BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

SEVENTH FRAMEWORK PROGRAMME

cmcc

Subgroup: Urban Areas and Coastal Management

Case-study: Venice

(CMCC, Venice)

Case study developed by:

Margaretha Breil

CMCC

Project:

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Purpose of this document:

"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living document will also (vii) allow WP6 & 7 partner to know the information."

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1. General Case Study Description

A. Location

GPS: N45°26'15'' _/ E 12°20'09''
Area: 8 km^2(excluding water surfaces)

B. Case Study Summary

The case study aims at analyzing processes of spontaneous private adaptation, using data on costs and benefits of measures undertaken by private and public actors to adapt their premises and urban structures (pavement levels) and services (alert systems and emergency services) to increasing sea levels.

C. Context

The historic centre of Venice is located in the centre of a coastal lagoon situated at the northwestern edge of the Adriatic sea and directly connected to the sea via three inlets serving as exchange for water between lagoon and sea and as shipping lines.

The historic part of the city actually has slightly less than 59.000 inhabitants, a number which is declining since the end of World War 2, when more than 170.000 persons lived in the city. It is part of a Municipality of approx. 270.000 inhabitants, further to the population of the historic city (*centro storico*) 30.000 persons live on smaller islands throughout the lagoon and 180.000 on the mainland.

Both the historic centre and the Venetian Lagoon are UNESCO Heritage sites visited each year by approx. 30million tourists.

The entire city is exposed to occasional flooding related to exceptionally high tides entering the Lagoon from the Adriatic sea. Due to subsidence, the city of Venice is actually sinking at a rate of approx. 0.05 cm/year (Carbognin, Teatini, Tomasin, & Tosi, 2009), but subsidence during the industrial phase of the city, from the 1930ies until 1971, contributed to a subsidence of 10 cm over the century. Tendencies of subsidence due to anthropogenic causes has been arrested when industrial uses of groundwater have been suspended in the early 70ies of the 20th century. With regards to the eustatic rise of sea levels, Carbognin et. al (2009) observed an increase of mean sea level of 0.12 ± 0.01 cm/year for the period from 1890 – 2007. On this background extreme flooding events created by a combination of meteorological, tidal and oceanographic phenomena are increasingly frequent in the city.

This situation which is only since recently discussed in connection with climate change, has nevertheless generated activities for the safeguarding of the city, implementing a range of hard and soft protection and early warning measures, where elements of preparedness and resilience are in some cases translated into interesting reinterpretation of traditional strategies of "living with the water".

D. Brief General Information on Climate CHANGE and related issues

Venice is situated on the northern rim of the Adriatic Sea, which is part of the Mediterranean basin. Climate change scenarios foresee rises in temperature above global means (OECD, 2010) decreases in precipitation, and in some cases, decreases in winter storminess (Gualdi et al., 2012). Projections for future levels of eustatism for the Mediterranean are complex and not straightforward; as a series of dynamics (rate of evaporation, salinity, patterns of exchange in the straight of Gibilterra) contribute in different ways to the evolution of sea levels in the basin. Gualdi et al. (2012) estimate a rate of increase of 7 – 12 cm for 2050; or 13 cm for 2100 under an A2 scenario for the steric component; Vellinga et al. (n.d.) find for the period until 2100 changes in the range of -22 to 31cm of steric sea level rise, according on single model outputs for three different scenarios (Vellinga et al., n.d.). It has to be underlined that contributions due to the melting of ice sheets are not considered in any of these scenarios With regards to tendencies in storminess, climate models for the Mediterranean show, a possible tendency of decreased storminess, but it is not possible to deduct any tendencies in the conditions creating of extreme events in the northern Adriatic (seiches, strong south-eastern winds, and tidal excursion).

E. Existing Information on Case Study's adaptation history

The city of Venice, supported by the national government, is tackling the problem of periodic flooding since the occurrence of a major flood event in 1966. Since then generic flood protection measures, buildings restauration, protection of historic monuments against high water, flood preview and alert systems have been put in place as, public pavements have been raised to ease traffic and communication during flooding. Furthermore, a major flood protection measure, called MOdulo Sperimentale Elettromeccanico, *Experimental Electromechanical Module, short MOSE*) is being implemented which aims at temporarily interrupting the influx of water into the lagoon in situations of high water.

The MOSE project dates back to debates led during the 80ies and its design was completed in 1992. Like the generic debate on rising sea levels and increases in the number of flooding events, until short time ago, have mainly been discussed in the context of local subsidence tendencies, determined by local anthropogenic and natural factors

(Camuffo & Sturaro, 2003; Carminati, Doglioni, & Scrocca, 2005). In recent years, climate change has gained some importance with respect to urban policies, but this has, up to now, led only to a series of international presentations of the Venice experience and strategies rather than to a change in local policies and a proactive policy of adaptation.

Major critiques have been advanced to the big infrastructure project MOSE which is actually under heavy criticism because of the political turmoil caused by the arrest of the Venice Mayor and several officials and businessmen being arrested with the claim of bribery committed in relation to the public tender process of the Moses project[1]. The high costs of the project (5.4bn euros spent up to today and more than 6 billion € expected costs at it's completion, the costs more than quadrupled with respect to the initial estimates[2]) caused criticism among citizens and some scientists. Although not designed in view of changing climatic conditions and increased sea levels, the constructor states its physical capacity of withstanding increasing sea levels (and consequently storm surge levels) up to 60 cm throughout the coming 100 years[3]. The implications for the urban (and harbour) economy of the implementation of this infrastructure under increasing sea levels are made explicit by some authors (Fontini, Umgiesser, & Vergano, 2010; Vergano, Umgiesser, & Nunes, 2010) in terms of delays and interruptions of the commercial traffic in the harbour.

With respect to the adaptation of the urban structure to rising sea levels, a common goal of ensuring a safeguard level independently from the mobile gates up to a medium high level of flooding led furthermore to some interventions on public floor space, rising floor levels as far as possible to the established measure of 120cm above the local tidal gauge. In parallel to these public interventions, private house owners started to adapt their dwellings to the rising flood levels, by raising ground floor levels and inserting small mobile flood barriers preventing flooding of ground floor units during "high water". The Case study focusses mainly on these private activities, attempting to quantify the benefits in terms of reduced damages of these spontaneous private interventions.

