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THE INTEGRATION PROCESS OF CLIMATE CHANGE ADAPTATION FOR FLOOD MANAGEMENT IN SPATIAL PLANNING

DRAWING EXAMPLES FROM ÄLVSTADEN-GOTHENBURG BETWEEN 1999-2015

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ABSTRACT

Due to climate change and natural variations in the hydrological cycle, global mean sea levels are increasing, causing the mean sea levels in different regions of the world to increase. In Sweden, coastal cities are facing rising water levels which is increasing flooding. The coastal community of Gothenburg, Sweden was identified the 18th most vulnerable city in the country both to flooding induced by water level rise and other climate change related impacts. Its location, in proximity of Lake Vänern, and in the mouth of the Göta River and its tributaries: Säveån, Mölndalsån and Lärjeån is heightening flood risk and vulnerability in the area. This thesis aims to contribute in comprehending the integration process of natural hazard and climate change adaptation for flood management in Älvstaden- central Gothenburg between 1999 and 2015. With the main objectives being" how the municipality of Gothenburg has applied the urban land use planning theory for the integration of natural hazard and climate change adaptation, with regards to adaptation for flood management in Älvstaden between 1999 and 2015? "What climate change adaptation policies for flood management have been implemented in Gothenburg within this time frame, and how the policies have been revised to match the reality of flood issues?" And "What improvements would be made in the integration process to better address adaptation for flood management?" A desk-based research and one case study approach was adopted for this study. The findings indicate that although the city has systematically used the steps involved in the integration process of natural hazard and climate change adaptation for flood management, it does not link the policies and the measures applied to adaptation for flood management. Which is an issue as it has led to the exclusion of vital functions of the integration process. Suggestions on how the integration process could be improved are provided.

Keywords: climate change; rising sea levels; adaptation for flood management; urban land use planning theory for the integration of natural hazard /climate change adaptation; Älvstaden- Gothenburg

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1. INTRODUCTION

Historic emission of greenhouse gases in the atmosphere is accountable for the changes which the planetary climate system is currently facing. Inter alia, rising sea level induced by climate change is heightening flood risk in urban, and low-lying coastal communities (Graeme 2015, Irannezhad et al. 2014, and Nicholls 2011). Although no clear link has been made yet between climate change and the changes observed in precipitation pattern, extreme weather conditions, rapid melting of the ice cape, sea level rise and flooding. There are enough evidences that, runoff and discharge is increasing, causing the global mean sea level to rise. As sea levels rise, it influences the water levels of within regions, causing floods (Royal Society 2014). Although both urban and rural environments are faced with flood, the complex structure ("interlinked social and ecological and technical system" (Sköld et al. 2015, p. 32) of the urban environment is increasing both flood risk and vulnerability (Roggema 2009 and Wong et al.2014).

Climate scenarios have projected that, rise in the global mean sea level would influence the mean sea levels in different parts of the globe. As a matter of fact, most of the projections made by the United Nation's leading organisation of climate change issues, Intergovernmental Panel on Climate Change (IPCC), with regards to rise in sea levels, increase temperature and flooding trends are happening (Royal Society 2014). With regards to this, it was projected that, as the global climate gets warmer, it would force the global mean sea level to rise with at least 0.18 to 0.59 by 2100. Within the Swedish context, rise in global mean sea level will cause the water levels in the North Sea to rise with at least 0.6-1.0 metre by 2100, while taking into consideration such factors as: extreme weather conditions, increase in storm surges, the estimated rise will be close to +2 metres above the present mean sea level by 2100 (Göteborgs Stad Stadskansliet 2009). This would hence, increase the water levels along Swedish coasts. Although the effects of this will not be evenly spread throughout the country, but it would in particular impact Gothenburg which is located close to the North Sea, in proximity to Lake Vänern, and surrounded by a network of water which passes across the city. As well as its low-lying nature, Gothenburg is expected to experience severe flood problems induced by rise in water levels (Sörensen et al.2013). Two main reasons explain why Gothenburg will be most affected. First, the water level of the North Sea and Vänern influences the water levels of the Göta River (Gothenburg is located in the mouth of the Göta River). Second, water levels in the Göta River will influence the water levels of its three main tributaries: Säveån, Mölndalsån and Lärjeån which run through the central part of the city also known as, Älvstaden (Irannezhad et al. 2014).

Besides rise in water levels, increase in downpour, runoff and extreme weather conditions such as wet spells and storm surges induced by climate change (Weisse et al. 2012) would increase the occurrence and frequency of flood. With regards to Gothenburg, there are enough evidences of change in the pattern of rainfall. Annual precipitation has increased since the mid-1980. In 1998-2000, annual precipitation increased by 40% and by almost 30% in 2001-2003 over the cumulative average from 1917. Moreover, rise in temperatures has accelerated ice melt and increased runoff. Extreme flows and storms have increased which has influenced the water levels (Göteborgs Stad Stadskansliet 2009) and caused flood events. Due to rising water levels Gothenburg was flooded in 2005, in 2006(Sörensen & Bengtsson 2014). And 2008, the Mölndalsån River and the tributaries of the Göta River flooded. And in 2010, heavy downpour caused flash flood which affected several basements. Events of floods were registered in 2011 in the areas of Stampen, Norra Gårda, Göta tunnel, Marieholm and Säveån (Filipoya et al.2012). In a nutshell, from 1999 to 2015 Gothenburg has experienced flood events. And flooding has been a direct threat to infrastructures, private and public property as well as human life. Since 1990, Sweden has registered 11 deaths due to flooding (Sörensen & Rana 2013).

Although both urban and rural coastal communities are facing heightening flood risk due to sea level rise, (Sköld et al. 2015), the complexity of the urban milieu (high urbanisation, increase in lakeside living and concentration of valuable asset near water courses) puts urban coastal citizens in a most vulnerable position with regards to both flood risk and vulnerability (Building Futures and ICE & Institution of Civil Engineers 2010, Swedish Government Official Report(SOU) 2007 and Moback 2014).This situation has equally created an awareness of flood risk and vulnerability within the urban citizens, and promoted the early introduction of climate change adaptation policies into land use planning (Ford & Ford 2011). In the case of Gothenburg, Sweden, flooding impacted by both climate change and natural variability is taken into consideration in the comprehensive plan (Göteborgs Stad Stadskansliet 2009), which is a tool of the land use planning (Grannis 2011). To turn a negative problem (rise in water levels) into a positive one, environmental objectives and goals have been integrated into the land use planning system (City Council of Gothenburg 2012).

Land use planning has been proven an effective tool in addressing the impacts of climate change and natural hazards, as well as in minimizing risk and vulnerability (Berke & Stevens 2016).Reason being, it has the potentials to facilitate the development and integration of climate change and natural hazard adaptation policies through its regulatory rules and strategy planning (Wilson & Piper 2010 and Wilson et al. 2009).With regards to the impacts of Sea Level Rise (SLR) such as flooding, (which is relevant in this study), land use planning is used to integrate flooding as an integral part of the planning process through which adaptation policies for flood management which seek to; protect (protection), accommodate (accommodation), retreat and even attack have been developed and implemented (Bray et al.1997, Klein et al. 1998, Few et al. 2007a, Abel et al. 2011 and Roth et al. 2011). Godschalk et al. (1998) in their urban land use planning theory for the integration of natural hazard and climate change adaptation showed that the integration process of natural hazard and climate change into land use planning involves four steps: (i) generating planning intelligence regarding hazard risks and vulnerability of the local population; (ii) setting goals and objectives for reducing risk and vulnerability; (iii) adopting policies and programs to achieve the goals and objectives; and (iv) monitoring and evaluating the results, making revisions to policies and programs over time as necessary. And Horowitz (2016) and Few et al. (2007a), underlined that, with regards to adaptation for flood management, the outcome of these steps are the development of three policies (which in some context have evolved to four policies that is the policy of attack); (1) protection(defence), whereby structural measures which involve heavy engineering are used to prevent intrusion of floodwater into the built-up area and the environment (Horowitz 2016), (2) accommodation, imposes adaptation measures such as building codes and green infrastructures, just a few to name, in zones which are highly exposed to flood risk and vulnerability. The objective of the accommodation policy, is to accommodate flood by adjusting the area to the changes (Lee 2014) and (3) retreat which is perceived as one of the toughest policies (Bary et al. 1997), as it avoids both flood risk and vulnerability by relocating (abandonment of human settlement) human population in higher elevation or safer grounds (Few et al.2007a). Pressure put on the local government with regards to the development of water fronts (Goytia et al.2016) has resulted in the flood management policy of (4) attack (Building Futures and ICE, Institution of Civil Engineers 2010). In the attack policy, there is an outward movement of people and development into the waters, that is the water surface is used for development by adopting the urban design to resist flooding (Building Futures & ICE, Institution of Civil Engineers 2010 and Roth et al. 2011).

1.1 Aim And Research Questions

The aim of this study is to describe and analyse the city of Gothenburg, Sweden, engagement in climate change adaptation for flood management between 1999 and 2015. This is done by analysing the various ways in which Gothenburg has integrated climate change adaptation for flood management, (as an impact of sea level rise extreme weather conditions due to climate change) as an integral part in the land use planning process (spatial planning), that is how the issue of reducing flood risk and vulnerability has been considered, laid out and problematised in the comprehensive or master plan and other policy documents of the city.

By using selected measures as presented and explained by the urban land use planning theory for natural hazard and climate change adaptation, focus will be laid on practical examples on how Gothenburg has actively engaged in the integration of natural hazard and climate change adaptation for flood management in its land use planning(spatial planning) between 1999 and 2015, hence the four steps of the integration process of urban land use planning for natural hazard and climate change adaptation: (1) generating planning intelligence regarding hazard risks and vulnerability of the local population; (2) setting goals and objectives for reducing risk and vulnerability; (3) adopting policies and programs to achieve the goals and objectives; and (4) monitoring and evaluating the results, making revisions to policies and programs over time as necessary, will be used. Further, to identify the climate change adaptation policies for flood management which has been developed and applied in Gothenburg hitherto, the four-main climate change adaptation policies for flood management: protection(defence), accommodation, retreat and attack will be used. And suggestions will be made to improve the integration process for adaptation for flood management. The following questions should however be answered:

- How has the municipality of Gothenburg applied the urban land use planning theory for the integration of natural hazard and climate change adaptation, with regards to adaptation for flood management in Älvstaden between 1999 and 2015?
- What climate change adaptation policies for flood management have been implemented in Gothenburg within this time frame, and how have the policies been revised to match the reality of flood issues?
- What improvements would be made in the integration process to better address adaptation for flood management?

2. METHODOLOGY

To comprehend the city of Gothenburg's engagement in the integration of natural hazard /climate change adaptation for flood management in its spatial planning system between 1999 and 2015 in Älvstaden (Central Gothenburg), as well as, to identify the adaptation policies for flood management implemented within this timeframe in the area, a desk-based research method was used, which is the strategy used for data collection. Based on the desk-based technique, data was thus, collected through document analysis and literature review. Whereas, to get a profound understanding and specific context (Creswell 2002), of practical examples both in the integration process of adaptation for flood management and identification of adaptation policies for flood management implemented in the study area, a single case study approach was selected. While, several case studies provide room to make comparison between different regions (Johansson et al. 2005), a single case study provides specificity and context. These two aspects are important while studying climate change or natural hazard adaptation. This is because climate change vulnerability and risk are location specific, and adaptation measures are better addressed at the local levels (Næss et al. 2005). By implication no two locations will have the same adaptive capacity, some might have relatively low adaptive capacity which will influence the implementation of adaptation measures, whereas the reverse will be true for certain locations. This implies if several case studies are used, they might not produce matching results (Johansson et al. 2005).

Limitation with this method is that, the desk -based research cannot provide all the answers to the research questions. This situation could have been avoided if an in-depth telephone or face to face interview was made in addition to the applied approaches of the study. Although the author had plans on conducting an in-depth telephone interview, it was cancelled. Because, the author loss her voice due to a severe cold during the set period for the interview. Although calls were made, but it was difficult for the respondents to hear the author. Another limitation is that, the case area is still undergoing development, as such most of the adaptation policies and measures for flood management in the area are based on pilot projects, which therefore limits the study as proper examples cannot be drawn.

Moreover, Älvstranden- central Gothenburg was selected because, it is most exposed to flooding induced by rising water levels and extreme weather conditions and has experience several flood events. The area also has development potentials. Currently, it is undergoing construction and the municipality intends to solve the housing problems it is facing by building residential quarters in the area. Considering its strategic location with regards to other locations of Gothenburg, it will be developed into a node to connect the different islands of the city (Göteborgs Stadsbyggnadskontoret 2003). Besides, the municipality also emphasized that, development in this area is based on political and economic reasons (Göteborgs Stad 2007). (See map(c) on page6). Building on this, the area presents an interesting case. This is because its vulnerability and exposure to flooding as well as its geographic location and political interest has attracted new developers in the area, whom in collaboration with the city planning office and other research bodies, have conducted several researches on climate change adaptation for flood management in the area (Sköld et al. 2015). The implication of this is that, the area can provide the necessary information needed to conduct the empirical analysis of the current study (Davidse et al.2015).

Besides, the timeframe for the study covers 1999 and 2015. This is because although Gothenburg (like the rest of Sweden) was active with climate adaptation issues, focus was on mitigation of greenhouse emission (Swedish Commission on Climate and Vulnerability 2007 (SOU 2007). It was not until 1999-2000 that, the municipality of Gothenburg shifted focus to climate change adaptation (Ebeling 2008). Furthermore, the new comprehensive plan which was enforced in 2009, took into consideration flooding impacted by sea level rise and recommended integration of climate change adaptation for flood management in physical planning (City Council of Gothenburg 2009). Besides, in 2010, when the Planning and Building Act (PBL) was revised, the new legislature required local governments to include climate change risk, vulnerability and impacts in their comprehensive plan (Lundqvist 2015). The current study, thus takes into consideration adaptation policies for flood management. That is, flooding induced by climate change or due to natural variation in the hydrological cycle. Flood management in the context of this study, therefore relates to the management of, rise in water levels, excess water due to heavy downpour, runoff and storm water which cause sewage systems to congest, triggering flooding. Whereas adaptation for flood management infers to the adaptation policies which have been used to adapt the built-up area and the environment to the changes these climatic parameters trigger (Wamsler et al.2013).

Map(c): Älvstaden in Gothenburg. Source adapted from: www.vestregion.no

2.1 Data Collection

To analyse the city of Gothenburg's engagement in the integration process of climate change adaptation for flood management into its land use planning system (spatial planning), a single case study and a desk-based research approach was used. And to relate practical engagement in the integration of flooding into land use planning(spatial planning), the development and enforcement of climate change adaptation policies for flood management- protection(defend), accommodation, retreat and attack, policy documents were selected to cover all relevant areas of the comprehensive plans of the municipality (Översiktsplan) for the periods 1980 to 2009, follow up of comprehensive plans from 1999-2015(översiktsplan för Göteborg – uppföljning 1999- 2015), detail plans (Detaljplan), Water Programmes ("Vatten så klart"), In-depth comprehensive plan for the water sector covering the periods 1999- 2015(fördjupad översiktsplan för sektorn vatten 1999-2015), municipality protocols, meeting minutes. Gothenburg's visions and goals from 1990s-2015, and Gothenburg Climate Strategy programme ("Klimatstrategiskt program för Göteborg" 1999- 2015). Protocols and policy documents on flood risk and vulnerability assessments, and adaptation measures for 1999 to 2015 were covered as well. Furthermore, to understand how storm water and drainage systems have been managed to avoid flooding in the area, relevant document from previous research between 1999 and 2015 have been covered. Whereas to get relevant information on the government's role in adaptation for flood management in the area as well as collaboration between the municipality and other actors of the land use game, all relevant documents from 1999 and 2015, from the Swedish Civil Contingencies Agency, County Administrative Boards (Länsstyrelsen i Västra Götalands län) and Mistra urban futures have been covered as well. To sum up, data collection for the analysis was performed so that no relevant information which might improve the analysis is left out.

