading of million program housing to passive house standard (Femenías and Lindén 2012). A discussion on how to make it possible to channel public funding into the upgrades of the million-program would be interesting. The following challenges would need to be addressed:

- The inhabitants are usually amongst the less well-off segments of the population making increased rents controversial and general inhabitant investments impossible.
- Sweden lacks a social housing program that offer dwellings at sub-market prices which otherwise could have been utilized in an environmental upgrade.
- The technical aspects of environmentally upgrading multifamily housing are challenging.

A lot of the million-program has been sold to private real estate owners. Based on the Kvillebäcken study (Article II) an interesting alternative that surfaced was the idea of using the planmonopol to require developers to include housing at public dispense for social housing at submarket costs in environmental sustainable areas. However, the problem with this suggestion is that the inhabitants will be forced to pick up the entire bill for environmental and social sustainable development improvements. Several scholars stress the need for societal investments to solve problems of ongoing segregation (Olsson 2012, Törnquist et al. 2012, Lennander et al. 2013, Werne 2013).

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