F. Connection with other research projects:

The case study will build on previous analysis of flood damages and protection measures produced for the italian research project VECTOR (VulnErabilità delle Coste e degli ecosistemi marini italiani ai cambiamenti climaTici e loro ruolO nei cicli del caRbonio mediterraneo, 2008 – 2010) coordinated by the Italian Interuniversity consortium for maritime research (Conisma) and major Italian research institutions as ISMAR, ENEA and OGS).

G. Case ID, Typologies and Dimensions

BASE OBJECTIVES	
1. Compile and analyze data and information on adaptation measures, their effectiveness. (…)	X
2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).	
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)	
4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular	X

[1] See, for instance http://www.bbc.com/news/world-latin-america-27692334 assessed on sept. 18th, 2014
[2] http://www.corriere.it/english/14_giugno_05/mose-s-quadrupled-costs-fc59e588-ecaf-11e3-9d13-7cdece27bf31.shtml assessed on sept. 18th, 2014
[3] https://www.mosevenezia.eu/?page_id=16&lang=en accsessed on sept. 18th, 2014

attention on sectors of high social and economic importance.

5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.

6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.

7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES	
A.	Public administration (municipality, regional, national, european)
B.	Research and education Centres (universities, research centres, projects and groups, schools)
C.	Public companies
D.	Companies (farms, SMEs, big businesses)
E.	Social enterprises (cooperatives, non profit companies, woofing farms, etc)
F.	Consortiums (partnerships, campaigns),
G.	NGOs (environmental NGO, local development NGO, charities, etc)
H.	Transition Initiative
I.	Ecovillage
J.	Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[4]
Italy Venice	[x] Objective 1 [ ] Objective 2 [ ] Objective 3 [x] Objective 4 [ ] Objective 5 [ ] Objective 6 [ ] Objective 7	Example: [A] Public administration/private actors	[ ] Rural [x] Urban [ ] Coastal [ ] River Basin	[x] Local [ ] Regional [ ] National [ ] Transnational [ ] European /Global	[x] Bottom-Up [x] Top-Down	[x] Retrospective [ ] Prospective	2000 - 2050

H. Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

Impacts	Sectors	Implementation

[4] Please insert year of start and year of end of case study.

Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[5]	Phase of Implementation[2]
☐ Temperatures ☐ Water Scarcity ☐ Flooding [1] Sea level Rise ☐ Droughts [2] Storms ☐ Ice and Snow	☐ Extreme temperatures ☐ Water scarcity [1] Flooding ☐ Coastal Erosion ☐ Droughts ☐ Soil Erosion ☐ Vector Borne Diseases ☐ Damages from extreme weather related events (storms, ice and snow)	☐ Agriculture and forest ☐ Biodiversity [2] Coastal Areas ☐ Disaster risk reduction ☐ Financial ☐ Health ☐ Infrastructure ☐ Marine and Fisheries ☐ Water Management [1] Urban	☐ Agriculture ☐ Biodiversity & Ecosystems [2] Coastal and Marine systems ☐ Energy ☐ Health and Social Policies ☐ Transport ☐ Production Systems and Physical Infrastructures ☐ Water resources ☐ Tourism [1] Urban Areas and Coastal Management	[1] Yes ☐ Ongoing ☐ No	☐ Assessment ☐ Planning [1] Implementation ☐ Monitoring ☐ Evaluation

The historic centre of Venice is built inside a coastal lagoon which is directly connected to the Adriatic sea at its north-western rim. Within the Mediterranean, the Adriatic, and especially the north-western rim is one of the few areas facing some relevant tidal excursion. Under specific conditions, which combine specific astronomic and meteorological characteristics, high floods exceed the normal range of tidal excursion and flood urban areas. These occasional flooding events are part of the venetian history, and to a certain extent, the city is adapted to these events, for example with the choice of building materials which are able to resist against salt water intrusion, protect buildings from humidity raising from the ground, etc.

Venice, being situated at the eastern edge of the Italian Po Plain, is subject to relevant subsidence processes caused by tectonic and, to a certain extent, also to man-made processes, as, for instance ground water abstraction from aquifers situated beyond the lagoon. These subsidence processes have determined a gradual process of sinking of the entire urban area, which has been on-going over centuries and has been gradually compensated by raising of floor level of public and private spaces. The subsidence process has exposed an increasing part of the urban surfaces to flooding; climate change induced sea level rise will additionally contribute to increase surface of flooded areas and increase frequency and levels of flooding.

The occasional flooding of urban areas generate relevant economic and social impacts, which increase with the level of reached by the flood event and its duration. Climate change related sea level rise will exacerbate this phenomena, making flooding events become more frequent and more intense.

Impacts considered in the context of the BASE case study refer mainly to damages by flooding and rising levels of ground water, caused on private building structures. These damages are expressed, mainly in terms of increases in maintenance costs encountered due to increasingly frequent flooding and rising levels of ground water, which brings building elements in closer and/or more frequent contact with salt water. This means that plaster and bricks need to

[5] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

be exchanged more frequently, and building elements such as doors or floors may have a shorter lifetime than in buildings not exposed to salt water.

Further impacts considered but not quantified relate to partial interruptions of urban life and activities caused by flooding of public urban spaces.

These impacts which are already well known and experienced will be exacerbated by climate change induced sea level rise.

I. Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

☐ Case developed and implemented as a climate change adaptation measure

☐ Case developed and implemented and partially funded as a climate change adaptation measure

☒ Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

2. Case study research Methodology

Research Goals

The experience accumulated in the city in adapting an urban system to rising levels of flooding, albeit not fruit of a homogeneous climate change adaptation plan, is nevertheless anticipating impacts other coastal urban areas might prepare for, and will provide insights into the possibilities and limits of adaptation of urban systems to sea level rising induced by climate change. The principal goal of the case study is to illustrate, and, as far as possible, quantify and assess, spontaneous adaptation efforts in the historic Centre of Venice, which is interested by periodic flooding events.

a) Stakeholders involved

Key stakeholders in for the case study are representatives of the different public administrations and agencies as well as scientists and stakeholders observing and participating in the implementation of sea level rise related policies. (key actors: local authority representatives and their agencies, state representatives for the infrastructure realization, representatives of environmental initiatives and economic actors.)

b) Methodology

Economic quantification of adaptation efforts on the side of private actors will be based on the analysis of a database on physical conditions of ground floor units resulting from a survey on ground floor units in the historic Centre. These information on investments can be confronted with an estimation of avoided damages from flooding thanks to the adaptation measures adopted. Information on costs and benefits of private adaptation activities are based on information on physical conditions, protection measures against flooding in ground floor units, and information on frequency of inundation. Applying standard values for costs of flooding, damages and avoided

damages from single flooding events can be summed up to estimates of damages from flooding on building structures in Venice under past climate conditions and future scenarios. The case study focuses on the individual adaptation strategies, estimating private investments and avoided damages (material damages and increased maintenance costs) assuming a BAU scenario (constant sea level) and one or two scenarios for sea level rise.

Albeit mainly a retrospective analysis, the Adaptation pathways approach can be applied for this case study questioning how critical thresholds are defined, either by private investors or, in hypothetic manner, at a general level;

The measures to be considered are mainly:

Public measures:

- Forecast and early warning system
- Raising of public pavements
- Flood protection infrastructure (MOSE)

Private investors /building level:

- Barriers
- Raising of floor levels,
- Impermeabilization (dry flood proofing) of ground floor units
- Changes of use in ground floor units.

If needed, the use of scenarios will be coordinated at project level, provided the possibility of quantifying measures of sea level rise for the Mediterranean and the Adriatic sea. In the case of use of scenarios, the design of specific storylines describing local (and national) strategies for the safeguarding of the socio-economic system of Venice with respect to tourism and alternative economic sectors will be crucial. This will be done in collaboration with local experts, representatives of the local scientific Community and of the local administration.

Determination of the adaptive capacity: in order to obtain information on adaptive capacity among private actors will be the presence (or lack) of protection measures for the private dwellings, physical factors such as exposure (frequency of flooding for the single unit), proximity to public adaptation works, value of real estate (including heritage character). The success of adaptation will be measured using cost benefit analysis. The results of this analysis will inform the question on factors that can influence adaptation.

The case study is focusing on private activities in adaptation, the institutional capacity is, from this point of view, not a relevant for the outcome. Nevertheless, the institutional aspects of the governance of the Venice lagoon, which involves a wide range of administrative levels and sectors and has been a determinant for the decision making process of the MOSE project, have been studied inter alia, by Munaretto et.al. (Munaretto & Huitema, 2012; Munaretto & Klostermann, 2011; Munaretto, Vellinga, & Tobi, 2012), the process is actually in continuous transformation with allegations on corruptions of local politicians involved in decision making for the MOSE project during the past months.

Economic aspects

Based on a database collected by the local authority during the first years of the century, evidence on building structures and availability of protection measures put in place by private owners of dwellings and economic activities located in in ground floor units is used for a Cost benefit analysis related to investments in adaptation measures and their impacts on building maintenance costs.

In fact, the frequent flooding of ground floors of buildings does not lead to complete losses of buildings, but determines a sharply increased costs of maintenance of buildings if compared to “normal” situations not interested by regular flooding by salt water. The “damages” caused by flooding in the building sector are thus defined as the major cost of maintenance due to flooding in the Venice lagoon. The confrontation of damages will encompass several different states modelled:

Damages caused in the actual state of buildings and the number and form of adaptation measures put in place and revealed by the survey, a state where all ground floor units are assumed to be protected with flood protection measures and a situation where no adaptation measures are put in place.

- Note: Partners/Case Studies using PRIMATE tool will be using CBA (to prioritize) and/or MCA (with stochastic PROMETHE II) and the Monte Carlo Uncertainty Analysis, so please check these boxes.

METHODS to be used in Case Studies[6]	YES // NO
A) Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA)	x
Cost-Effectiveness Analysis (CEA)	
Multi-criteria Analysis (MCA)	
Analytic Hierarchy Process (AHP)	
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	
Influence Diagrams	
Process-based Modelling	
Welfare variation analysis under restrictions	(x?)
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	
Monte Carlo simulations (PRIMATE uses this method)	
Real option analysis	
Climate risk management process	
Maximim	
D) Participatory Methods	
Scenario Workshop	
Participatory Cost Benefit Analysis (PCBA)	
Participatory add-ons to CBA	
Participatory add-ons to Multi Criteria Decision Analysis	
Participatory add-ons to Adaptation Pathways	
Other Observation on some participative measures (interviews, literature, newspaper articles)	

[6] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

(Máx 500 words) *Please highlight if you have any special need or focus regarding any of these methods and their use on your case study.*

c) Case study Timeline

	2013				2014				2015			
Phase 1: analysis of existing data												
Collecting and georef. of database				x								
Analysis of network of relevant interview partners,				x	x							
Analysis of additional data sources				x	x							
Analysis of relevant strategic documents			x	x								
			x	x	x			x				
Phase 2: quantification of adaptation measures												
Analysis of adaptation measures,						x						
Data for assessment of adaptation measures						x						
Data for economic assessment					x	x	x					
Economic assessment of adaptation options							x		x			
Phase 3: formulation of results												
With representatives of public administration discuss implications and findings									x	x		
Journal article										x	x	x
BASE reporting												
D5.1 Climate change, impact and adaptation scenarios for case studies					x							
D5.2 Impacts, costs and benefits of adaptation measures								x				
D5.3 Case specific adaptation strategies and measures								x				
D5.4 Methodologies and tools for adaptation planning and implementing adaptation in cases										x		

d) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK)**: (to be defined according to necessity)**

Case: _____; Person: _____

Collaboration within BASE partners/researchers (to be defined according to necessity):

Name: _____; Partner: _____

Name: _____; Partner: _____

e) Research Outputs

a. Scientific Publications (to be defined)