2.1.1 Analysis of Data

This paragraph presents the selection of documents used for the analysis of the thesis and how the documents have been used to relate the urban land use planning theory for the integration of natural hazard / climate change adaptation to practical cases in the study area. It therefore presents the key factors which were taken into consideration during the findings. Table(a) on page8

3. THEORETICAL BACKGROUND

In this section, the urban land use planning theory for the integration of natural hazards and climate change adaptation, on which the current study is based, is presented as well as adaptation policies for flood management which have been developed during the process. The urban land use theory can be used to comprehend the steps involve in the integration of natural hazards and climate change adaptation into the land use planning process (spatial planning) at the local level (Berker & Stevens 2016, Richardson & Otero 2012, Bajracharya et al.2011 and Collins et al. 2005). It is however important to bear in mind that, in a general perspective, climate change adaptation in the context of urban land use (spatial) planning is perceived as "hazard mitigation through the identification of constrained land" (King et al.2013, p.5). This infers flooding being a natural phenomenon, cannot be completed prevented. However, flood risk and vulnerability can be reduced (Richardson et al. 2012). Planners hold a key role in the development and enforcement of adaptation policies. By mainstreaming climate change into existing policies, programmes and legislation, climate change adaptation policies have been adopted and implemented (Grannis 2011). By way of example, the four-key climate change adaptation policies for flood management in coastal regions facing sea level rise: protection(defence), accommodation, retreat and attack, which are some of the outcomes of implemented policies, legislations and programmes during the integration phrase of natural hazard and climate change adaptation into land use planning process (Richardson et al.2012).

Steps involved in the urban land use planning theory for the integration of natural hazard /climate change adaptation	Key Factors	Documents used
(i)Generating planning intelligence regarding hazard risks and vulnerability of the local population	Identification of natural hazard/climate change hazard Collaboration between different actors of the land use planning game for data collection Identification of expert and distribution of task Development of flood risk and vulnerability maps Flood simulation and projections of future rise in water levels Identification of vulnerable group Suggestions of adaptation measures for flood management Dissimilation of flood risk and vulnerability information Comprehensive plan and website Public participation	The Swedish Civil Contingencies Agency (MSB)(report) Göteborg Stadsbyggsnadskontoret (2008) Ramböll (2015), Göteborg stadskansliets (2006) (municipality's policy document -report), Sörensen & Rana (2013) Länsstyrelsen i Västra Götalands län (2015) (policy document) Göteborgs stadskansliets (2006) municipality policy document in the form of report), Göteborg Stadsbyggsnadskontoret (2008) and Roth et al. (2011) Göteborg Stadsbyggsnadskontoret (2015) municipality policy protocol), Comprehensive plan (2009) Comprehensive Plan (2009)
(ii)Setting goals and objectives for reducing risk and vulnerability	Robust community "Living with Water" and "keep water away" Measures to achieve "living with the water": Minimum floor level, zoning ordinances, the adaptation policies accommodation, attack, defense(protection) and retreat	Comprehensive Plan (2009) and Stadsbyggnadskontoret (2010) (municipality policy document in the form of report) City Council of Gothenburg (2012) (policy document -report) Göteborgs Stadskansliet 2009, Compehensive Plan of Gothenburg (2009), detail plan-Water Programme" Vatten Så Klart" City of Gothenburg (2016), Nilsson (2016) (Research document), City Council of Gothenburg (2011) Göteborg stadskansliets (2006), City of Gothenburg (2012) and Roth et al. (2011)
(iii)Adopting policies and programmes to achieve the goals and objectives	Protection- hard measures: Construction of dams and floodwalls Protection-soft measures: Vegetation-green space, parks, green corridor, green roofs green courts and forest Accommodation: Minimum floor level, land uplift, upgrading of Sewerage pipes Attack: The clever little student flats (on water and near water), floating homes in Södra Älvstranden and floating stages Retreat: Vital functions of community built in the high elevations of Frihamnen while the low-lying piers are used for recreational purposes	Goytia et al. (2016), SWECO (2014) (report) and Sörensen & Rana (2013) Goytia et al. (2016), Söndergaard (2015), City Council of Gothenburg (2012) and Sköld et al. (2015) Göteborg stadskansliets (2006), Nilsson (2016), Goytia et al. (2016), Sörensen & Rana 2013 and stadsbyggnadskontoret 2010(Uppföljning 2009 Överskitplan) Söndergaard (municipality's policy document – on vision) Roth et al. 2011(Mistra urban futures and municipality of Gothenburg scientific document)
(v)Monitoring and evaluating results, making revisions to policies and pogramme over time as necessary	Addition of safety margin based on new IPPC sea level rise projections, Water programmes New storm water management approach and new sewerage system	Göteborg stadskansliets (2009), Göteborg stadskansliets (2006) and Goytia et al. (2016) Goytia et al. (2016) (scientific document)

Table(a): Key factors, and documents used for the analysis of the results. Source: The Author

3.1 Urban land use (spatial) planning theory for the integration of natural hazards /climate change adaptation

Land use planning infers the procedures and tools the local government employs to manage the use of land for the common benefit of the citizens (Richardson and Otero 2012, P.3 and Kaiser et al.1995), it officialises the role of the planner. And is an integral part of [spatial] planning (Chapin and Kaiser 1995). Land use planning for climate change adaptation which is concerned with anticipating and adapting to future problems rather than providing solutions to past problems (Godschalk et al. 1998), has been proven effective in addressing climate change related impacts (flooding) by helping communities achieve their goals with regards to reduction of flood risk and vulnerability in the built –up area and the environment (Kaiser et al.1995, Collins et al. 2005, Grannis 2011 and Berke & Stevens 2016).

Prior literature on the urban land use planning theory identified a series of steps involved in the integration of natural hazards and climate change adaptation into the land use planning process. By way of example, Kaiser et al. (1995), Collins et al. (2005), Caribbean Handbook on Risk Management (2016), Asian Development Bank (2016) and Godschalk et al. (1998). Moreover, Grannis (2011) developed an 18-land use tool kit through which adaptation measures to sea level rise and its impacts could be integrated into existing land use planning tools. Although the different studies specify varied number of steps involved in the integration process, in a large scale, they all use general steps. This study builds on the urban land use planning theory for natural hazard and climate change adaptation as proposed by Godschalk et al. (1998). This basis was selected for the following reasons: it is relatively general, as such, it could be applied to varying case areas and in addition, it could be used as guidelines for planners and policy makers while integrating natural hazard and climate change into land use planning, and in the development and implementation of adaptation policies for flood management.

In Godschalk et al. (1998) theory, they identified four steps which are essential for the integration of natural hazards and climate change adaptation into the urban land use planning process, which can be added to and related to through other literature. These four steps lay the basis for the development and implementation of natural hazard and climate change adaptation policies. Figure1 on page 12, presents a flowchart of these steps and they are further discussed below.

(i)Generating planning intelligence regarding hazard risks and vulnerability of the local population

The purpose of this step is to identify the scale of the climate change related hazard or natural hazard to be addressed, and determine the experts whose skills will be needed to perform the duty (UK Planning Impacts and Risk (UKCIP) 2008 & Collins et al.2005). By generating planning intelligence, the vulnerable groups of a community are identified as well (Godschalk et al.1998). And making hazard risk and vulnerability information accessible to the citizens stimulates citizen's participation in issues related to climate change and urban land use planning (Berke & Stevens 2016). Whittemore (2014) clarified that, citizens participate in building information fact by adding new information based on their everyday experiences (Whittemore 2014), which means involvement of citizens in land use issues indicate, decision making, goals and objectives settings as well as development and implementation of policies have been done in a democratic (Friedmann 1998) and communicative platform (Forester

1980) Per Arnstein (1969), there is still a social ladder and the citizens fall in the lowest level, which means sometimes public participation is more of routines and formality (Innes 1990).

Policy makers and other actors of the land use planning game use the planning intelligence to keep track of the trend of climate change related hazard, which is vital while developing objectives, goals and policies (Kaiser et al. al.1995). Therefore, the construction of an information based fact of hazard type and outcomes of the hazards as well as the exposure to risk and vulnerability is a vital step in the process (Berke &Stevens 2016). Construction of information based fact are generally done under two broad headings: collection of hazard data and collection of risk and vulnerability data (Asian Development Bank 2016). With regards to the collection of hazard data, emphasis is laid on the current and projected hazard, as well as the current and projected nature of the hazard. Such data are generally gathered from existing "Multihazard maps" and from local research institutes, scientists, researchers and private firms (Asian Development Bank 2016, p.30). Collins et al. (2005) showed that, additional hazard data obtained from local scientists and organisations were useful while building climate change intelligence with regards to sea level rise in Canada. And in the small community of Iqaluit, Canada, Richardson et al. (2012) found out that, local scientists and researcher's data on hazard maps were useful while tracking the trend of flooding induced by sea level rise the last decade. On the other hand, gathering of hazard risk and vulnerability data focuses on the variables which might expose the citizens to further risk and vulnerability (Asian Development Bank 2016) and the expected outcomes (Berke &Stevens 2016), that is in terms of economic, social and environmental damages (Collins et al. 2005) the event might cause. The vulnerable groups of the community (which include: old persons, poor, children, pregnant women physically challenged persons and even those who cannot use the language of the region) are equally identified and specific climate change adaptation measures are developed and applied with regards to these groups (Godschalk et al.1998).

After the collection of hazard, risk and vulnerability data, the planner, then presents them in the form of hazard, risk and vulnerability maps, graphs and summary statistics tables. With the prevalence of computer technology within planning, geographic information system and remote sensing (Patro et al.2009) have been used to build maps and models to identify locations with high risk and vulnerability (Godschalk et al. 1998). In Canada, GIS maps were used to identify locations with are most exposed to risk and vulnerability with regards to the impacts of sea level rise. Bedford Basin in Halifax and the shores of Sambro Harbour-, NS were the identified hotspots (Kershner 2010). Collected data are also presented in simulation models, which present current and future prediction of the behaviour of the natural hazard, variables which might cause the hazard to occur, as well as the estimated damage the hazard could cause in specific locations (Kourgialas & Karatzas 2014). Examples of simulation models with regards to flooding include the hydrological model, which is a planning tool used to understand and predict the behaviour and movement of water. It shows low elevations which could be flooded during high sea level rise or tides and measures water pressure from the drainage system and sewerage. A variant of the hydrological model, is the hydraulic model MIKE11 and MIKE 21. Kourgialas & Karatzas (2014) used Mike 11 in the small Greek Island of Crete to estimate how the depth of water, discharge, and flow velocity could contribute in flood propensity.

Once data on hazard, risk and vulnerability are collected, it is the task of the planner to make the information accessible to the different actors of the land use game (Kaiser et al.1995). The media used is the comprehensive plan, the detail planning and protocols (Grannis 2011). In some cases, municipalities have developed climate change adaptation portal, municipality websites, workshops and focus groups to dissimilate information and stimulate public participation (Roggemma 2009). Grannis (2011), outlined that, development of a planning intelligence is not complete until the gathered information is dissimulated to the different actors of the land use planning game. The crucial function of the comprehensive plan in land use planning and water management as well as in decision making with regards to how land and water should be used and managed in the future, makes it paramount in the dissimilation process. Therefore, once the comprehensive plan considers climate change, it is an indication that, the municipality is ready to engage in the integration of natural hazard /climate change adaptation into land use planning process (Wong et al.2014).

(ii)Setting goals and objectives for reducing risk and vulnerability

The purpose of this step is to lay down the basis for the development of future policies, and programmes which could be implemented to reduce flood risk and flood vulnerability (Collins et al.2005). Planning goals and objectives are developed from the people's desires and wishes to improve their living environment and quality of life, while taking into consideration the economic, environmental and social practical constraints (Kaiser et al.1995). This thus imply that; goals and objectives setting should be broad and flexible to permit changes which might occur due to the uncertainty of climate change impacts (Collins et al. 2005). Another implication is made based on the nature of climate change impacts- flooding, since the impact are location specific (Davidse et al.2015), that is vary from one area to the other, goals and objectives should be location specific as well (Caribbean Handbook on Risk Management 2016). Different goals and objectives should be developed depending on the behaviour of water discharge, height and flow of water in specific areas (Collins et al.2005). Since water levels are definitely different from one part of a region to another, depending on their goals, their proximity to other water sources which might influence their water inputs, goals and objectives to reduce flood risk and vulnerability in the built-up area and the environment have become more and more location specific (King et al.2013).

Figure1: Four steps of the urban land use planning process for addressing natural hazard and climate change hazard

Source: The Author

Examples of goals and objectives set to reduce or prevent the intrusion of floodwater into the built-up area could be: aim to build a robust and resilience community which is able to absorb flood events without the economy collapsing (Weichselgartner & Kelman 2014). To increase the community's robustness, innovative climate change adaptation measures could be integrated in urban design and land forms as well as infrastructure(Lee 2014).Such goals and objectives would discourage new development in flood prone areas, that is development will be allowed inland on safe zones (Horowitz 2016) or encourage development in flood prone zones (Bray et al.1997) by increasing the adaptive capacity of the area through flood proofing individual homes(Horowitz 2016), imposing building codes and regulations (Lee 2014, & Lundqvist 2015). In Denmark, one of the goal and objective with regards to the integration of climate change adaptation into land use planning was to strengthen the coordination of climate change adaptation research activities between the national level, the local and other organisation who work with climate change related issues (Government of Denmark 2012).

Whereas goals and objectives set to reduce flood in king County Georgia, aimed to promote public awareness, improve preparedness by upgrading early flood and storm warning systems and emergency communications (King County Council 2015). In some cases, zoning ordinances are made and areas are classified according to their functions that is residential, commercial, or industrial. The idea of the zoning mapping is to identify parts of the community which are highly exposed to flood risk and vulnerability and to impose specific building codes and regulations in such areas (Kaiser et al.1995 & Horowitz 2016). In some cases, goals and objectives set have been influenced by a particular group of persons in the community (Bajracharya et al.2011), by way of example, in waterfront areas which are attractive locations for development, pressure put on the planners from politicians, the middle and high-income citizens (Frantzeskaki et al. 2014) have led to goals settings which encourage development in these locations although they are highly exposed to flood risk.

(iii)Adopting policies and programs to achieve the goals and objectives

The purpose of this stage is to integrate natural hazard and climate change adaptation into existing policies, by way of example climate change adaptation policies could be integrated into the comprehensive plan through; planning tools, regulatory tools, spending tools and tax market, which are identified existing policies (Grannis 2011). To meet the set goals and objectives of the community, these polices are later enforced (Kaiser et al.1995). In some cases, new policies and programmes are enforced to march the current climate change reality of the community and to enable local government to effectively deal with adaption (Collins et al.2005). To enumerate, the old climate change and natural hazard polices in the local districts of Queensland, which treated climate change issues and planning as separate events, and made the development and implementation of climate change adaptation measures for flood management in these districts difficult. The local government opposed this system, which led to the implementation of the Sustainable Planning Act (2009), which treated climate change issues and spatial planning as integral parts. Therefore, a shift from the old Integrated Planning Act (1997) into Sustainable Planning Act (2009) facilitated the implementation of climate change adaptation measures in Queensland (Bajracharya et al.2011).

Existing policies and programmes for the reduction of flood risk and vulnerability due to sea level rise aim to; protect, accommodate, displace human population from areas which are heavily exposed to flood risk and vulnerability or even build outward into the waters –attack (Horowitz 2016). Bray et al. (1997), Klein et al. (1998), Few et al. (2007a) and Abel et al. (2011) outlined three main climate change adaptation strategies for flood management commonly used by coastal communities faced with Sea Level Rise (SLR): (1) protection, (2) accommodation and (3) retreat. A combination of the strategies could be applied in an area (Bray et al.1996), whereas (4) attack is a policy which is rapidly developing amid coastal communities (Roggemma 2009). The paragraphs below elaborate on these policies.

(1) Protection(defence) policy, seeks to defend the built-up area from intrusion of floodwater (Horowitz 2016 and Bray et al.1997). It involves heavy engineering (Kim et al. 2012) and its methods are grouped into two distinctive categories "hard" and "soft" (Lee 2014). It is implemented through existing arrangement which could be between the national level and the local level or the planner and other actors in the urban land use game (Bray et al.1997).