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers: #

Provisional Title: _____

_____; Month/Year: ___/_____

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title: _____

_____; Month/Year: ___/_____

c. Other

- Scientific conferences: # ___

Provisional Title: _____

_____ Conference: _____ Month/Year: ____/_____

Provisional Title: _____

_____ Conference: _____ Month/Year: ____/_____

- Invited seminars, presentations at local events, etc…

3. Participation in Climate Change Adaptation

Investigation of participatory elements of adaptation in BASE case studies

The case study focusses on autonomous adaptation, but is developed on the background of a great infrastructure project which is being promoted since some time as potential adaptation measure. As far as private activities are concerned, participation is not relevant for the process, as decision making is based on individual preferences only and no public decision making processes are relevant. Nevertheless, the background of the case study, the construction of the flood protection barriers (MOSE) is characterized by a technocratic public decision making process with no participative elements and high conflict levels arising between different public actors. The subsequent responses refer to this background project. *It can be discussed whether a literature review (based on, Dente et. al, 2001, Munaretto & Huitema 2012, newspaper articles and personal knowledge) regarding this project and the participative processes should be included in the deliverable. (it would be a report on errors to be avoided, see for instance Munaretto & Huitema, 2012)*

Being the adaptation activity considered in the Venice case study based on private initiative, considerations on participative processes are not appropriate. On the contrary, the very recent ongoing process of defining a local climate adaptation plan for the city of Venice points to a public policy process, where participation and democratic processes are relevant and determinant for the contents of the policy, The on-going process has actually produced a declaration of intents for the redaction of ca climate plan, in which the areas of future action for climate change have been outlined both in terms of climate change mitigation and adaptation. This document has been approved by the city council in 2014 and published by the municipal authority[7]. Actually the activities have been stopped as the city has a provisory, not elected government (commissioner) and local policy action is limited to strictly necessary activities, whereas decisions related to strategic planning cannot be legitimized because of the lack of citizens representatives and properly elected policy organs.

The interview has been made with two representatives of the municipality which have been actively involved in the organization of this process and the definition of the draft plan.

Simone Tola AGIRE-Agenzia Veneziana per l'Energia (municipal agency for energy) and

Alessandro Caparelli, responsible for participative processes and urban sustainability.

The interview loosely followed the guidance for the questionnaire on participatory experiences defined in the BASE project.

1. Democratic and political tradition for participation

Generally speaking, participative experiences are not part of every-day policy processes in Italy. In cases where they are part of established procedures because of international obligations (eg. WFD, Marine Strategy, EIA) they often are fulfilled in a more or less bureaucratic manner which does not help citizens to properly understand the issues at stake and the real contents of decisions proposed.

7 http://www.comune.venezia.it/flex/cm/pages/ServeAttachment.php/L/IT/D/6%252Fe%252F6%252FD.da5d926f3453bb363eed/P/BLOB%3AID%3D73377/E/pdf

Nevertheless, both in Italy and in Venice, there are interesting experiences for successful and participative processes. This is the case for Venice, for instance, for the revision of some parts of the urban master plan, where professional assistance was used for organizing and facilitating the participation of citizens, environmental issues (*consulta ambiente*) and, more recently, in an inter-municipal experience of a contract for a river in the mainland part of the municipality (*contratto di fiume Marzenego*), where local initiatives have driven the creation of a consortium of local authorities, agencies and citizen's organization for the rehabilitation of a river which has caused major inundations in relation to heavy rainfalls in recent years.

In other occasions, as for instance for the definition of the "piano strategico" the municipal strategic development plan, has been redacted using the involvement of local stakeholders such as representatives of economic actors, important institutions university, transport, employers' and traders' organization, unions, etc.) who were directly interested in the strategic decisions being taken. The same stakeholder platform has been used when the urban energy plan (PAES) was defined to collect the projects that permitted to achieve the goals set by the Covenant of Mayors.

A further participative initiative in the municipality of Venice involved stakeholders, and different public institutions, including the civil protection agency for the creation of a network of citizens trained to stand up to emergency situations: this activity was born to deal with the industrial risk in the neighbourhood around the chemical pole of Porto Marghera (the GIPS Project[8]); more recently these organizational skills has been use to manage post flood activities. A case of collaboration between public and private, very demanding for the city budget, is the realization of the anti-fire network in the historic centre of Venice The urban adaptation plan for the city of Venice has not yet entered in the phase of public participation, as actually no decisions are being taken, and the preliminary plan is limited to the indication of areas of further investigation.

2. Important historic events

The historic event that has changed the consciousness on urban vulnerability to weather events in the largest sense in the historic centre of Venice was the "Acqua Alta" which hit Venice on November 4th, 1966, when an extraordinary tidal event reached the level of 194cm above the local tidal gauge. This event during which more than 90% of the area of the historic centre were flooded, triggered a series of national and local initiatives for the safeguarding of the city, comprising both physical and socio-economic measures. The design and later the construction of the flood barriers is part of the initiatives financed by the special legislation for Venice and its lagoon after this period as well as subsidies for private and public interventions for building general maintenance, which in fact allowed, inter alia, for the realization of flood protection measures in public and private premises, and flood forecast and alerting systems put in place.

There was no connection recognized between this event and trends towards a changing climate, the event is rather attributed to a coincidence between extreme weather conditions and a peak in the astronomic tide. Nevertheless, local transformation around the lagoon were identified as factors having contributed worsening the situation, as the freshwater abstraction for industrial purposes increasing the natural subsidence process the city is subjected to, and the transformation of the lagoon, especially land reclamation and shipping channels created for adapting the natural

8 http://www.comune.venezia.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/8838

lagoon environment to the needs of modern transport facilities (port and airport). The measures and laws put in place in that period partially addressed these issues, as freshwater abstraction form beneath the lagoon was stopped and further transformation of the lagoon morphology banned.

The Acqua Alta event exclusively hit the historical part of the city within the lagoon, whereas the mainland part of the city was hit by two extreme rainfall events in 2006 and 2007, causing flash floods that hit some parts of the residential and industrial areas with heavy economic damages. In the wake of these events, a special commissioner for flooding was appointed in order to overcome the institutional fragmentation of responsibilities for water management in this area, and to define a series of urgent measures for adapting the territory to extreme events of this kind. The event had been recognized "*calamità naturale*" (disaster), a declaration that opened the way to compensation claims for citizens and economic activities. The preliminary survey of the fragilities of the territory and the identification of priorities for action was conducted with an in-depth collaboration with citizens, which in some cases set up themselves as "Committee".

This process has furthermore triggered the formation of citizen's initiatives demanding an improved governance of the territory and leading, inter alia, to the river contract for the Marzenego river (see above) which engages both single citizens and public institutions for a sustainable management of the local river.

The mandate of the commissioner has ended leaving as heritage projects and competences to the municipalities involved. A program of works has been produced to be undertaken for increasing the hydraulic security of the mainland part of the municipality: most of these works, after scoring the most urgent, have remained on the paper until now waiting for public funding. Currently, among citizens, there is a great expectation that is carried out what has been defined in the process of collaboration.

3+4 Institutional responsibilities and participation

The future activities will be improved by the recent regional legislation which requires water planning by local authorities as a preliminary part of the urban planning activities. The urban planning law does indeed require participation by stakeholders, but these obligations can be (and normally are) satisfied with bureaucratic forms of communication to citizens, inviting them to communicate objections and observations to draft plans.

The urban climate plan is not subject to legal planning frameworks, so no formal obligation for participation exist. Nevertheless, during the envisaged second phase, dedicated at the proper definition of the local climate plan, participation of both stakeholders (institutions, representatives of social and economic actors) and citizens are envisaged.

5. Who has been involved?

The plan has been initiated by the municipal directory for the environment, and aims, in a first phase, at involving the relevant departments of the municipal administration and introducing the consideration of climate change in their planning and management activities. The response from the departments was various, with a generally low availability by administrators to formally take into account climate change in their activities. The most positive reaction came, according to the interviewees, from the department (institution) for flood forecast that has a high awareness of Climate Change going on and an important scientific activity in collaboration with various research institutions. Another positive response came from the Civil Protection department that is involved in the processes

described above (floods, industrial risk, anti-fire network) and also has in charge the emergency intervention for the heat-island phenomena. In other departments, specific requests aiming at enhancing climate resilience have been accepted, for instance in the redaction of the recent municipal bye-law which shall include measures reducing the effects of heat islands and flash floods– the legislative process is still ongoing.

6. Participatory methods

During the definition of the preliminary document, face to face contacts with responsible of the different municipal departments have been organized in order to create consensus for the initiative. The department for the environment has furthermore used formal channels of involvement in ongoing processes for promoting adaptation related issues, as in the case of the new bye-law.

7. Time of involvement

The interviewees were among the promoters of the initiative, and thus involved from the beginning, whereas some parts of the municipal administration have not participated. The preliminary document has been formally approved by the city council in early 2014.

9. Use of economic assessments

In relation to the forthcoming process and the vulnerability assessment, the consideration of quantitative criteria, including the economic assessments of potential damages to be used for cost benefit assessments has been discussed as an option. Nevertheless, the interviewees fear that these strategies might encounter scarce enthusiasm, especially considering the range of intangible values (human lives, cultural heritage) at stake. Nevertheless, some quantifications of economic damages are already available, for instance in relation to the compensation claims following the extreme events in 2006/07.

4. Climate Change Adaptation Measures and Strategies

a) Adaptation Measures under analysis in your case study

(Please identify your Adaptation Measures considered in this case-study and provide a short description of each)

Adaptation Measure(s):

1) Adaptation to privately owned residential and commercial buildings mitigating flood risks
2) _____
3) _____
4) _____

b) Adaptation Measures selection and data availability prior to BASE

At the beginning of the 21st century, the municipal authority has conducted a survey aiming at creating evidence on building structures and availability of protection measures put in place by private owners of dwellings and commercial activities located in in ground floor units in the historic centre of Venice. This database comprises ca. 7800 premises surveyed; for a sub sample of 64% of these, detailed information on the physical characteristics are available; corresponding to approximately 48% of the privately used ground floor units in the Venetian centre. For those premises chosen, the database details floor levels for each of the rooms, which are determinant for the frequency of flooding, building materials and the existence of flood protection measures put in place by the owners of the premises.

c) Full description of Adaptation Measures

Table: Type and function of protection measure

Type of Protection	Function	Type of damages avoided
Raising floor levels	Raising the floor levels inside the premise reduces the number of flooding events the unit is exposed to.	All types of damages from direct contact with water are avoided as long as the level of flooding remains below the new floor level.
Tank (Vasca) (combined with Barrier)	This measure consists of a complete waterproofing of the floor and the walls of the unit, preventing thus the entrance of water (including a barrier for the entrance, special design of outlets, waterproofing and enforcement of the floor).	Preventing salt water from penetrating walls, all types of damages are avoided, as long as the flood does not reach the maximum level of waterproofing realised, for this maximum level, the level of the mobile barrier in the entrances and of the waterproofing of the walls are crucial.
Pump	Mechanical device expelling water entering the unit.	If not combined with other measures, it only avoids damages at internal doors,
Barrier	Prevents water from entering at the entrance door with a mechanical barrier.	If not accompanied by other measures it reduces damages at externals doors, as water may enter from the ground, passing by outlets or the floor.
Pump + Barrier	Combines protection offered by pumps and barrier	Reduces damages at internal and external doors
Cutting of walls	Cutting walls and inserting an impermeable barrier between the layers of bricks (sheet of lead, chemical products), preventing thus the capillary rise of water from the ground.	Reduces damages to walls and plaster.

Table 1: Description of type and function of protection measures

	Any measure*	Raising of floor levels	Barriers	Pumps	Vasca	Cutting of walls
residential units						
sample	1026	783	310	62	85	182
all units (estimated)	1.854	1.415	560	112	154	329
%	42	32	13	3	4	8
commercial units						
sample	944	469	502	191	98	86

all units (estimated)	2.179	1.083	1.159	441	226	199
%	36	18	19	7	4	3
*units may have employed more than one measure at a time						

Table 2: Quantitative importance of protection measures adopted

Estimating the diffusion of different protection measures adopted on the basis of the sample, more than one third of the ground floor units are equipped with one or more forms of protection measures, with a slightly higher incidence for residential than for commercial units.

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

The measures analyzed depend exclusively on private initiative and decisions are taken in the private domain.