(a) Hard protection measures are the most used by planners and policy makers (Klein et al. 1998). They include: building of dykes, breakwaters, construction of tidal walls (Bray et al.1997), embankments, permanent structures (Lee 2014) such as floodgates, which are built in the form of flexible barrier. Floodgates more or less create space for water (Horowitz 2016). This infers, as water level rises, they redirect excess water to the right source which might be open space created for the purpose such as: water storage areas or retention ponds (Sköld et al.2015). Although the hard methods are efficient in reducing flood risk and vulnerability, there is the issue of environmental consideration, which allowing to Lee (2014) & Horowitz 2016) is the least environmental friendly method, as it damages the marine ecosystem. Aesthetic considerations matter as well (Bray et al. 1997). Although there is an urgent need to reduce risk and vulnerability, there is equally the need to encourage sea view, hence embankment, be it permanent or temporal must be adjusted to the area it is constructed so it does not block sea view of the occupants (Ford & Ford 2011).

(b) "Soft" protection are the most environmental friendly flood protection measures (Lee 2014). They involve green infrastructure, such as beach nourishment (Bray et al.1997) used to absorb excess water (Nicholls 2011). Berms which are low cost flood barriers could be designed as a "soft" protection and used by individuals, it could be temporal or permanent (Horowitz 2016). And to avoid flood in the interior of low lands, pumping stations are installed and the floodwater pumped out on daily basis. This practice is common with basement floods (Grannis 2011). Soft protection methods involve wetland reclamation (Horowitz 2016 & Bray et al.1997).

(2) Accommodation Strategy: The objective of this strategy is not only to protect the area from rising waters and flooding, but to encourage resilience building (Horowitz 2016). By adjusting buildings to flooding, development is encouraged to continue in flood prone areas (Bray et al.1997). The decision for the continuation of development in such areas is driven by economic and connectivity potentials of the area (Roggema 2009). This strategy is relatively flexible and allows for the combination of other strategies (Bray et al.1997). Furthermore, accommodation strategies are outcomes of "organisational policies and strategies" (Horowitz 2016, p.44). Examples of accommodation methods include: Building codes, elevating buildings and land uplifting (Grannis 2011). With regards to elevating buildings, Wamsler et al. (2013) outlined that, restrictions which allows for the first floor to be used as empty spaces, will reduce flood damage. By this, they meant that, during flood events, the occupants of the house would move to the upper floor which processes all of the valuable assets, while the first floor is deliberately allowed to flood. This method reduces property damage. Besides, minimum level of construction based on the rise of water levels are imposed (Few et al. 2007a). Whereas to improve preparedness, flood and storm warning signal systems are improved (Wamsler et al. 2013). In some areas, this has been done by developing flood simulation models which seeks to understand the behaviour and movement of water especially during extreme weather conditions (Kourgialas & Karatzas 2014). Meanwhile, to accommodate temporal inundation, green corridors are created between open spaces especially in water front areas (Grannis 2011). These corridors serve both as recreational area and nodes between the built-up area and water (Lee 2014 and Nicholls 2011). The accommodation strategy is implemented through coordinated planning, zoning and identification of high flood risk zones (Bray et al.1997).

(3) Retreat means moving inland to safer ground, or relocation of vulnerable persons and economic assets in high flood risk zones to safer grounds (Lee 2014). Bray et al. (1997, p.22), see this strategy instead as "planned abandonment of land and structures in vulnerable areas and the resettlement of inhabitants" on safe ground Grannis (2011) considers retreat as the most controversial climate change adaptation strategy but nonetheless, holds that, when flood risk and vulnerability are highest, retreat turns to be the most effective measure the local government can apply (Nicholls 2011), moreover, retreat can occur without he intervention of the local government, that is when the impacts of flooding or the natural hazard is life threating ,people would move out of the zone voluntary (Kershner 2010). The implementation of retreat strategies is done through strict government legislation and through integration and advanced planning programmes (Bray et al.1997).

(4) Attack policy : In this policy, the population as well as buildings and infrastructures move seawards, that is development is encouraged on the water(Graeme 2015).Notwithstanding, some forms of attack encourage development in proximity of the existing coastline(Building Futures Institution of Civil Engineers (ICE) 2010).To prevent the buildings and infrastructures from flood damage, innovative technologies as well as traditional urban design and construction approaches are used to adopt the features to flood risk and vulnerability impacted by water level rise(Graeme 2015). By way of example, floating or amphibious homes are constructed on concrete floating platform or concrete pontoons and wood frames at low water level, which helps to maintain them suspended on the waters(Hendriks 1999).In some cases, EP-foam and concrete are used to prevent the homes from sinking into the waters (Rijcken 2003).When amphibious homes are constructed close to the water, they are anchored in sea level heights and are adjusted to different heights depending on the projected variations in sea levels. In both cases, rise in sea levels projections are taken into consideration before the development of the homes (Building Futures Institution of Civil Engineers (ICE) 2010). Furthermore, floating vegetation are used to block flood water from entering into the city, and constructed wetlands to close down the height of waves (Graaf et al.2006).Although the concept of attack is to reduce flood risk and vulnerability by building on the water, the primary aim of this concept is to reduce urban sprawl by redistributing population into the waters, by so doing, the growing housing pressure coastal urban communities are facing is reduced(Building Futures Institution of Civil Engineers (ICE) 2010).

Existing example where the policy of attack has been implemented to manage flood is in the Netherlands, where the Floating City IJmeer has been developed on the Rhine delta. Future sea level rise projections and the ongoing high flood risk and vulnerability in the area is the driving force for the development of this floating city. With the primary aim being to provide housing facilities and reduce urban sprawl. The floating City IJmeer, presents a full package just like with the case of cities built on the land surface. It has a highway, which is built such that it would withstand flood damage, and the floating vegetation is used to protect the high way from damage due to rise in sea levels. To facilitate its inhabitant's accessibility with regrades to transport, single car parking lots, floating bridges, with two highways exits, a metro system and a dock are constructed as well as ferries to transport the cars from the land into the sea (Graaf et al.2004). Another example of amphibious homes is in New Orleans which is also vulnerable to sea level rise and flood risk. Here the homes are built near of the existing shoreline and to hinder floodwater from entering the house, the house is elevated on stilt. Hence the bottom level which consist of the stilt is used as car parking while the occupants of the house as well as other critical technical elements of the house are occupy the upper floor which is safe from flood damage during a flood event. Amphibious homes have also been developed in Maasbommel in the Netherlands, in Japan and in Louvre in Abu Dhabi construction of amphibious homes are underway (Building Futures Institution of Civil Engineers (ICE) 2010). Table1 on page 17, shows the four-main climate change adaptation policies for flood management, their features and methods used.

(v) Monitoring and evaluating the results, making revisions to policies and programs over time as necessary

This last step recapitulates the effectiveness of the entire integration process of climate change adaptation or hazard into land use planning. It makes evaluation of the cons and pros of the policies and programmes implemented (Collins et al.2005). Policies and programmes which are considered not efficient are replaced and depending on new climate change projections, some policies and programmes in the three climate change adaptation policies mentioned above might change or be integrated in a particular location (Asian Development Bank 2016). The uncertainty which underlines climate change is the main reason for this last step (Berke &Stevens 2016). The step hence, test the effectiveness and importance of the different techniques applied to reduce flood risk and vulnerability (Collins et al.2005), it monitors sea level rise related changed (Grannis 2011) and uses consultants to investigate, appraise and make suggestions to more relevant flood management techniques (U.K. Climate Impacts Programme (UKCIP) 2008).

Policies	Features	Methods
Protection	"Hard": Temporal and permanent embankments for instance: sandbags, construction of walls and breakwaters, retention ponds, use of dams for the regulation of flow of water and flood gates. "Soft": Vegetation cover and afforestation: incorporation of green parks in waterfronts, green corridors and green spaces, green roofs and rain gardens to reduce runoff and storm water, berms, wetlands and land reclamation.	Build physical barrier to block water from entering the built-up area and environment using heavy engineering. Create buffer with vegetation or land form. Reduce runoff with vegetation cover and forest.
Accommodation	Building codes and regulations; such as minimum floor levels, land uplift, zoning ordinances, choice of building material adapted to flooding, upgrading drainage and sewerage systems, improving flood and storm early warning signal, pump stations, pumps at individual level, permeable surfaces such as; parks, parking spaces and other surfaces which facilitate infiltration.	Citizens are encouraged to live in flood risk and vulnerable areas. To accommodate flooding, functions are upgraded, buildings are adapted to sea level rise and extreme weather conditions which trigger flooding.
Retreat	Abandonment or relocation.	Vital facilities of the society such as, residential facilities, hospitals, schools, offices etc. are relocated in land to safer ground.
Attack	Construction of floating or amphibious homes (using innovative technologies such as building on concrete pontoons, Ep -foam and concrete), floating vegetation and constructed wetlands to reduce flood risk and heights of waves	Move seaward and build on the waters or near the waters, by applying innovative technology to avoid flooding due to sea level rise

Table 1: Adaptation policies for Sea level rise impacts- flooding. Source: The Author

3.1.1. Previous Research

There are many studies on adaptation for flood management. For example, Horowitz (2016) showed how three communities in the United States (St. Augustine, Florida; Elizabeth City, North Carolina; and Alexandria, Virginia) have applied the adaptation polices "retreat", "attack" and "defend" to reduce flood risk and vulnerability in the area. Lee (2014) relates the application of these policies within the context of Mokpo, Korea. In both studies, it was highlighted that the scramble for space in water front areas has been the driving force for the implementation of these polices. They also gave examples of the measures applied for each policy. Moreover, they pinpointed that, hard protection is most applied by coastal communities, which is troublesome as it is the most environmental unfriendly adaptation policy for flood management. According to them to deal with flooding induced by sea level rise, a combination of both polices are recommended.

The current study has been influenced by the study carried out by Wamsler & Brink (2014). This is because their study relates to adaptation for flood management within the Swedish context. Wamsler & Brink (2014) focused on the current adaptation strategies which have been applied in the municipalities of; “Gothenburg, Falun, Arvika, Botkyrka, Danderyd, Helsingborg, Kristianstad, Lilla Edet, Lund, Malmö, Salem, Ystad and the greater urban regions of Stockholm”. The method applied for the study was desk-based research and focus groups. In their study, they found out that, to reduce flood risk and vulnerability in the case areas, physical measures such as: building of dams, embankments and other permanent structures to control the flow of water, recommendation for lowest floor level for new construction, integration of adaptation in the urban fabric, just a few to name were the most used adaptation strategies and accounted for 60% of the measures used. Environmental measures which are sometimes referred to as blue and green measures, were the second most used measures. The aims of this measure are to manage runoff and storm water via rain gardens, green roofs, permeable pavements etc. A third measure they identified is the socio-economic measures which according to them, is the least used. These measures aim at improving “preparedness for response” by way of example, early warning systems and availability of risk information to the public etc. They concluded that, both at the local and institutional levels, “there are no comprehensive approach to adaptation to planning, instead focus have been on the evaluation of barriers for mainstreaming implemented strategies. And highlighted that, the adaptation measures which have been applied in the study areas are not often discussed nor evaluated, which according to them is an issue (Wamsler & Brink 2014).

3.1.1.1 Significance of Study

While most studies on climate or natural hazard adaptation laid emphasis on the identification of adaptation measures applied at the local level (King et al.2013, Grannis 2011 and Collins et al. 2005) and the constraints local governments face while implementing these policies (Levina & Tripak 2006), the current study seeks to highlight on the underling processes which determine a successful integration of natural hazard or climate change adaptation for flood management. By critically examining the four stages involved in land use planning for the integration of natural hazard and climate adaptation. The study therefore, contributes by pinpointing certain key factors, such as the absence of defining vulnerability in terms of social vulnerability and class of citizens who comprise the group. Identification of social vulnerability with regards to the vulnerable group of the community (pregnant women, children, older persons, physically challenged individuals and non- speakers of native language) would help the local government while developing adaptation measures. Which will mean vulnerability will be adequately covered but with just two dimensions of vulnerabilities (economic and geographic) considered, we cannot claim vulnerability has been totally covered which is an issue.

Moreover, the study highlights on the “illusion of inclusion” (Few et al.2007b), that is although the citizens participate in meetings, their voices have not been heard. This is an issue which has affected step(i) to steps(iii) of the integration process. Whereby goals and objectives set as well as adaptation policies for flood management and even suggestions on how the flood issue could be dealt with, has been made while excluding citizens. Exclusion of citizens in matters that directly affects their daily life is undemocratic (Friedmann 1998). Whereas inclusion of citizens would encourage exchange of information from both the planners and other actors of the land use planning game (Forester 1980).

4. CLIMATE CHANGE IS HAPPENING IN SWEDEN

In 2007, the Swedish Commission on climate and Vulnerability made an investigation on climate change impacts and risks in the Swedish society. In a nutshell, the investigation outlined that, average temperature all over the country is expected to increase and winters will be warmer. Increase in precipitation will be witnessed during the autumn, winter and spring. Furthermore, rainfall and runoff will increase. Although no clear trend was made with regards to the speed and strength of winds and storms, there are high chances that they will increase. Sea levels on the other hand are expected to rise by anything around 0.2 metres. As these climatic variables increase, the frequency and occurrence of flood as well as flood risk will be heightened around the valley of the Göta Älv River, eastern Svealand, Lake Vänern and most of the east coast. Increase in lakeside living will increase flood vulnerability exposing both buildings and infrastructures to flood damage. On the other hand, climate change will increase agricultural productivity in the country, hydropower production and forestry. Aside, a warmer climate will increase pests, insects, and fungus and cause health problems for the elderly. Therefore, to take advantage of the positive sides of climate change, the commission recommends the integration of climate change adaptation into spatial planning (Swedish Commission on Climate and Vulnerability 2007(SOU 2007).

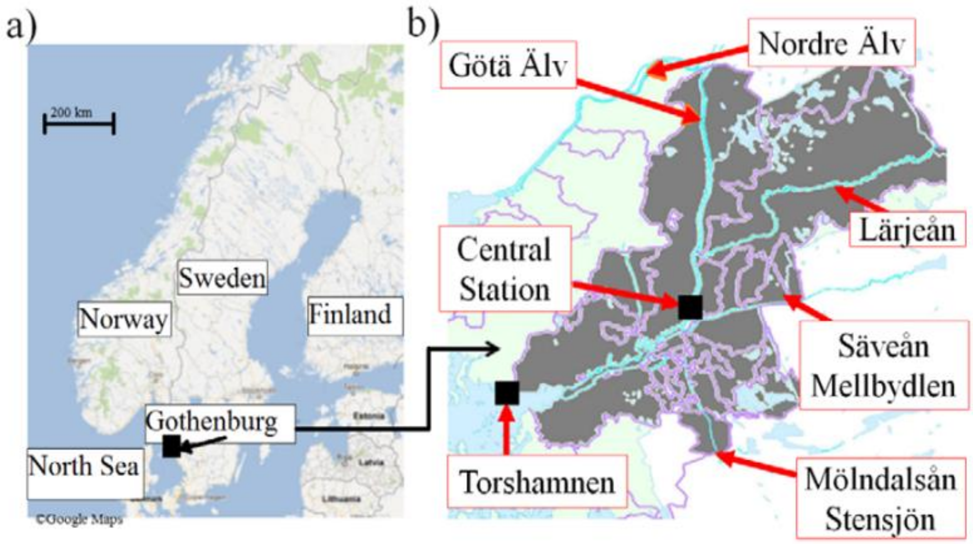
4.1 Actors of climate change adaptation (Sweden)

The task of climate change adaptation in Sweden is shared across all levels of governments that is: the national, local and regional levels. And the national climate change strategy is concerned with economic and regulatory measures (Lundqvist 2015). At the local level, Swedish municipalities are responsible for the development and enforcement of climate change adaptation strategies as well as other natural crises- flooding inclusive (MSB 2009). This implies the practical application of climate change adaptation is conducted in the local level and involves local authorities, individuals, private firms and businesses as well as international organisations (Johansson & Mobjörk 2009). However, local climate change adaptation policies and strategies should fall in line with those of the national level and in accordance with the legislation- Planning and Building Act (PBL). Besides, Swedish municipalities have the municipal monopoly which allows them to act and make decisions which they consider will be beneficial for the development of their community (Cullberg et al.2014).