II. Does the measure initiate further activities for adaptation to climate change?
no

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? no

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? the performance of the measures under different scenarios (in terms of sea level rise is part of the analysis

The volume of investments required creates some economic barriers to single owners of ground floor units. The physical presence of users and their experience in mitigating the consequences of flood events is able to reduce some of the damages not accounted for in this exercise because of lack of data. Under a scenario of increasing touristic use of residential units in the historic centre, protection of mobile assets and stress due to flood events could be a factor contributing to an increasing application of expensive protection measures that are able to totally impermeabilize the interior of the unit.

V. Is the adaptation measure iterative? no

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? no

a. Please describe briefly how

There is no relationship to factors influencing directly sustainable development

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y) Measures can be repeated adapting to higher levels of flooding, limits are the level of ceilings, and, with regards to the raising of public floor levels (not assessed economically, as the agency does not disclose information on this) the level of entrances to private houses.

Outcome

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health ?

Periodic flooding has always been part of the urban life in Venice, but levels of flooding are continuously are increasing so that higher parts of the building structures come in contact with salt water which traditionally were not built in a way to resist against salt water intrusion. This makes further protection measures necessary. Most of these measures do not interfere with the visual aspect of the building and

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%)

Under the present state of adaptation measures, approx. 5,8 % of the overall damage costs are avoided, under a scenario of dry flood proofing, this rate would go up to approx.. 64%.

Scenario	Bau	+10	+30
present adaptation			
benefits	5,85	5,81	5,88
damages avoided	94,15	94,19	94,12
scenario small measures			

benefits	35,78	35,68	35,53
damages avoided	64,22	64,32	64,47
scenario full impermeabilization			
benefits	62,08	62,05	61,88
damages avoided	37,92	37,95	38,12
scenario raising floor levels			
benefits	10,10	9,91	9,89
damages	89,90	90,09	90,11

Table 3: Effectiveness of adaptation measures (2001-2050)

Efficiency

How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits

Scenario	BAU	+10	+30
present adaptation			
investment costs	36.437.376		
benefits	10.158.065	10.172.303	10.382.814
damages	163.517.205	164.841.131	166.091.558
%	5,08	5,05	5,13
scenario small measures			
investment costs	39.967.298		
benefits	62.149.435	62.445.346	62.702.910
damages	111.525.836	112.568.087	113.771.461
%	41,02	40,94	40,79
scenario full impermeabilization			
investment costs	351.684.738		
benefits	107.812.419	108.594.451	109.206.965
damages	65.862.851	66.418.982	67.267.406
%	25,82	25,97	26,07
scenario raising floor levels			
investment costs	80.186.830		
benefits	17.539.564	17.350.264	17.455.617
damages	156.135.707	157.663.169	159.018.755
%	7,42	7,29	7,30

Table 4 Efficiency of adaptation measures 2001-2050, cost benefit ratios at NPV (1%)

According to the calculations made (see details in tables in chapter 5); measures actually in place are able to avoid only a small potential damages under present day conditions, with benefits corresponding to approx., 5% of the costs (investment and net present value of residual damages) under a sea level rise scenario of 30 cm, this rate would increase only very slightly to approx. 5,1%.

Under a scenario of the most expensive protection measures being applied in all residential units, (full impermeabilization or dry flood proofing) the relation between costs and benefits would be slightly above 25%, again with very small changes under different scenarios of sea level rise.

The best relation between costs and benefits would be reached by an application of small punctual measures like barriers and pumps, whereas the application of the actually most popular measure, raising floor levels, to all ground floor units reaches only slightly better results than the actual state of protection.

As a conclusion of the results of these simulations and taking into account that damages resulting from the flooding of public spaces in terms of difficulties in movements, that private flood adaptation measures for buildings can considerably reduce damages, but will not avoid them totally; especially with regards to non-monetary damages. Private adaptation comes, furthermore under most of the options with a considerable level of investment cost which may not be affordable for all households.

X. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies (eg. CAP/Cohesion policy ?

Administrative costs are connected to the normal administration of building permits, no additional costs on that side. Finance used to be possible in the context of the special finance resources for building restoration home owners in the historic centre could apply for according to the special law for Venice. The future of this form of finance is not sure.

XI. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? no

XII. Does the measure have effects on employment? no

XIII. How long is the time-lag between implementation of the adaptation measure and the effect of the measure?

The effect is immediate for the first event after the ultimation of the works

XIV. What is the timeframe during which the measure will have an effect?

During the lifetime of the building

XV. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)?

no

XVI. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

(fill with your answer)

Equity

XVII. What are the impacts on different social or economic groups, are there expected impacts on particularly vulnerable groups? (distributional impact)

> The high investment costs of the measures has impacts in terms of equity, considered the extremely fragmented structure of homeownership. Frequently individual homeowners, especially elderly and pensioners, do not have the financial resources for the necessary investments and find problems in receiving loans from banks.

XVIII. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (N) no impact)

5. Impacts, Costs and Benefits of Adaptation measures

Step 1 – Preliminary Risk Assessment and identification of adaptation tipping points

What is the climate change related problem/risk you would like to reduce by adaptation?

- Which problems already exist, what is/are the current risk/s?
- Which assets and sectors are at risk under current climate variability?
- Which adaptation or protection measures are already in place? (refer to typology of measures in D6.1, table 2)
- How do these risks presumably change due to climate and socio-economic change?
- What are the main drivers, impacts and affected sectors (refer to BASE impact and sector categories, see also Table 1 of D6.1)
- Which climate and socio-economic scenarios are used?

Frequent flooding of ground floors of buildings in the historic centre of Venice determines a significantly higher level of building maintenance costs if compared to "normal" cities not interested by regular flooding by salt water. The "damages" caused by flooding in the building sector are thus defined as the major cost of maintenance due to flooding in the Venice lagoon, depending either on the number of inundation after which maintenance is required, or the distance to the water level in the ground which determines different frequencies of maintenance interventions for walls without protection.

Flooding already happens periodically, and with an increasing frequency due to local subsidence processes and will intensify in the future with increasing sea levels. Adaptation measures already put in place and considered in the CBA belong to the category of Flood proofing of existing buildings[9].