Furthermore, the central government agencies work in collaboration with the local governments. Their functions are operational and in a broad sense they are responsible for the provision of necessary information with regards to climatic parameters such as: measurements and forecasts as well as funding. They could be therefore perceived as the providers of the regulatory frameworks (Johansson & Mobjörk 2009). Examples of the central government agencies are: the Swedish Geotechnical Institute (SGI), the Swedish Meteorological and Hydrological Institute (SMHI) and the Swedish Civil Contingencies Agency (MSB) who provide the local governments with relevant information on climate change and other natural hazards. Moreover, enforcement of climate change adaptation for flood management in Sweden has been done under the Planning and Building Act (PBL) and at the municipal level, this has been translated in the physical planning and strengthened by the municipality monopoly (Cullberg et al.2014).

4.1.1 Background: Gothenburg

With a population of more than 500,000 inhabitants, Gothenburg is the second largest city of Sweden. It has a population density of 1,200 persons/km2 and covers a surface area of 722 km2, of which 271 km2 is water. The city lies in the mouth of the Göta River which has a catchment of 50,000 km2.The three tributaries of the Göta River: "Säveån", "Mölndalsån" and "Lärjeån", flow into the city (Irannezhad 2009) which exposes it to flood risk induced by rising water levels. Extreme weather conditions induced by climate change as well as the soil type (mostly clay) of the region are also a cause for heightening flood risk (Hjerpe & Glaas 2012), whereas concentration of buildings and population along the water courses is increasing flood vulnerability (Moback 2014). Map1 (a) on page21 shows the geographic location of the city of Gothenburg in Sweden and map1 (b) shows the limit of the Göta River catchment and its three tributaries. Aside the impacts of climate change, the sewage system triggers flooding in the area (Göteborg Stad 2007).



Map 1 (a) geographic location of the city of Gothenburg and (b) shows the Göta River catchment and its three tributaries, the grey colour indicates the limits of the Göta River catchment within Gothenburg city. Source: Adapted from Irannezhad et al. (2014)

5. RESULTS

In this section, the results from the desk-based research documents are presented. The section is thus, divided into two sections: the first section (5.1) answers the question: *"How has the municipality of Gothenburg applied the urban land use planning theory for the integration of natural hazard and climate change adaptation, with regards to adaptation for flood management in Älvstaden between 1999 and 2015?"* This cover, steps (i) and (ii) of the urban land use planning theory for the integration of natural hazard and climate change adaptation. The second section (5.2) focuses on the climate change adaptation policies for flood management which has been implemented between 1999 and 2015 in Älvstaden and how the policies have been revised within this timeframe. Hence steps (iii) and IV of the urban land use theory for the integration of natural hazard and climate change adaptation will be relevant.

5.1 SECTION ONE

(i) Generating planning intelligence regarding hazard risks and vulnerability of the local population

As shown in the theory, identification of the type of climate or natural hazard the area is facing, is an important part in the integration process of natural hazard or climate change adaptation in the land use planning and pivotal while building an information fact. With regards to Gothenburg, based on a flood risk assessment conducted by the Swedish Civil Contingencies Agency (MSB) in collaboration with the EU directive in 2007, the municipality was identified one of the 18th Swedish metropolitan area highly exposed to flood risk and the seventh metropolitan area in Sweden which fits the five climate parameters the assessment was based on. Besides, climate change will cause downpour and precipitation to increase in the area

(Sörensen & Rana 2013). Although increase in extreme weather conditions and rise in water levels could be due to natural occurrence (Nilsson 2016)

"As a part of the work with the EU directive, 2007/60/EC, Swedish Civil Contingencies Agency (MSB) has finished an assessment where Gothenburg is considered as one of the 18 Swedish cities at risk of flooding (MSB, 2011). Gothenburg is one of seven cities matching all five criteria in the assessment. Higher precipitation and sea level rise are expected in the future due to climate change" (Sörensen & Rana 2013, p.7).

To integrate climate change adaptation for flood management as an integral part of the planning system, Gothenburg has gathered flood risk and vulnerability information via joint and coordinated work between different members of the land use planning game, the city planning office and administration (Göteborg Stad Stadskansliet 2009). By way of example, during the 2006 and 2008 "Extrema vädersituationer- Hur väl rustat är Göteborg?" [Extreme weather conditions- How well prepared is Gothenburg phase 1(2006)] and "Extrema Väderhändelser Fas2 Gullbergsvass(2008) [Extreme weather conditions Gullbergsvass phase2 (2008)], as well as the 2014 "Evaluations of flood risk in Central Gothenburg(Älvstaden), the city planners worked in close collaboration with meteorologist, hydrologist ,climate experts, specialist in oceanography, specialist in mechanical engineering, GIS experts, geotechnics specialist, experts in construction, specialist in port and coastal hydraulics, specialist in hydropower mechanics, expert in pump station facilities, research bodies and industrial world, economists and companies (Göteborg Stad Stadskansliet 2009 and Ramböll 2015). From such collaboration experts whose skills are needed to perform flood related jobs have been determined and assigned either to develop flood risk and flood vulnerability maps or make assessments on the consequences of flooding to the community and projections of water level rise. In some cases, experts have been tasked to test new adaptation policies for flood management Göteborg Stad Stadskansliet (2008) elaborates more on this.

By way of example, during the "Extreme weather conditions phase1" investigations in 2006 and phase 2 in 2008, the Swedish Meteorological and Hydrological Institution (SMHI) was hired to conduct metrological and hydrological investigations and to simulate the effects of the global rise in mean sea level to water levels in the area.

"SMHI has been hired for metrological and hydrological investigations" (Göteborg Stad stadskansliets 2006, p.1 and 4). Author's translation

The SMHI also worked in collaboration with the city planning office, Gothenburg water, Gothenburg energy, Älvstrand company (which is a land developer company), Emergency services, the traffic office, Environmental office and Real Estate (see fig1 in appendix). These different actors of the land use planning game were assigned the tasks which matches their skills. For example, the Real Estate and the environmental office personals were tasked to evaluate the cost of protecting central Gothenburg(Älvstanden) from Älvsborgsbron Tingstadstunneln from flood damages (Göteborg Stad stadskansliets 2006).

*"The Real Estate officials in collaboration with the Environmental Management officials have made an estimate with regards to the cost of protection of the Centre of the city from Älvsborgsbron to Tingstadstunneln ..." (*Göteborg Stad stadskansliets 2008, p.5). Author's translation.

Furthermore, to develop flood risk and vulnerability maps, the SMHI compiled relevant weather parameters which influence the water levels of the Göta River. The data was obtained from existing weather statistics in the area (Göteborg Stad stadskansliets 2006).

"Relevant weather parameters provided by the city council ... based on available statistics has also been compiled by the SMHI (Göteborg Stad stadskansliets 2006, p.6). Author's translation.

Here it could be noticed that, there has been a contribution of knowledge from the planner to the meteorological and hydrological specialist, who transformed the knowledge into simple and accessible form, by developing flood risk and flood vulnerability summary statistics tables based on pre-existing data (Göteborg Stad stadskansliets 2008). These tables were used to construct flood risk and vulnerability maps. And in 2000, a mapping for flooding was performed by the SMHI for the Göta River and in 2008, a mapping was done for its tributaries- the Mölndalsån River and the Säveån River. The assessment was done using a hydrological model MIKE 21(1D-model) in combination with a digital elevation model (DEM) and maps were produced using GIS software programmes (Sörensen & Rana 2013). And was based on a return period of 50 and 100years of extreme weather conditions

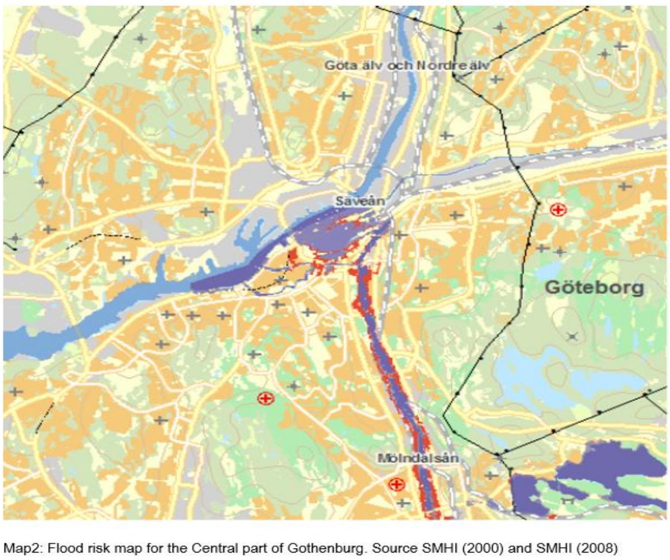
"SMHI made a mapping of flooding from Göta River in 2000 and Mölndal River in 2008. According to the SMHI (2000) and SMHI (2008), Gullbergsvass in central Gothenburg is at risk of getting flooded by the Mölndal River with a return period of 100 years. The central station, the railway and several buildings along Mölndal River are situated in the risk area. The analysis where conducted with a 1D-model with interpolation of the water level on the surface with a rough digital elevation model (DEM)" (Sörensen & Rana 2013, p.7).

As illustrated on the flood risk: map2 on page24, Gullbergsvass, in central Gothenburg(Älvstaden) is identified the most exposed to flood risk and stands the chances of getting flooded by the Mölndalsån River and the Säveån River if their water levels rise (Red and blue locations in the map are identified areas which are exposed to flood risk). The flood vulnerability map3 on page 25, on the other hand identified buildings, the railway, the central train station, persons who work in the area and offices as the vital functions of the community which are exposed to flood damage in the area.

“The central station, the railway and several buildings along Mölndal River are situated in the risk area” (Sörensen & Rana 2013, p.7).

” The area where the 100-year flow investigation was conducted inhabitants about 2801 persons and 21047 persons are employed in the area. Meanwhile, at the estimated highest flow (BHF), the area which is most vulnerable to flood risk had a population of 6767 persons, of which, 2511 are employed in the area and 37,657 have their offices in the area.” (Länsstyrelsen i Västra Götalands län 2015, P.12). Author’s translation.

A remark which could be made with regards to the flood vulnerability map is that, vulnerability has been defined in terms of geographic and economic vulnerabilities. Although the assessment mentioned the studied area have human population who lived in the residential areas and some who worked in the area both during the day and the night (Länsstyrelsen i Västra Götalands län 2015), no further comment was made with regards to the group of persons, that is in terms of their sex (men or women), age (old persons and small children), and physical condition (pregnant and physically challenged) and how a flood event might affect them. We just see figures which makes no sense especially for those who know nothing about Gothenburg. The absence of the vulnerable group in flood vulnerability assessment is problematic as it means goals and objectives set, development of policies and implementation will exclude these group of people who are members of the society and need to be protected from the danger flooding exposes them to. This therefore implies flood vulnerability and risk has not been entirely covered.



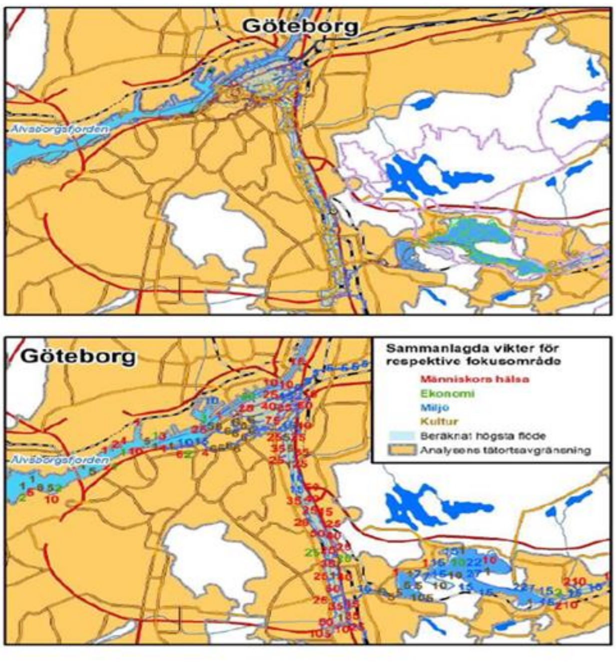
Map2: Flood risk map for the Central part of Gothenburg. Source SMHI (2000) and SMHI (2008)

Locations coloured red and blue in the map are identified areas which will be flooded as water levels of Mölndalsån River and Säveån River rises (SMHI 2000 and SMHI 2008).

The SMHI was equally tasked to make projections on the effects of the global rise in mean sea level (based on the IPCC projections) to water levels in the region. This was performed using a hydrologic simulation which was based on 100-year return period of extreme weather conditions. The simulation showed the normal water levels, peak and average water levels as well as suggested safety levels, it also took into consideration the worst extreme weather scenarios. From the model, global sea level will rise between 0,1 and 0,9 meters, which will cause average water levels in Gothenburg to rise between 0 and 0,8 meters (Göteborgs Stadskansliets 2006).

" *... Increase between 0.1 and 0.9 meters ... in 100 years. ... The effect on Gothenburg will be a rise in average sea levels between 0 and 0.8 meters* (Göteborgs Stadskansliets 2006, p.13). Author's translation.

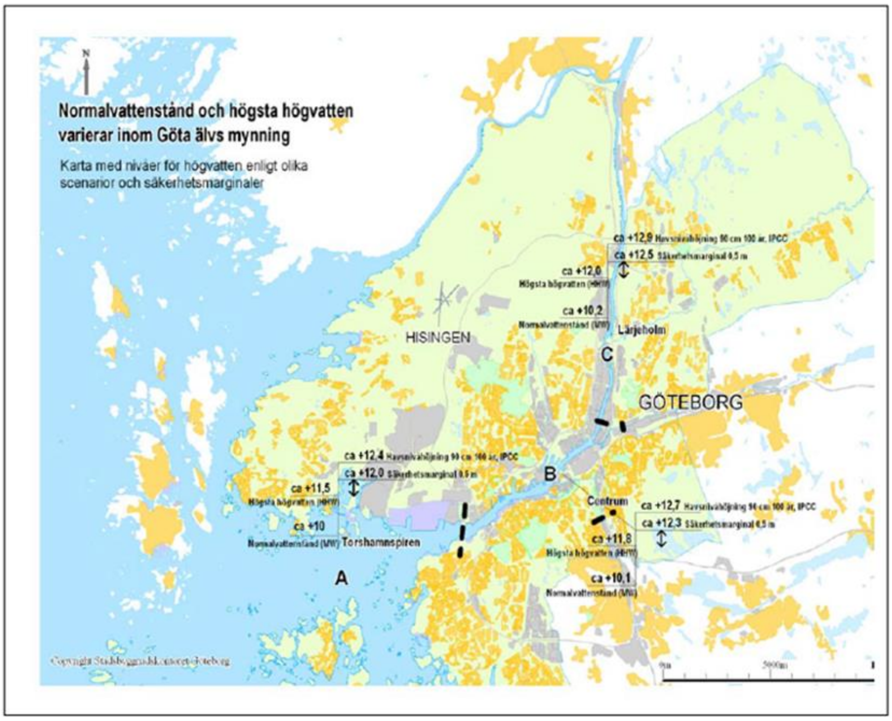
Results from the simulation showed that, in 2003, normal water levels in central Gothenburg was about +10,1meter, peak water levels were proximity +11,8meter, forecasted water levels over 100 years extreme weather conditions were estimated at +12,7 meter, thus to adapt the buildings to reduce flood damage a safety margin of about +12,3 meter was suggested.



Map3: Flood vulnerability map of Central Gothenburg. Source: SMHI (2000) and (2008). The maps indicate what is exposed to flood damage in the study area if water levels of River Mölndalsån and the Säveån river rises.

Whereas in Lärjeholm, normal water levels were close to +10,2 meter, peak water levels +12,0 meter, projected water levels over a 100-year return period of extreme weather conditions was about 12,9metre. Suggested safety margin for building was set at 12,5meter. Torshamnen which is located close to the case study area was also taken into consideration in the simulation.

Normal water levels in the area was about +10 meter and peak water levels +11.5meter, projected water levels based on a 100 years' extreme weather condition +12,4meter for the region and to reduce flood damage, a suggested safety level for buildings of +12,4meter is required (Göteborgs Stad stadskansliets 2006). See map4 below (page 26).