The confrontation of damages will encompass several different states modelled:

- damages caused in the actual state of buildings and the number and form of adaptation measures put in place and revealed by the survey,
- a state where all ground floor units are assumed to be protected with flood protection measures and
- two different scenarios assuming (1) the generic application of smaller measures (at lower costs) , and (2) the generic realization of the most costly measure which consists of the impermeabilization of the entire ground floor, including the static enforcement of the floor by a so called "vasca"
- a situation where no adaptation measures are put in place

Results from the 5th IPCC Assessment report do not provide further detail with regards to specific prospective on sea level rise for the Mediterranean: "For 2081–2100 compared to 1986–2005, projected global mean sea level rises (meters) are in the range 0.29 to 0.55 for RCP2.6, 0.36 to 0.63 for RCP4.5, 0.37 to 0.64 for RCP6.0, and 0.48 to 0.82 for RCP8.5 (medium confidence; WGIII AR5 Chapter 5). There is a low confidence on projected regional changes (Slangen et al., 2012; WGI AR5 Section 13.6). Low-

[9] Calculations are made so far only for residential units, the integration with commercially used units can follow briefly.

probability/high-impact estimates of extreme mean sea level rise projections derived from the SRES A1FI scenario for the Netherlands (Katsman et al., 2011) indicate that the mean sea level could rise globally between 0.55 and 1.15 m, and locally (Netherlands) by 0.40 to 1.05 m, by 2100. Extreme (very unlikely) scenarios for the UK vary from 0.9 to 1.9 m by 2100 (Lowe et al., 2009). "(Kovats, et al., 2014, p. 1276))

With regards to the Mediterranean, climate change scenarios foresee rises in temperature above global means (OECD, 2010) decreases in precipitation, and in some cases, decreases in winter storminess (Gualdi et al., 2012). Projections for future levels of eustatism for the Mediterranean are complex and not straightforward; as a series of dynamics (rate of evaporation, salinity, patterns of exchange in the straight of Gibilterra) contribute in different ways to the evolution of sea levels in the basin. Gualdi et al. (2012) estimate a rate of increase of 7 – 12 cm for 2050; or 13 cm for 2100 under an A2 scenario for the steric component; Vellinga et al. (n.d.) find for the period until 2100 changes in the range of -22 to 31cm of steric sea level rise, according on single model outputs for three different scenarios (Vellinga et al., n.d.). It has to be underlined that contributions due to the melting of ice sheets are not considered in any of these scenarios With regards to tendencies in storminess, climate models for the Mediterranean show, a possible tendency of decreased storminess, but it is not possible to deduct any tendencies in the conditions creating of extreme events in the northern Adriatic (seiches, strong south-eastern winds, and tidal excursion).

Which adaptation tipping points can be identified?

- Can adaptation tipping points, critical levels for adaptation, be defined for this current strategy? (=when objectives are not met anymore due to changes)
- Refer to otherwise expand on Table 3 of D6.1
- When (roughly) will these critical levels be reached due to climate change or socio-economic change
- Give appropriate period (2015-2030, 2030-2050, after 2050) for each considered combination of climate and socio-economic scenario.

A key tipping point in the case of flood proofing of buildings and ground floor units is given by physical conditions of the building, especially the heights of ceilings of the indoor spaces: floor levels cannot be raised beyond a certain level without compromising indoor living quality.. With regards to cultural heritage, raising floor levels potentially creates conflicts with the conservation aims, whereas other techniques for safeguarding (insulation in a "vasca"/basin) will reduce accessibility. If flooding becomes more frequent or flood levels increase, usability of buildings will be limited. These tipping points might be crossed well after 2050.

Step 2 – Identification of Adaptation Measure and Adaptation Pathways

What are the alternative adaptation measures?

- What are the primary and secondary objectives of adaptation?

The primary objective of adaptation measures is to reduce damages from flooding on private real estate assets in the historic centre of Venice. The secondary aim is to maintain the city as a living environment. At building levels, which is the one considered in this assessment, the measures aim at flood proofing existing buildings. New construction is quantitatively less important in the historic centre of Venice; those few cases of new buildings are generally realized with ground floor levels above the actual 1 in 100 years threshold for flooding, which corresponds to the level of flood reached in 1966, which is the highest level of flooding measured so far.

The measures for adapting existing buildings (flood proofing) consist of changes in building materials and techniques, aiming at protecting living environments from being flooded (raising floor levels, small barriers, protection of building elements against intrusion of salt water, with protective construction elements (vasca)) and preventing saline water from penetrating into brick walls by physical barriers introduced into walls.

In the public space, pavement levels have been raised as far as possible in order to improve pedestrian circulation during flood events. Costs of these interventions could not be quantified as the public agency does not release the data.

Both public and private strategies mainly refer to current risk levels, increasing flood levels/flood frequencies will lead to tipping points and/or require different flood protection measures

residential units	Raising floor levels	barriers	pumps	Imper-meabilization	Cutting walls	any measure*
sample	783	310	62	85	182	1026
all units (estimated)	1.415	560	112	154	329	1.854
%	32	13	3	4	8	42
commerciale						
sample	469	502	191	98	86	944
all units (estimated)	1.083	1.159	441	226	199	2.179
	18	19	7	4	3	36

*units may have employed more than one measure

The baseline situation, defined by the state of the database available, is 2001, as for this year, both detailed information on indoor conditions and about adaptation measures implemented in ground floor units in the historic centre are available. Some adaptation measures have been implemented in a approx.. 36% of of the cases; reducing or completely eliminating damages; in the remaining cases flooding occurs and causes damages (see Table 2).

Complementary measures for flood protection consist of the establishment of a sophisticated early warning system managed by the local authority's flood forecasting centre. It provides timely (at least 4 hours in advance, if possible some days in advance) alerts to the population via internet, text messages, answering machines, call managers and apps for smartphones, and, four hours in advance, a system of alerting sirens which provide information on the maximum flood level expected.

In case of flooding, up to a threshold level of 120 cm above local mean sea level, a system of public walkways is organized ensuring access to important places within the city, especially public boat stops.

Figure : map of connections (green) and walkways (red) up to 120cm (Comune di Venezia, 2013)

In a pathway perspective, the measures of adaptation of the public space can be seen as part of a two-steps approach where up to "minor" flood levels these local measures will contribute the damages of flooding that continue occurring, whereas higher flood levels, (the actual discussion points to a threshold of 110cm) should be completely eliminated by the activation of the flood protection barriers actually under construction in the three lagoon inlets (Mose Project).