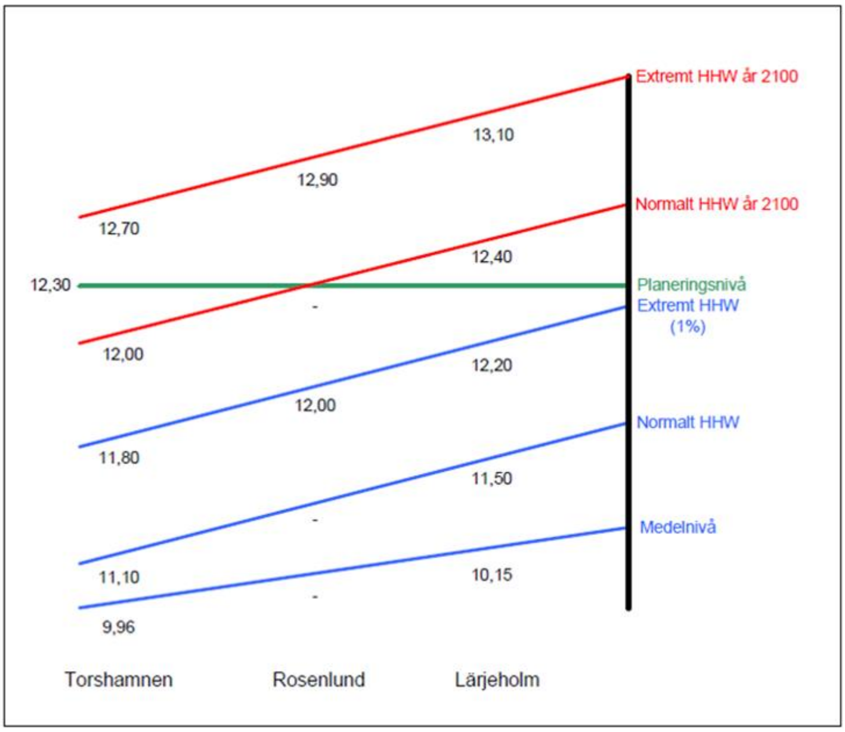


Map4: Normal, peak, projected water levels under extreme weather conditions based on 100 years return periods and safety margin for buildings in Central Gothenburg, Lärjeholm and Torshamnen. Source: Adapted from Göteborgs stadskansliets (2006)

From the map, the SMHI developed graphs which contained suggested lowest foundation level for new buildings based on extreme weather conditions event. The graph considered changes in water levels based on 100 years' climate change scenario and a projection up to the year 2100. The graph shows a summary of water levels for the year 2003 based on the worst climate change scenario, and a 100-year climate change scenario. The average water levels for the year is presented, the annual recurring highest and high-water level which occurs in the autumn and winter ("normal HHW") and extreme value with a yearly probability of 1% (return time 100 years). The figure equally shows a suggested overall dimensioned planning lowest level foundation level for building, +12.30 meters for the year 2003. (Göteborgs Stadskansliets 2006). See graph1 on page 27.

The hydrologic simulation models on the effect of rise in water levels at different points in the city as well as the water level rise graphs, were useful, as they constitute the basis on which suggestions for possible climate change adaptation measures for flood management during the phase1 and phase2 of the Extreme weather conditions were made. In the 2006 investigation, the burning questions were to know the preparedness, knowledge on risk and available measures in connection to extreme weather conditions in Gothenburg (Göteborgs Stad stadskansliets 2006).

"Investigate *a number of questions about preparedness, knowledge, risk and action related to extreme weather conditions*" (Göteborgs Stadskansliets 2006, p.1). Author's translation.



Graph1: Lowest foundation levels based on future rise in water levels. Source: adapted from Göteborgs stadskansliets (2006)

Thus, based on the SMHI projections, to reduce flood damage in the built-up area, buildings and infrastructures should be built such that, they can withstand flood damage (Göteborgs Stad stadskansliets 2006) and this can be done by making suggestions, with regards to specific measures which seek to reduce the negative impacts of flooding (Länsstyrelsen i Västra Götalands län 2015). By way of example, temporal measures were suggested especially for locations which due to their geotechnically cannot tolerate permanent measures. Permanent barriers are however, not the municipality's preference. Therefore, building embankments in the form of walls around individual houses and installing pumps which drain the floodwater could be considered. Besides, embankments should be well dimensioned to function well and fit the aesthetic of the area (Göteborgs Stad stadskansliets 2008).

"Even temporary measures are possible … for those parts where the geotechnical of the ground does not withstand a permanent solution or where a permanent increase is considered too expensive. For single properties, it is possible to similarly build an

embankment or wall around the house and have pumps that take care of excess water" (Göteborgs Stad stadskansliets 2006, p.26). Author's translation

"Permanent barriers are thus nothing we in the municipality advocate (Göteborgs Stadskansliets 2008, p.19). Author's translation. ... *However, they need to be well - dimensioned for their task. And need to be designed in a manner that is aesthetically appealing to the site."* (Göteborgs Stadskansliets 2008, p.17). Author's translation.

Suggestions were made to construct two open flood barriers one in the Göta River - Nordre Älv and the other outside the Älvsborgsbron. Or even close permanent flood barriers in Älvsborgsbron, which will imply Rivers: Mölndalsån, Säveån and Lärjeån will have to be pumped out continuously (Göteborgs Stadskansliets 2008).

" *Construction of open flood barriers ... over the current normal water level, it is most probable with a flood barrier... With regards to the situation of Gothenburg, it would necessitate two barriers, one placed in the Göta River - Nordre Älv and the other outside the Älvsborgsbron"* (Göteborgs Stadskansliets 2008, p.18). Author's translation.

Other suggestions to adapt the built-up area to flooding is to design the buildings such that, they can cope during flood events. For example, in low-lying areas, houses could be built such that, their bottom level is allowed to deliberately flood. This means vital equipment of the house are stored in the upper floor of the building and the furniture are designed such that, they can withstand flooding and be reused after drying.

" Another way is that, buildings and land are designed so that, they can withstand flooding. This implies, vital equipment should not be stored in basements or ground floor on low-lying houses and that, furniture can withstand flooding and can be reused after drying" (Göteborgs Stadskansliets 2006, p.26). Author's translation.

Suggestions were also made to raise lowest level of buildings (minimum floor level) to an acceptable level, or block flood water from entering the built-up area and the environment by using embankments such as sandbags. With regards to this, it was suggested that embankments in the form of sand bags be placed in West of Älvsborgsbron and the Göta River - Nordre River. However, it will require that investigations be carried out with regards to the behaviour of water levels from the Säveån, Lärjeån and Mölndalsån.

"*... to raise the lowest level of buildings to an acceptable level ... Build embankments such as sandbags in the Göta and Nordre Älv. In addition, an investigation is required on how water from Säveån, Lärjeån and Mölndalsån should be taken care"* (Göteborgs Stadskansliets 2006, p.26). Author's translation.

Furthermore, the investigations highlighted that due to climate change, downpour is increasing which is affecting the carrying capacity of drainage systems and triggering basement flood. Therefore, to reduce flooding caused by congested drainage, consideration should be taken with regards to the design and dimension of pipes especially in new development areas. With regards to this, it was suggested that, in new development areas, pipes should be adapted to extreme weather conditions which might lead to flooding (Göteborgs Stadskansliets 2006).

... "*Climate change ... is increasing downpour and sea levels and affecting the water levels of the Göta River, which in turn is increasing the risk of: basement flooding, groundwater floods, congestion in the sewage system and pipes*" (Göteborgs Stadskansliets 2006, p.46). Author's translation.

In the worst-case scenario, to adapt the built -up area to flooding, it was suggested that central Gothenburg be reallocated to higher elevations, which per the city planning office, it will be more expensive than moving Kiruna"

"... An alternative is to rellocate Central Gothenburg to higher elevation. Such relocation is far more extensive than the relocation of Kiruna's center" (Göteborgs Stadskansliets 2006, p.27). Author's translation.

In the same light of things, Roth et al. (2011) suggested that, to adapt Frihamnen to rising water levels which is increasing flood vulnerability in the area, three climate change adaptation policies could be considered: retreat, which in the case of Frihamnen will be operational in the low-lying pier, where water levels are highest. Thus, no vital functions of the community will be built there. Defend and attack.

"... The climate change adaptation strategies – attack, retreat and defend – could be integrated into planning and be used to develop the *area of Frihamnen in Gothenburg"* (Roth et al. 2011, p.13–16). Author's translation.

Dissimilation of the gathered information was done via the following: the water level map has been published in the detail plan, the Water Plan for Gothenburg (" Vatten - så klart" Vattenplan för Göteborg), which is a complementary detail plan (Göteborg Stadsbyggsnadskontoret 2003). Besides, the comprehensive plan has included a map of flood risk and flood vulnerability of the city (map2 of the 2009 Comprehensive plan) (Comprehensive Plan of Gothenburg 2009) and the results from the "Extreme weather conditions: How well prepared is Gothenburgvädersituationer Hur väl rustat är Göteborg? Was published in 2006 (Göteborg Stad Stadsbyggsnadskontoret 2006) and" Extrema Väderhändelser Fas 2" Gullbergsvass, december 2008(Göteborg Stad Stadsbyggnadskontoret 2008). Moreover, the investigation on climate change adaptation policies for Frihamnen was published in 2011" (Roth et al. 2011). But we cannot for sure tell how many citizens have had access to these documents, as available policy documents of the area give no cues with regards to these.

What is missing is how the public was involved in the construction of the flood information fact. We see that throughout the extreme weather condition processes (2006 and 2008). (See fig 1 and fig 2 in the appendix), no citizens were involved in the investigations, just experts and planners participated in the building of the information and while making suggestions on how to adapt the built-up area for flood management, citizens are absent. Cases where citizen participation has been mentioned (as shown in fig3 in the appendix) was during the investigations conducted in Frihamnen. Whereby the public showed how adapting the three policies would affect them. The article mentioned that, the citizens outlined that, the policies would encourage segregation since newly built apartments are often most expensive, only those in the society with enough money would be able to afford them. They also commented about the safety of the buildings considering their heights as presented in the scenarios. And, people won't find it safe to let their kids play outside in the yards (Roth et al.2011).

" Below are the statements of the focus group participants on what social consequences adaptation strategies can lead to in Frihamnen... One participant described a basic problem with the three adaptation strategies .... Several participants expressed concern that the Frihamnen area will be a highly segregated area. Newly created apartments are always expensive and therefore they attract only a kind of people with a lot of money ... that which will also increase segregation in the city is that, Frihamnen is being isolated from the rest of the city ... The buildings in the scenarios are quite high and living over a certain floor, you do not feel safe to let [their] children play freely outdoors" (Roth et al. 2011, p.47).

Based on the theory, the aim of citizen's participation is to improve awareness of the flood issue and improve preparedness. It is also to identify and include the vulnerable group while developing and implementing adaptation policies for flood management. Exclusion of citizens in this process is problematic. Aside, the city council holds that, participation during the 2007 exhibition comprehensive plan draft meeting, was richly attended. Per the city council, 124 persons participated in the meeting and of these persons, included: members of the municipal council, consultees, and the public. From the figure, it is hard to see how many "citizens" part took in the meeting. This is because out of the 124 persons just 2 might be "citizens". Besides, no relevant information is made on how the public participated and impacted the changes which were made in the draft before the comprehensive plan was published. Citizens' participation is described here as "numerous comments received", which is unclear what it means exactly. Although it is stressed, some changes were made based on these comments, no examples are linked to the types of comments which influenced the changes. It gives the illusion of "inclusion in exclusion"

“Consultation on the Comprehensive Plan occurred in the spring of 2007. The consultation draft of the plan (including the local programs) attracted considerable interest, as witnessed by the well-attended consultation meetings … During the exhibition, consultees, other partner organisations and members of the public were invited to meetings on the Proposed Comprehensive Plan. A total of 124 responses were received during the exhibition stage” … and numerous comments received. … The consultation draft and the local programs were modified on the basis of these comments “(Comprehensive Plan 2009, p.3).

Moreover, about 100 copies of the completed plan was sent out to the public, whereas the entire plan was published in the municipality website.

“*The exhibition documents were sent out to over 100 respondents…. The documents in their entirety were made available on the municipality’s website during both consultation and exhibition”* (City Council of Gothenburg 2009, p.3).

Taking the population of Gothenburg in consideration, this figure is relatively small. Besides, the fact that, the plan is published on the website does not imply the public have had or has access to the information. What is important is how to know the public have been in contact with this information. What parameters are there to be used to have this knowledge? These very questions apply to the water level meter Website which was created in 2011. It is actually a 3D model which simulates the effects of water level rise for each year and even the future over central Gothenburg and access is free for everyone (Göteborg Stadsbyggsnadskontoret 2015). Although the aim of this site is to improve the preparedness of the citizens and improve awareness with regards to flooding, it is difficult to say how this really operates. It cannot be said with certitude if the city planning office knows how many visitors have navigated the site on purpose to acquire knowledge on flood issues. This is because there are no indicators on the visitor’s activity on the site (that is why the visitor logged into the site, it could be out of curiosity or per chance). Just because a water level website has been operational since 2011 does not imply it has fulfilled its function as a media through which citizen’s preparedness and awareness has been improved and information has been dissimulated to the public.

Aside, citizen participation has not been identified during key investigation processes such as the “Extreme weather conditions phase1 and 2. During these investigations, there has been total exclusion of the layman. Which means contribution of information has been made between experts only. By implication the day to day realities of life which the citizen faces with regards to flooding has not been included while developing flood risk and vulnerability information fact. Although it could be contested that, not all the daily experiences of the citizen with regards to flooding are relevant, but it is essential to involve the citizens.

(ii)Setting goals and objectives for reducing risk and vulnerability

Right from when Gothenburg was founded, some 400 years ago, the aim has been to control the flow of water into the city (City Council of Gothenburg 2012). To achieve this, the main goal and objective set strives on building a robust and resilience community by building safe, and avoiding development in risk prone areas as well as to be innovative, prepared and ready with regards to flooding (City Council of Gothenburg 2009).

"Göteborg will be a fundamentally robust city by building safely…and by increasing security against unforeseeable events such as…By avoiding development in geological unstable areas and having regard to rising water levels, readiness against extreme weather events and flooding can be improved" (City Council of Gothenburg 2009, p.5).

These goals are not only related to adaptation for flood management, but to other climate change related hazards. However, adaptation for flood management goals and objectives have been in-cooperated into this main goal. By way of example, "Living with water" and "keep the water out" goals and objectives, have been pivotal in the integration of adaptation measures that protect the built-up area from intrusion of floodwater and accommodates flood water (City Council of Gothenburg 2011). Without any much ado, after the" Extreme Weather Conditions Phase 2"(2008) investigations, it became clear that Gothenburg has to increase its preparedness for the future changes of the climate by building a robust community (Göteborg Stads Stadsbyggnadskontoret 2010).

"Robust *community: The municipal council decided after the "Extreme weather conditions phase2" investigations on February 25th 2010 [which means], that the municipality was commissioned to continue the planning work to prepare Gothenburg in the future with regards to climate change".* (Göteborg Stadsbyggnadskontoret 2010, p.7). Author's translation.

Based on the suggestions made by the research team (which consisted of experts) of the "Extreme weather conditions phase 1 and 2 ", climate change adaptation measures have been integrated into goals and objectives set, which seek to adapt the built -up area to flooding induced by rising water levels and extreme weather conditions. And via physical planning, regulatory and planning goals and objectives have been implemented (Wamsler & Brink 2014 and Nilsson 2016). By way of example, to achieve "living with water" goals and objectives, infers implementing adaptation measures for flood management which make way for water to enter the city and in a regulated manner, is stored and sent back into the river (City Council of Gothenburg 2011).

"*Adaption, that addresses living with water: Creating space for water to enter the city, to be stored and to be released slowly back into the river"* (City Council of Gothenburg 2011, p.13).

To achieve "living with water", minimum floor level, as an adaptation measure for flood management as suggested in step(i) has been imposed.

- **Minimum floor level /foundation level**

As shown on map4 on page 26, to adapt buildings to flooding induced by rise in water levels, a minimum floor level of +12.80 has been imposed for all new buildings in central Gothenburg and in areas where protection measures are low, additional protection measure such as protective barriers are recommended. Moreover, investigation ought to be carried out in the area as well. This regulation was approved and published in the 2009 comprehensive plan, making it a building regulation (Göteborgs Stad Stadskansliet 2009).

" To avoid new risk, location and construction of buildings should be done while taking into consideration such risk as …, … and flooding. In old built-up areas where protection is low, reinforcement measures should be considered. In the central parts of Gothenburg, new buildings must have foundation levels above +12.8 m. Minimum foundation level ought to be increased in low-lying areas which are most exposed to flood risk due to rise in water levels or extreme weather conditions. Extra protection during peak water levels would include for example, protective barriers" (Göteborgs Stadskansliet 2009, p.60). Author's translation

Since water levels are different from one location to the other, in Gullbergvass, required minimum floor level for new buildings is 11.80 meter (according to the city's water height system), which is the estimated level buildings can cope during flooding induced by water levels rise in the area. In old buildings, triple security is required (Göteborg Stadskansliets 2006).

"*Foundation levels: With regards to lowest foundation level, the idea is that, foundation should be raised with regards to the water levels. That is, based on the water height system of the city of Gothenburg, buildings should be constructed such that, they can withstand peak water levels of 11,80 m. … In older designs, triple security has often been used"* (Göteborg Stad stadskansliets 2006, p.23 and 24). Author's translation.

With regards to Frihamnen, which is low-lying. For example, land level around the viaduct, (which is its lowest point) is +8 meters, compared to a general water level in the area of about +11.4 meters. Moreover, all of Frihamnen lies below the required minimum floor level of Gothenburg (+12.80 meters), additional safety heights for new constructions is an option which has been discussed with regards to the area and the rest of central Gothenburg. Besides, the differences in the land levels and relative high-water levels in Frihamnen requires regulations via zoning ordinances (Nilsson 2016). Hence it was approved that adaptation for flood management be applied in the area via zoning ordinances. Furthermore, goals and objectives have been set to rise the planning level in the centre of the city to about +13.5 meters to cope with the rising water levels which cause flooding. This will be done based on the water levels of different locations in the area (City Council of Gothenburg 2012).

"At Frihamnen, large areas are around +11.4. At the lowest point, the viaduct close to Frihamnen, the land level is approximately +8 … At present, the minimum floor level for new buildings in Gothenburg is approximately 1 m above the current maximum sea level, which gives a level of +12.8 metres for the city centre. There is good reason for assigning key buildings a greater safety margin against flooding than is the case for normal buildings if they are to withstand a further rise in sea level. Discussions currently taking place indicate that the planning level for the city centre ought to be raised to around +13.5. The fact that the land throughout virtually the whole of Frihamnen is below the +12.8 level makes it vitally important to decide on requirements in order to deal with the impact of climate change and to lay down the principles for future construction" (City Council of Gothenburg 2011, p.9).

- **Measures based on implementation of adaptation policies – Accommodation - Attack- Defend(protection) and- Retreat**

Consideration was given to the three climate change adaptation policies for flood management- "attack, retreat and defence (also known as protection)" which was proposed by Roth et al. (2011) in step(i). It was approved that, the built-up area and the environment could adapt to flooding by integrating at least one or all three of the adaptation policies for flood management in their urban design. The idea is to achieve the set goals which seeks to "make way for water" and "live with the water "and build a robust and resilience community. Therefore, to "keep the water out" by building resilience, retreat and defend (protection)policies was approved (City Council of Gothenburg 2012, p.26). To achieve "living with the water", accommodation and attack policy was accepted (City Council of Gothenburg 2011, p.13 & City Council of Gothenburg 2012, p.26).

- **Measures towards adding more Greenery**

Considering that, central Gothenburg does not have extensive vegetation cover, compared to the inland (Sörensen & Bengtsson 2014).

"*Gothenburg has no bigger green areas in the city centre or close to the riverside, which makes the city static and not resilient. Most of the green areas are in the hills, where they are least needed when it comes to flood resilience"* (Sörensen & Bengtsson 2014, p.2).

It was agreed that, more green space, trees, green roofs, parks and green corridors between waterfront be created. For instance, a Jubilee park next to the water at Frihamnen and

Gullbergsvass and green corridor from Kvillebäcken via Frihamnen (City Council of Gothenburg 2012).

"Add more greenery: We will build on the Gothenburg tradition of creating parks…Several large parks and a large number of small green spaces are required…Our urban paths and streets will be viewed as an integral part of the city's green space network…create a number of large parks; one being the Jubilee Park beside the water at Frihamnen and a park at Gullbergsvass, create a network of small green spaces linked to the large parks and the water and channel the stream Kvillebäcken and make it a green corridor through Frihamnen" (City Council of Gothenburg 2012, p.23).

As well as green corridors which will link from "Mölndal to Hisingen, through the Botanical Garden". Cultivation of greeneries in parks and jetties are encouraged (Söndergaard 2015).

*"It's easy to get from Bergsjön to the sea along the south bank of the river. Green corridors will take us from Mölndal to Hisingen, through the Botanical Garden, which is now merged with the Slottsskogen city park. …Together we fill the connecting spaces – with growing things, jetties" (*Söndergaard 2015, p.34 and 35).

The aim of this measure was however not provided by the policy documents used for this research. Which is an issue, as is difficult to say if it is for adaptation for flood management or not.

- **Measures to increase open spaces, ponds and flood reservoirs and drainage system**

Due to extreme weather conditions such as heavy downpour, Gothenburg will have water entering into the city from all directions (Nilsson 2016). To regulate the flow of water means to achieve the goal "living with the water". Therefore, it has been approved that, more open spaces, ponds, permeable surface such as car parks and cycle path would be created in the area to delay infiltration and storm water flow. Aside, extreme weather conditions would influence the carrying capacity of drainage systems which will trigger basement flooding. To address this issue, the city's drainage capacity ought to be adapted to the changing environment (City Council of Gothenburg 2012 & City Council of Gothenburg 2011, p.13).

"Climate change will mean extreme weather events in the form of heavy rain and strong winds and more precipitation…, ponds created from surface water and a flood reservoir that can absorb and delay the water… Run-off needs to take place in open systems along streets, cycle paths and tram tracks. Large, open grassed areas and sports areas could be used as temporary reservoirs. The city's sewage system needs to be adapted to harmonise with open systems and storage" (City of Gothenburg 2012, p.27).

The following paragraphs have presented the main goals and objectives set (building a robust and resilience community, "living with water" and "keep the water out") with regards to adaptation for flood management (and other hazards) in Älvstaden, central Gothenburg. It also showed that, the goals and objectives have been approved and implemented through adaptation measures for flood management such as: required minimum floor level (zoning ordinances, land uplift, additional safety level), application of four adaptation policies for flood management: protection, accommodation, retreat and attack. Creation of green spaces and more retention ponds. Although the policy document used for this study impose different minimum floor levels based on location specificity, the purpose of some of the measures for adaptation for flood management have not been linked to adaptation for flood management. By way of example vegetation cover and forest. This is an issue as it cannot be agreed upon that these measures are meant for what it represents. Based on the theory, it could be said that, these goals and objectives have been set not through a democratic platform, as available policy document does not specify if these goals are made based on the citizen's desire to improve their community. This could be further linked to the exclusion of the citizens in step(i).

On a general note, the above section has answered the research question: "*How has the municipality of Gothenburg applied the urban land use planning theory for the integration of natural hazard and climate change adaptation, with regards to adaptation for flood management in Älvstaden between 1999 and 2015*?" by showing that, the municipality has generated planning intelligence regarding hazard risks and vulnerability of the local population, by developing flood risk and vulnerability maps, identifying zones and objects at risk and making suggestions on how to address the issue at hand. The findings also showed that dissimilation of information and public participation has been poorly integrated during the process, which gives the impression of "exclusion in inclusion"

5.2 SECTION TWO

This section seeks to provide answers to the research question: "What climate change adaptation policies for flood management have been implemented in Gothenburg within this time frame, and how have the policies been revised to match the reality of flood issues? Therefore, step *(iii) Adopting policies and programmes to achieve the goals and objectives,* of the theory will be required. The section is further divided into four subsections (1) application of protection policy(defend) (which is divided into (a) application of hard protection measures and (b) application of soft protection measures), (2) application of accommodation policy, (3) application of retreat policy and (4) application of attack policy. And for each adaptation policy, adaptation measures for flood management which have already been applied in Älvstaden in Gothenburg between 1999 and 2015 and even those underway or planned to be implemented will be discussed and presented. As well as steps(v) of the theory would be required.

(iii) Adopting policies and programmes to achieve the goals and objectives

A distinction which is to be made between steps (ii) and (iii) is that, goals and objectives are suggestions. They are also perceived as the desires and wishes of the way the citizens would want to develop their community. Goals and objectives could be disapproved; therefore, they do not have any effect until they have been accepted and implemented. Whereas step (iii) represents the goals and objectives which have been accepted in step(ii). Climate change adaptation policies for flood management are usually formed based on the approved goals and objectives and they are legalised through zoning ordinances and detail planning (Nilsson 2016).

(1) Application of protection(defence) policy.

(a) Hard protection measures

To achieve" Keep the water away", hard protection measures have been used in the study area. According to Goytia et al. (2016), due to the city's desire to continue development in high flood prone areas -that is developing central, this measure is most preferred and various forms of hard protection have been applied, with large scale plans underway. They also underline that, some of the measures were not initially connected to flooding, by way of example construction of dams are linked to hydropower but now are used for flooding. According to them, this is an issue to Gothenburg.

"*Flood defence measures seem to be at the centre of flood risk management in Gothenburg. There are several potential reasons for this: the municipality wishes to develop central, densely constructed areas; diverse purpose defence measures have recently been implemented; and large-scale plans are under discussion. There are moreover several non-purpose flood defence structures which affect Gothenburg*. (Goytia et al. 2016, p.49).

- **High floodwalls in Central Gothenburg**

Per Sörensen & Rana (2013), to adapt central Gothenburg to flooding induced by rising sea levels, construction of embankments in the form of "high floodwalls", are the most preferred protection options. They explained that, central Gothenburg which happens to be the most attractive location of the region has a very low elevation which exposes it to flood risk and vulnerability. Therefore, to encourage development in this, the rule which restricts building in low elevation areas has not been applied. Instead, flood walls have been constructed to limit flood damage on buildings and infrastructures in the area.

*"Gothenburg city wants to cope with climate change by being restrictive in building on low-lying areas, but the low-lying areas are close to the city centre and attractive for building. Important buildings and constructions in the city centre are at risk of flooding when the sea level rises. It seems like Gothenburg is more heading for flood resistance, building high floodwalls to prevent from flooding…" (*Sörensen & Rana 2013, p.8).

- **Four Hydropower dams at the Göta River and "mitre gates" in Drottningtorget**

Rise in water levels in the Göta River is influenced by the water levels of Lake Vänern. This means to reduce flood risk in Gothenburg, it is pivotal to control water discharge from Lake Vänern into the Göta River. This has been done by constructing four hydropower dams upstream the Göta River. Whereas water rulings are used to reduce flood risk by taking into consideration peak and lowest water levels in Lake Vänern. This means during peaks, water is stored in the lake, and to regulate the flow of water, two movable flood barriers are used. There are arrangements to reduce sea levels flow and from 2008, a new flow measure has been implemented to reduce peak water levels in the lake. Therefore, construction of dams has been useful in achieving the goal and objective set" keep water away"

"*…the regulation of Göta River has consequences for flood risk management in Gothenburg. Four hydropower dams are in operation along the upper course of the river, and several of the water rulings contain provisions relevant for flood and landslide risks in Gothenburg, for example regarding the highest and lowest limits of the water levels in Lake Vänern. For the periods when water is stored in the lake by reducing discharge, a set of movable barriers must be used to maintain the water flow levels…. There are also provisions to limit discharge in case of high sea water levels. Since 2008 a new discharge strategy to reduce higher water levels in the lake is applied"* (Goytia et al. 2016, p.50)

Furthermore, to" keep water away" embankments in the form of" mitre gates" have been constructed in Drottningtorget in Gothenburg (SWECO 2014).

"*Existing "mitre gates" in the lock at Drottningtorget in Gothenburg"* (SWECO 2014, p.36). Author's translation.

And in 2014, a feasibility study was carried out in central Gothenburg with regards to two alternative hard protection measures: "construction of embankments along Göta River in the central areas of Gothenburg, and use of movable barriers at the Älvsborg Bridge and Jordfall Bridge". The second protection measure was considered the best alternative, but it was however warned that, even movable barriers cannot protect Gothenburg as water gets into the city from all directions especially during downpour. Other issues with the assessment was that, it was not entirely conducted, which means it was based on uncertainties as well (Goytia et al.2016).

"In March 2014, a feasibility study consisting, a risk based cost-benefit analysis of large scale flood defence measures in Gothenburg were completed. Two *alternatives were studied: a) embankments along Göta River in the central areas of Gothenburg, and b) movable barriers at the Älvsborg Bridge and Jordfall Bridge. The analysis showed that the second alternative would be preferable, but it was pointed out that the study was incomplete and associated with significant un-certainties…. In relation to this project, an official at the Urban Development Unit at the County Administrative Board (Interview 6) warns that while it may seem to the developer as the simpler option, it will not protect Gothenburg from fall and autumn and spring flows or from heavy rains; "water comes from all sides"* (Goytia et al.2016, p.49-50).

(b) Soft protection measures

- **Vegetation cover and forest**

Soft protection measures identified in Gothenburg are vegetation cover and forest. However, there are controversy with regards to their role in adaptation for flood management. Goytia et al. (2016) pinpointed that, the initial functions of vegetation in the form of green areas and parks in Gothenburg are for recreational and aesthetic purposes and the role of vegetation to reduce flood risk occupies a marginal position in policy documents of the city. Nonetheless, in an interview conducted by Goytia et al. (2016), with the Parks and Nature Department, one of the official identified the role of vegetation in storm water management in the municipality and water detention. But could this one testimony be enough to draw a conclusion that vegetation cover is associated with adaptation for flood management in the area?

"Note that park and green areas in Gothenburg are still primarily thought of in terms of their aesthetic and recreational features, with their capacity to contribute to flood risk management only marginally discussed in policy documents. When asked about the role of the Parks and Nature Department in flood risk management, an official at that department expressed that they work to protect the municipality's green areas and watercourses (mostly through small-scale measures against erosion) as well as maintain embankments at lakes (Interview 3). The interviewee also stated that the Park and Nature Department could eventually contribute to storm water management in the municipality with land areas that can be used for water detention" (Goytia et al. 2016, p.51).

There has been transformation in the landscape of central Gothenburg, whereby more green spaces are visible in the city. Still is difficult to identify their role in adaptation for flood management. By way of example, the old Göta River Bridge has been transformed into "Green Cultural Bridge", the areas where cars used to travel on, trees are growing now on them. Although this area is exposed to high water levels which makes it vulnerable to flooding and increases the risk of flood, no link was made in the available policy document between the role of these greenies in relation to adaptation for flood management. Instead it was stressed that, the greenery will be used for culture and meetings (Söndergaard 2015)

"*The old Götaälv Bridge has been transformed into the Green Cultural Bridge. Trees now grow where traffic once reigned; the open spaces are now used for greenery, culture and meetings*" (Söndergaard 2015, p.32 and 33).

The role of vegetation with regards to adaptation for flood management has been ignored in most policy documents of the city, or has been associated with other climate change impacts such as reduction of heat, by regulating temperature, protection against the wind, improve good air quality and even to block noise. And, its ability in creating a good residential area such as green courtyards, roofs and walls (City Council of Gothenburg 2012). We therefore, do not see the role of green roofs and green courtyards in the delay of storm water as highlighted by Wamsler & Brink (2014, p.1365). Instead the role of vegetation is presented with regards to its social aspect to the community and the city.

"The vegetation in the area should contribute to creating a healthy urban environment with stabilised temperatures, wind protection, good air quality and low noise levels. As the temperatures rises due to climate impact, greenery in the urban spaces will become increasingly important to create a comfortable local climate" (City Council of Gothenburg 2012, p.23).

What is most striking is that, projects underway with regards to making the city greener, are concerned with creating more green spaces in high flood prone areas but no connections are made with adaptation for flood management in these locations. For example, there are ongoing plans for the creation of green corridors linking "Mölndal to Hisingen, through the Botanical Garden" (such was suggested in step(ii)), which also include growing of plants in the parks. Besides, projects to create a Centenary Park in the high flood prone area of Frihamnen are underway. Yet no connection has been established with regards to how the flood situation in the area will be improved thanks to these green spaces. Focus is still on the connecting capacity, recreational and good health of vegetation to the area, and what is most important- adaptation for flood management has been left out completely.

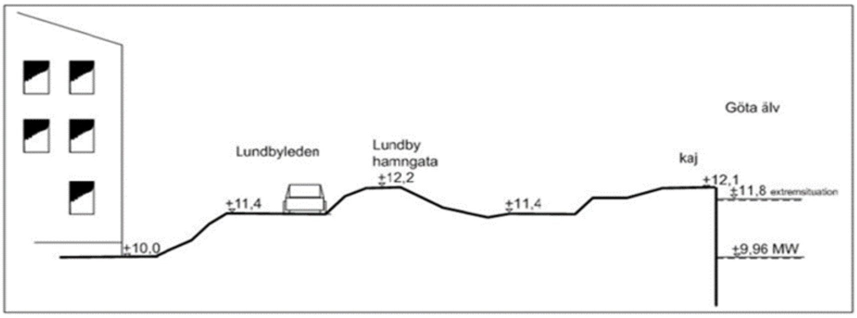
"It's easy to get from Bergsjön to the sea along the south bank of the river. Green corridors will take us from Mölndal to Hisingen, through the Botanical Garden, which is now merged with the Slottsskogen city park. We increasingly choose to travel by bike or on foot. Together we fill the connecting spaces – with growing things, jetties and parks. There will be new spaces for meetings, fun and games and rest. The blueways and greenways entice us to discover other parts of the city. They make us get out more, breathe fresher air and simply feel better. … Centenary Park will be inaugurated in Frihamnen. It's one of many new green public spaces, characterised by biodiversity and closeness to the water. The greenery improves the local climate. The park will evolve continuously, creating a lasting impression for the future, … A new, green meeting place where people can meet and socialise right in the heart of the city. A place for all ages! (Söndergaard 2015, p.34 and 35, 58-59 and 62-63).

Although there are good ideas with regards to afforestation in high flood prone areas, for example, between 2013 to 2015, about 3,285 trees have been planted (Söndergaard 2015) as well as creating of parks and other green spaces, we still cannot link these measures to climate change adaptation for flood management.

Application of Accommodation policy

Minimum floor level, zoning ordinances and land uplift

As learnt in the" Extreme weather conditions phase 1 and 2", the Water Programme- "Vatten så Klart" was influential in the implementation of building codes and regulations which aim at adapting the built-up area and the environment to flooding induced by climate change impacts (rising water levels, precipitation and excess rainfall). Thus, to accommodate flooding and achieve "living with water", minimum floor level (foundation level) has been imposed in different locations in Gullbergsvass while taking into consideration the water level of the Göta River. Hence to accommodate flooding in Lundbyleden, required minimum floor level is +11.4meter, in Lundby hamngata+12.2meter and in Kaj +12.1meter. As illustrated on diagram1 below(page41) (Göteborg stadskansliets 2006, p.23-24).



Dagram1: Required Minimum floor level for new buildings and safety level in Gullbergsvass. Source adapted from Göteborg Stadskansliets(2006, p.24)

In Frihamnen, zoning ordinances have been applied (Nilsson 2016) to accommodate flood water in the area. The adaptation measure used in the area is land uplift, whereby land is raised to varying heights across its three piers (Roth et al. 2011) to adapt to rising water levels as well as "seal the level rise" (Nilsson 2016). For instance, the streets in the piers are increased to +2.8 meters and to protect important functions of the community (such as hospitals) entrances are raised to +3.8 meters, housing +2.8 meter. And in low-lying areas of the piers, an uplift of +2.5 meter for the dockside and +2.0 meters for the park (Nilsson 2016). As illustrated on fig1 below (page 42). Although land uplift is a good measure to accommodate flooding especially when the need for space for development is a pressing issue, but the long-term consequences of the land uplift with regards to predictions of sea level should be considered while undertaking this measure. That said, although Frihamnen presents a good location for land uplift, since, it is undergoing new development, so is easy to integrate climate change adaptation strategies while designing the buildings, an issue which arises is that, after 2070, the land uplift will not be able to cope with the rising water levels on which the zoning ordinances in the detail planning of the area was based on (0.5meter). This is because, it is projected that, peak tides will reach 2.31 meter in the area, making a difference with less than 0.5meter (Nilsson 2016), so the buildings will be lower than the heights of the waters after 2070.

"Frihamnen will be a newly developed area and therefore it has good conditions to include climate adaptation strategies from the beginning. However, the raising of the ground will only be able to cope with the sea level rise until around 2070, after this point the land levels do not meet the zoning plan requirements, where in is stated that the entrance of buildings needs to be 0.5 meter above the maximum tide. When in 2070 the maximum tide is 2.31 meter, the difference is less than 0.5 meter" (Nilsson 2016, p.57).

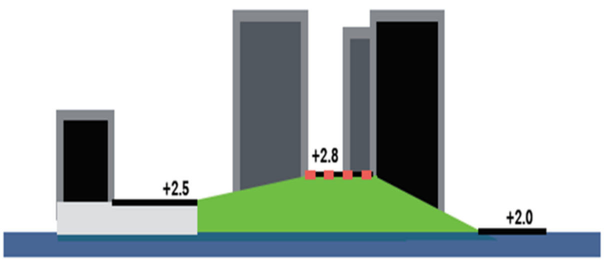


Fig1: Adaptation strategy in Frihamnen. Source adpated from: Klimatanpassningsstrategi (2015)

This calls for concern as the area will be exposed to both flood risk and vulnerability. This thus, imply all flood risk and vulnerability have not been adequately covered in the area with regards to the safety of the inhabitants. In connection to this, in 2014, the County Administration Board disapproved the detail planning for the central area of Lindholmen, as it did not have tangible implementation policy with regards to flood management in flood prone areas. According to the Board, the guides for planning in flood risk areas were not adequately considered in the plan. By way of example, the Broad requires planning levels +2.90 meters, while taking into consideration "future -day extreme water levels", in addition to this, safety levels of "half a meter" that is level 1 or one meter -level2 are required. But in the detail plan developed, although it was outlined that, high water level rise in the Göta River will be regulated with protective barriers, this detail was not included in the version which was accessible to the public. Per the municipality, construction of flood barriers and land uplift in Lindholmen are measures which are too early to consider during this stage, aside, the municipality is making assessments with regards to large scale flood protection barriers. Nonetheless, these measures were mentioned in the detail plan which was later developed, hence the Board approved of it and is now implemented (Goytia et al.2016, p.49 and Nilsson 2016, p.57).

"*In 2014, the detail plan for the central area of Lindholmen was taken up for revision by the County Administrative Board since it was not considered to follow the guidelines for planning in flood prone areas. The planning levels required by the Board for areas near the maritime coast are based on future-day extreme water levels (+2.90 meters) in combination with safety margins of half a meter (level 1) or one meter (level 2). In the detail plan originally prepared for consultation, barriers to protect the area from high water levels in the Göta River were considered, but were left out in the version that was later subjected to public announcement, which was noted by the Board. The municipality responded that building barriers or raising the land-level in the area was not reasonable at that stage, and that larger-scale protective measures for the whole municipality were investigated. The detail plan finally adopted by the municipality mentions these potential measures: one alternative is an outer barrier that provide protection against future flood risks (in a 50-year perspective) and is expandable in order to allow for flexibility in decision-making. The County Administrative Board ultimately did not revoke the detail plan, which has now come into force"* (Goytia et al.2016, p.49).

Update Sewerage pipes and Storm water management

As discussed in step(ii) there has been rules to improve the sewerage system in Älvstaden (central Gothenburg). Sewerage pipes cover about 163 km2 of Gothenburg and 29% of the system comprises of the combined system. While separate storm water system is built for a return period of five or two years, the combined system is built not to induce flooding in regular basis within a period of ten years. On the other hand, the separate wastewater system is built such that, it would "never get flooded", a function which it has not been able to provide. Due to pumping "failures and construction mistakes", these systems have triggered 20-200 flood events every year in Gothenburg (Sörensen & Rana 2013).

"The sewage system covers an area of 163 km2 of Gothenburg. 20% of this is combined system…the separate stormwater system of Gothenburg is mainly designed for a return period of two or five years. The combined system is design not to give flooding more often than every ten years. The separate wastewater system is designed never to get flooded, but due to construction mistakes and pumping failures, there are 20–200 cases of flooding every year" (Sörensen & Rana 2013, p.5).

The combined sewerage systems are most used in the older parts of central Gothenburg and the separate (storm water) systems is predominant in the newer parts of central Gothenburg. Hence to reduce flooding which result due to these systems, combined sewerage systems which are constructed for a ten-year rain are used in central Gothenburg as recommended by the Swedish Water and Wastewater Association. With regards to storm water, it has been treated through infiltration and in some cases, piped systems as well as ditches have been used to control the flow (Goytia et al. 2016). With regards to storm water management in the reduction of flooding, there have been request for better management of storm water.

"While combined sewerage networks predominate in the older, central areas, the newer, surrounding areas primarily have duplicate or separate systems. The water and sewerage system has been found to be vulnerable to extreme weather events; in periods of intense rains, the capacity of the system can be exceeded and lead to flooding of basements…. In connection with new development, the rule is therefore to use duplicate systems which are dimensioned for a 10-year rain, following the recommendations of the Swedish Water and Wastewater Association. Storm water is also to some extent treated locally, principally through infiltration or detention Storm water management facilities, both in the form of piped systems and open solutions (e.g. ditches)," (Goytia et al. 2016, p.50-51).

A remark made with regards to storm water and flood management in Gothenburg is that, while there are abundant information and projects on the treatment of storm water for flood management, it has not been applied in practice. Reasons being, the soil type of Gothenburg which is mostly clay does not facilitate infiltration, moreover, it demands a lot of space to dig up drainage wells, which is not a possibility in central Gothenburg. Aside, these measures require upgrading and are not the fastest. These qualities, hence make them not adequate especially during heavy down pour (Goytia et al. 2016).

"All in all, while knowledge, investigations and projects on local treatment of storm water are plentiful in Gothenburg, these have not extensively translated into practice. Interviewees at the municipality (1, 2 and 3) have pointed at difficulties associated with this kind of measures: the predominance of clay soils does not favour infiltration; drainage wells require a lot of space, which is not available in the central areas; the measures require a lot of maintenance and are also slow, which makes them insufficient when it comes to heavy rain" (Goytia et al. 2016, p.51).

(3) Application of Attack Policy

"*The buildings are both near and on the water. Central city environments close to the river have made Gothenburg's new district a big hit, even attracting international researchers in sustainable city development. The streets can tolerate flooding and rain. The clever little student flats have won an award for best energy efficiency and are surrounded by garden plots. The two shores of the river are united by new pedestrian and cycling bridges. Gothenburg is growing, but distances are shrinking…Clever, green homes with water right outside the door" (*Söndergaard 2015, p.20-23)

Although floating homes are already operational in central Gothenburg, but the aim of these structures are not related to climate change adaptation for flood management. Although, the words "The streets can tolerate flooding and rain" (Söndergaard 2015, p.20-21) have been used as an indicator of its adaptation property. Tolerant can be interpreted in different ways which will does not necessarily mean adaptation. By way of example, "The clever little student flats", which are both "near" and on the water" (floating and amphibious structures), although they can tolerate flood, which means they have been constructed with water-proof material (Wamsler & Brink 2014), no links were made with regards to how these structures can contribute in the reduction of flood risk and vulnerability, nor the connection between adaptation for flood management and these structures. Instead it was underlined that, due to the sustainable way the flats are built, it has attracted researchers, plus it won a price for being "energy efficiency" (Söndergaard 2015, p.20-21). This creates a lot of uncertainty with regards to the roles the structures play in climate change adaptation for flood management, as it seems the buildings have been used to improve energy efficiency, since, it won a price with regards to this.

Apart from "The little clever student apartments, there are ongoing construction of floating residential areas on the water in Södra Älvstranden. It will include "floating gardens, homes, restaurants and theatrical stages", whereas the coastline and beneath the water will be used as meeting place. Just like with the other floating structures, the role of such structures as vegetation and buildings which are essential component in the attack policy have not been identified and linked to adaptation for flood management (see theory on attack policy). Instead, both the floating homes and the components which fills the functions of the floating homes (vegetation and building design) have been used as measures of making Central Gothenburg a unique and attractive environment.

"The water is a part of the city's lands. A residential quarter is being built on the water by the southern riverside, Södra Älvstranden, with floating gardens, homes, restaurants and theatrical stages. At the shoreline and under the water, a unique, social, informal meeting place awaits" (Söndergaard 2015, p.24-25).

Besides, floating stages which is an attack measure are used in the area for concerts. The idea of floating stages is to bring the performance to the people, this maybe is to achieve the living with the water" goals and objective but it does not help in flood risk and vulnerability reduction. Moreover, does it help while adapting the buildings in the area to rising water levels and other extreme weather conditions which trigger flooding. The aim of the attack policy is to forge the way into the water, build on it and settle on it while, provisions with regards to measures which reduces flood risk and vulnerability are made. It is meant to achieve the goal and objective set" living with water", while building robust and resilience. But so far, these qualities have not been identified and linked to these structures.

"The barge is a floating stage, which puts into port from west to northeast. If you can't come to the culture, the culture will come to you… A floating stage offers a whole new take on live entertainment, allowing everyone to help plan the programme" (Söndergaard 2015, p.22-25).

Ongoing projections which include the attack policy, are in Frihamnen, which according to Nilsson (2016), the reason behind the development of this area is due to the scramble for space and housing shortages.

"The housing shortages and the competition for space in Sweden and Gothenburg is causing the municipality of Gothenburg to increase the pace of housing developments, which is leading to a plan in Frihamnen" (Nilsson 2016, p.63).

So, to create extra space, and building facilities for the citizens, the city has to build on the waters and Frihamnen presents significant development potentials. A pertinent question with regards to this is? Can such development assure the safety of the other areas around even when other adaptation policies for flood management are included in the package? This is a relevant question because, the aim is not only to provide housing facilities to the citizens but also to guarantee the good health of the citizens. With regards to this, after Frihamnen is developed, flood risk and vulnerability will increase irrespective of the flood management measures which are applied in the area. For example, if outer storm surge barriers are used to keep the away water, flood vulnerability will heighten in some parts of central Gothenburg. Whereas if embankments (river protection) are constructed, flood damage will be witnessed but lesser than with the outer storm surge barriers. An issue which arises with the river protection is that, there is not enough space to construct such structures (Nilsson 2016)

"From a cost-benefit analysis these two measures were studied. The research showed that both solutions would generate a negative net present value of -2717 million Swedish crowns for the älv protection and -567 million Swedish crowns for the outer barriers. However, with the river protection there would be a damage reduction of 3450 million Swedish crown and with the outer barrier the damage reduction would be 1760 million Swedish crowns. In this research, the value of the new developments in Frihamnen have not been taken into account when calculating the damages costs. … the damages cost would increase significantly after the realization of the developments in Frihamnen… concluded that even with the outer storm surge barriers, some parts of central Gothenburg would still be vulnerable for flooding. Therefore, the river protection will protect more areas from flooding then the storm surge barriers. A challenge with the river protection is the space that is needed to build the protection" (Nilsson 2016, p.52).

(4) Application of Retreat Policy

Although currently, there are no practical cases where the retreat policy has been applied, however, in the Frihamnen pilot project, test was made with regards to the application of this policy in the area. The idea was that, retreat would be applied in the low-lying piers of Frihamnen, which are highly exposed to flooding. To reduce flood vulnerability in the area, vital functions of the community such as homes, offices, railways, streets roads will not be constructed in these areas. Instead, the areas will be used for green space and recreational facilities (Roth et al.2011).

"In the application of Retreat in Frihamnen, the low-lying areas of the three piers will not be used for the construction of houses, offices, railways or major roads and roads. However, the idea is not to leave the piers empty, it will be used for green spaces, recreational facilities and the like. The retreat scenario also opens for temporary uses of space, for example, music concerts, motor races and car and boat shows. Currently, the piers are used for such events. In Retreat, the runway of the piers would become an active area with ballroom, skateboard, inline, bicycle and parkour venues and for hosting temporary events such as concerts and the like. On the Northern pier, boat platform capacity is built and unused areas can be used for boat and car spaces" (Roth et al.2011, p.14). Author's translation.

- **Additional safety margins**

Considering that, sea level rise predictions are uncertain, the city of Gothenburg has made some changes in its adaptation measures for flood management in connection to prediction of future rise in the sea level, based on the Intergovernmental Panel on Climate Change(IPCC) prognosis. This implies new minimum foundation levels will be imposed as water levels increase. Therefore, to protect vital functions of the community from flood damage, new rules have been enforced which impose a safety margin of 2meters for buildings above the current peak water level (Göteborg stadskansliets 2009).

"*As the scenarios for future rise in sea levels are uncertain, measures that we make now should allow to easily rebuild to a higher level. In addition, we believe that for vital functions of the society, the ambition should be to secure these to a level 2m above today's extreme peak water.*" (Göteborg stadskansliets 2009, p.4). Author's translation.

These revisions were made in connection to the municipality's Water Plan -Vatten Så Klart (Göteborg stadskansliets 2006). This means, a safety margin of 0.5 meters was added to protect vital functions in the central part of Gothenburg from flood damage. This thus gives a required minimum floor level for new buildings in this part of the city of (+12.80 meter (Göteborg stadskansliets 2006).

"By *decision in connection with the Water Plan, the city has determined that in new buildings the safety margin shall be increased by an additional 0.5 meter (+12,80 m)" [Author's translation]* (Göteborg stadskansliets 2006, p.23). Author's translation.

In 2010, an additional one meter was recommended for Älvstaden, which increased the minimum floor level for new buildings with +3.80meters. The implementation of the new safety margin was also influenced by the "extreme weather conditions" investigations and new sea level predictions (Goytia et al.2016).

"*In connection with investigations on extreme weather events and as newer estimations on sea level rise became available, the necessity to further raise the safety marginal in relation to critical infrastructure was discussed, and in 2010 the Municipal Assembly adopted a decision … to strive to achieve a safety level of one additional meter above the required level for the central areas of Gothenburg in case of especially critical services. The required lowest foundation level for these is then +3.80 meters" (Goytia et al.2016, p.48-50)*

- **Management of storm water**

With regards to the management of storm water in the reduction of flooding, there have been changes, whereby storm water issues both for old and new developments are included in the early stage of the planning process. For the treatment of excess water during extreme weather conditions, actions have been made, whereby provisions are made for the redirection of the water when the capacity of the sewerage system surpasses. Furthermore, there are ongoing discussions for the inclusion of storm water management in the comprehensive plan, whereas the detail planning should do an assessment on storm water, which informs on the actual holding capacity of piped systems and waterways as well as possible consequences of extreme weather conditions (Goytia et al.2016).

"…The consideration of storm water management issues early in the planning processes, both when it comes to new development and to expansion of already existing development…. for extreme rain events, by calculating where the water will be headed once the capacity of the system is exceeded and if possible redirecting it. A number of documents supporting these developments have been adopted, including the 2003 Water Plan and in particular the handbook "Storm water management, this is how we do it! According to this policy document, storm water management should be considered already in connection with the comprehensive planning and detail plans should include a storm water investigation, showing the current capacity of piped systems and watercourses, as well as the potential consequences of extreme weather events" (Goytia et al. 2016, p.51).

The above section has shown that, the city of Gothenburg has implemented the adaptation policies for flood management: protection, accommodation, retreat and attack in Älvstaden between 1999 and 2015. However, some features such as vegetation cover (in soft protection) has not been linked to adaptation for flood management. Besides, the purpose of floating homes in adaptation for flood management has not been stated in policy documents. Instead it has been linked to other climate change hazards. The findings also show that, there has been revision in some of the measures. By way of example, the management of storm water has been improved upon and new rules now exist for the sewerage system.

6. DISCUSSIONS

This research has shown that, the city of Gothenburg has engaged in the integration of adaptation for flood management into its spatial planning system and that, in the course of the engagement process adaptation policies for flood management have been implemented in the area. Based on the theory applied in the current study, the engagment process has been grouped and analysed as four: (i)Generating planning intelligence regarding hazard risks and vulnerability of the local population, (ii) setting goals and objectives for reducing risk and vulnerability,(iii)Adopting policies and programs to achieve the goals and objectives and (v) monitoring and evaluating the results, making revisions to policies and programs over time as necessary.

However, there are some unclarities with regards to the way the city has linked some of the adaptation measures for flood managent and the prodcedure of the integration process. By way of example, the vulnerable group under step(i) has been defined in terms of geographic and economic vulnerability ,while social vulnerability has been excluded. Public participation has been defined in terms of relative figures which does not say anything on how the public actually contributed in the implementation and development of adaptation measures.Per Innes(1998), public participation is a relevant step in spatial planning and if left out, it affects the entire planning process(Forster 1982 and 1980).And with regards to the dissimilation of flood information to the public, it is hard to tell, as the municipality's website provides no feedback nor can track online visitors. Other studies equally highligt on these issues. For example, Grannis (2011) outlined that, flood risk and vulnerabilty was not completely covered in Georgetown due to the fact that, during the integration process, the investigation team consisted of planners and other experts who were not in touch with the day to day realities of the community. She stressed out that, the outcome of this was exlusion of certain vulnerable group of the society , whose needs were excluded during policy implementation. Per Grannis(2011), the media- the climate portal of Georgetown is not sufficient enough to claim the citizens have received and acquired the needed information with regards to flood risk and vulnerability. Futhermore, the intergrartion process being a chain, would affect the other steps. By way of example, with a certain class of persons being excluded in step(i), it would be felt in step(ii), as they will be underpresented or exluded while setting goals and objectives for the reduction of flood risk and vulnerability(Grannis 2011).A similar observation was made in step(ii) of the current study.

Moreover, the study has also shown that, the city of Gothenburg has applied the four adaptation policies for flood management(although some projects are underway - attack).However, the aim of the purpose of the structures such as floating homes,vegetation have not been linked to adaptation for flood management.Even though in step(ii) the role of permeable surfaces was stated in relation to adaptation for flood management, this was excluded during the implemtation of accommodation policy. Nonetheless, some differences found are that, in step(iii)vegetation cover in the waterfront area of Mokpo, southwest Korea has been linked to adaptation measures for flood management in the area. Aside, floating homes in Rhine Delta, in the Almere-Amsterdam region have been linked to adaptation for flood management and detail information was outlined with regards to the use of the different features of the floating city. For example, the floating vegetation's role is to block the strong tides , thereby reducing flooding, the choice of the building material, such as the EP-foam is to make the structures unsinkable(Graaf et al.2004). The similarities between Graaf et al.(2004), Horowitz (2016) and Lee(2014) findings and the current study is that, due to scarcity of land and housing shortages, local governements have to think of innovative alternatives, which include building on the waters. Although these stuctures are protected from flood risk and vulnerability, the rest of the city is left unprotected.The study also found that,most of the applied "hard protection measures" such as consturction of dams are not initially adaptation measures but are connected to agriculture and hydropower which makes it difficult to identify hard protection measures which are developed with pure intensions for adaptation for flood management(Goytia et al.2016). Besides, the retreat policy has a totally different perception and application with regards to Gothenburg, as it does not suggest rellocation of human population and buildings. A reason for this is that, the area where this policy is underway is a new development area which does not have any infrastructure , so it is easy to plan with regards to the location of vital functions of the community , by avoiding the low-lying piers which are most vulnerable to flooding(Roth et al.2011).This way of applying the retreat policy is different compared to previous findings, whereby human population is relocated and infrastructure in high flood prone areas are abandoned (Bray et al.1997, Klein et al. 2001, Few et al. 2007a and Abel et al. 2011).

The results from the study could be used by planners, local governements and different actors of the land use planning game. Being aware of the issues which arises while integrating adaptation for flood management in the spatial planning system is a first step, while attempting to reduce flood risk and vulnerability in a community.Besides, it is relevant that all actors of the land use planning game be represented during flood risk and vulnerability investigations and policy development. Findings from the current study has shown that, goals and objective set, although flexible ,broad and location specific, their purposes do not relate to adaptation for flood management purposes. There seem to be some kind of discordination between the steps , which makes some vital functions of the integration process disappear.And hard to identify the purposes of the steps involved in the integration process.

6.1 Suggestions for further research

A lot of aspects with regards to the integration process of adaptation for flood management into the spatial planning process are yet to be studied.The findings of the current study showed that, although there has been integration, but it has not been linked to adaptation for flood management. Which is an indication that flood risk and vulnerability has not been completely covered. Underlining these aspects is a contribution which the current study makes to adaptation for flood management studies. It would be useful if further research is carried on this topic whereby different approaches such as in-depth interviews and focus groups are adapted involving citizens and experts.In this way, insight on citizens particiaptation in the four steps of the theory could be observed from different angles which might reveal different results.

6.1.1 Policy implications

To successfully adapt the built up area and the environment to flooding, all three dimensions of flood vulnerability and risk should be identified and represented during the integration process and, while developing the maps. Flood risk and vulnerability information should be dissmiliated within wider community flood programmes and policies(such as school programmes and other programmes which could be share in meeting places), which seek to target the most vulnerable group of the community by educating them on these issues. In the long run, lack of basic knowledge on the flood issues might even contribute in increasing flood risk in the area, as it might trigger maladaptation, that is failure to properly adapt. This implication is not new, it has been pinpointed that,lack of basic information has increased flood risk and vulnerability in some areas, as citizens lacked the fundamentals(Grannis 2011). Moreover, to adapt the area to flooding, a clear distinction should be made with regards to adaptation measures for flood management, their role in the reduction of flood risk and vulnerability. This is because, seemingly there is a missunderstanding between adaptation measures for flood management and making the city appealing. This can be done by clearly redefining the role of each climate adaptation for flood management measure. And including these measures at the early stage while developing the comprehensive plan and the detail plan of the city. Moreover, decision makers should be educated on the importance of each adaptation tool for flood management.

7. CONCLUSION

The aim of this thesis has been to describe and analyse the city of Gothenburg, Sweden, engagement in climate change adaptation for flood management in Älvstaden between 1999 and 2015, by tracing its integration process based on the urban land use planning theory for the integration of natural hazard and climate change adaptation , as well as identify the adaptation policies for flood management developed and implemented within this timeframe. Constructing on the urban land use planning theory for the integration of natural hazard/climate change adaptation, the study has shown that, step(i) has been used by the city to provide flood risk and vulnerability maps and identfy locations and objects at risk of getting flooded when water level rise in the Göta River. In step(ii) integration was done by setting goals and objectives towards reduction of flood risk and vulnerability in the area and step(iii)identified the application of four adapatation policies: protection, accommodation, attack and retreat have been applied in the area.

The study has also shown that, there have been some issues during the application process, for instance in step(i), vulnerability has been treated in terms of geographic and economic vulnerabilities excluding social vulnerability , that is the vulnerable group which include; pregnant women, old persons, children , physically challenged persons and non speakers of the language.Dissimilation of flood risk and vulnerability information via the municipality's website and the comprehensive plan has not been properly handled, by this it infers the city can not for sure attest if the public has acquired the information. As the argument goes, information can be avialable but not acquired. With regards to public participation, the public has been excluded during measure investigations. Whereby, public participation has been defined in relative numbers and other words such as "well attended" and "positive comments". Based on the theory, it could be nice to identifiy how the public influenced decisions during these meetings they took part.Per the author, this defintion of public participation is shallow and implies nothing.Issues also arose in step(ii) during the goals and objectives whereby, the citizens were not represented, which is an outcome of step(i) considering that the public have been excluded already from this stage. And in step(iii) the author showed that, the city does not relate the applied measures for the adaptation policies to flood management but with the esthetic of the area and other climate change impacts, which is also problematic as it indicates the perception of flood risk and vulnerability is marginal compared to the wellness of the people and beauty of the city.And lastly in step(V), it was indicated that, new policies such as safety margins, additional metres of the minimum floor levels and new rules with regards to the sewerage system have been uppdated to fit the realities of rising sea levels which trigger flooding.

Departing from these, this concluding section provides answer to the research question:"*What improvements would be made in the integration process to better address adaptation for flood management?"*

To cover all of the vulnerable class of the community, it is vital to construct flood vulnerability maps which takes into consideration the different groups of persons who reside in the neighbourhood the assessements are conducted. A way to this is by identifying which groups of persons are predominant in the area, it terms of family housewholes, single housewholes with old or physically challenged persons and those who donot master the language. Dissimilation of flood risk and vulnerability information via the website can be improved by integrating a section in the website which indicates the number of visitors who have been on the site. An interface could pop up each time a visitor browses the site, such that a brief questionnaire (5seconds)flashes with questions which seek to know:the purpose for their visit, if they acquired the information they were searching for. With this, a distinction would be made between curious visitors and those who navigated to get information.Moreover, the comprehenisve plan should include the changes which were made due to citizen participation and show clearly the number of citzens during meetings. A way to do this is by stating the number of citizens and collaborators of the organising committee, not just grouping the participants. Through snail -mail, invitation letters to participate in meetings could be sent to random citizens. The best way is to send out as many invitations as possible, to cover the most of the population. It is true that, it would be difficult to reach out to the citizens but a large coverage will produce positive results and stimulate public particiaption. This applies for step(ii) as well. It would be assumped that, the absence of the public in this step is due to the fact that, they have not been reached, if they are reached as suggested above, they would positivly participate in the main investigations and during decision makings. Finally with regards to step(iii), adaptation for flood management must be the primary goal and not marginal goal when applied in connection to the developed policies :protection,accommodation,attack and retreat. This can be done by including these policies while drawing the comprehensive plan and linking it up with adaptation for flood management.Whereas in the detail planning, it will be shown how it could be applied in different locations and the purpose of each measure(floating homes and vegetation) in reducing flood risk and vulnerability, as well as adapting the built-up area to rising water levels which trigger flooding will be elaborated and discussed.

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APPENDIX

Organisation of the investigation

Under Stadskansliets ledning och med start 2005-01-28 bildades en arbetsgrupp för samordning av utredningsförfarandet:

- **Stadsbyggnadskontoret;**
  Karin Bergdahl, tfn 61 16 00
  Ulf Moback, tfn 61 16 74
- **Göteborg Energi AB;**
  Lennart Bernram, tfn 62 62 81
- **Kretsloppskontoret;**
  Agneta Sander, tfn 61 34 78
- **Va-verket**
  Henrik Kant, tfn 62 71 09
- **Trafikkontoret**
  Lars Ohlsson, tfn 61 16 67
- **Stadskansliet (projektledning)**
  Leif Johansson, tfn 61 11 75
  Jakob Rydén, tfn 61 22 52

Fig2: List of participants "Extrema vädersituationer - Hur väl rustat är Göteborg? . Source adapted from Göteborg Stadsbyggsnadskontoret (2008, p.5)

Projektet "Klimatanpassad stadsstruktur: scenarier för framtida Frihamnen", som påbörjades våren 2010 och avslutades hösten 2011, var ett pilotprojekt inom ramen för Mistra Urban Futures – centrum för hållbar stadsutveckling. Projektet var transdisciplinärt, vilket innebar ett gränsöverskridande samarbete mellan praktiker och forskare från olika ämnesdiscipliner. Med hjälp av workshops och fokusgrupper producerades ett underlag vilket har legat till grund för både vetenskapliga och praktiska resultat. Denna rapport presenterar resultat från pilotprojektet och riktar sig mot verksamhetsutövare vilka sysslar med klimatanpassning och hållbart byggande. Ytterligare resultat från projektet kommer att presenteras i vetenskapliga forum.

Projektgruppen bestående av Philip Thörn (IVL Svenska Miljöinstitutet), Ulf Moback (Göteborg stad), Greg Morrison (Chalmers), Katarina Buhr (IVL Svenska Miljöinstitutet), Per Knutsson (Göteborgs Universitet), Susanna Roth (IVL Svenska Miljöinstitutet) och Hanna Areslätt (Centrala Älvstaden) har gemensamt producerat de vetenskapliga och praktiska resultaten.

Projektet har möjliggjorts tack vare finansiering från Mistra Urban Futures, Trafikverket och Stiftelsen IVL.

Fig3: Collaboration between international organisation (Mistra Urban Futures), the planning office and other actors of the land use game, the public (workshops and focus groups) -investigations of climate change adaptation policies in Frihamnen. Source adapted from Roth et al. (2010, p.5)