What are alternative adaptation pathways?

The official "sell by" date of the public flood protection measure is a sea level rise superior to 60 cm[10]. For individual flood proofing sell by dates are dictated by the possibility of raising floor levels and/or protection barriers without compromising possibilities of access and minimum standards for room heights. Sell by dates are thus determined by specific characteristics of the buildings which are difficult to identify under this strategy, as some units, situated at a lower level, will reach this tipping point sooner than others.

[10] https://www.mosevenezia.eu/?page_id=16&lang=en accessed on sept. 18th, 2014

Step 3 - Evaluation Criteria and Method

Step 3a Selection of evaluation criteria

Which evaluation criteria should be used?

- *What are the relevant positive and negative properties of the measures (costs and benefits) to be considered in the evaluation process (economic, ecological and social effects)?*

The case study focuses on the costs and benefits of private measures put in place, as far as economic factors (damages in terms of increasing costs of maintenance, and investment costs (costs for flood proofing measures) are concerned. Investment costs are principally borne by private homeowners, but public finance subventions was available for private intervention in restoration of buildings. The last assignment of funding was made in 2009. Funding was not specific for the implementation of protection measures, but for restoration work which could also include the realization of protection measures.

With regards to the public adaptation measures, a cost effectiveness assessment would have been suitable if alternative options were assessed. During an attempt of revising the state policy with respect to the protection project, the existence of alternative projects with considerably lower costs was highlighted (Città di Venezia, 2005), but the assessment procedure did not lead to changes in the project realization.

With regards to public flood proofing measures, benefits can be assessed in only in terms of qualitative improvements, costs are transparent only in part.

Step 3b Selection of evaluation method(s)

What is the appropriate evaluation method?

- Is it possible to express all relevant cost and benefit criteria in monetary terms? (→ cost-benefit analysis)
- Is it possible to express the positive effect (objective) by a single non-monetary indicator? (→ cost-effectiveness analysis)
- Are there several relevant criteria which cannot or cannot easily be expressed in monetary terms? (→ multi-criteria analysis, PCBA)

The economic analysis focuses on private investments in flood proofing measures of buildings in the historic centre of Venice. The assessment is based on the assumption that maintenance cost for buildings in Venice are higher because of flooding and the exposure of buildings to salt water in the ground and the fact that maintenance cost vary in relation to the frequency of inundation and the distance to the water level in the ground. Costs considered are based on the expenditure for specific measures that are realized for the protection of essential structures against salt water intrusion and direct flooding of buildings. Benefits are calculated in terms of reduced costs of expenditure on building maintenance, based on average frequencies of maintenance intervention, compared to cities not affected by high water.

Public measures of adaptation and flood proofing (raising public floor space, walkways) will not be quantified but assessed on a qualitative basis, as costs are not being revealed by the public agency in charge of the works and benefits (being able to walk to all parts of the city) can be assessed only in a qualitative manner.

Step 3c Weighting of evaluation criteria

What are the preferences of stakeholders regarding the different evaluation criteria?

- Are there different stakeholder groups with varying preferences regarding the evaluation criteria?

Investment decisions are based on individual preferences, and decisions taken without public deliberation processes.

- Which weight do stakeholders and/or decision makers attach to a substantial change in the performance of the adaptation options regarding each evaluation criterion? (see D4.1, chapter 4.10.2 for guidance for the Swing-Weight method)

N/A as the work will probably conduct a CBA not an MCA.

Step 4 - Data collection

What are the costs and what are the benefits of the alternative adaptation options?

- What potential data sources are available, including damage & impact assessment methods or existing CBA studies on adaptation measures?
- If no relevant data sources are available and modelling cannot be undertaken: Which experts can estimate proxies for assessing the performance of measures regarding the respective criterion?
- How do the adaptation options perform with regard to each of the cost and benefit criteria selected in step 3a?

The database used for the assessment of damages on ground floor units has been connected to a GIS of the historic centre of Venice, and information on levels of public pavements which is important for defining the frequency of flooding for the single buildings has been inserted in the map.

Data on annual flood frequencies registered from 1966 until 2013 has been obtained the municipal centre for flood forecasting. These annual frequencies are detailed for levels in steps of 10cm, measured with reference to the local tidal reference point.

The cost estimate is based on the information extracted from the data- base created by the municipal authorities which contains a detailed description of the ground floor unites in the city. The database used for this analysis consists of a selection of data extracted from a database in 2001 the City of Venice, which registers more than 25.0000 building units, including doorways, courtyards, entrance halls, etc. (see Table 5).

	Data base	Sample	%
Residential use	3140	2425	77,20%
Commercial use	4709	2598	55,17%
Total number of units surveyed	7849	5023	64%

Table 5: Description of sample

the construction of the sample is essentially driven by the criteria of availability of sufficient detail of data. For the

purposes of this investigation information on those ground floor units registered as "residence" and commercial activities have been extracted for which detailed measurements were available.

In this way two sample database were created, one containing the information on residential units and one with information on commercial units. The database created consists of a total of 2598 observations regarding commercial use, which correspond to 55% of commercial units surveyed, and 2,425 or 77% of residential units surveyed in the database. For all units in the sample information is available for the kind of activities, as well as on on physical parameters such as size, material, condition and on the intensity with which the unit is interested by flooding, measured in terms of floor level with respect to the local tidal reference point.

Costs of intervention for maintenance and information on frequency according to the frequency of flooding for each building element have been collected from expert judgement in a previous research in terms of difference between normal frequencies of maintenance works and frequencies caused by periodic contacts of building elements with salt water (cite vector). also the costs of adaptation measures have been elicited in the same manner.

In this way two sample database were created, one containing the information on residential units and one with information on commercial units. The database created consists of a total of 2598 observations regarding commercial use, which correspond to 55% of commercial units surveyed, and 2,425 or 77% of residential units surveyed in the database. For all units in the sample information is available for the kind of activities, as well as on on physical parameters such as size, material, condition and on the intensity with which the unit is interested by flooding, measured in terms of floor level with respect to the local tidal reference point.

The economic values of costs or damages are calculated using specific depth-damage functions for single building elements (pavements, walls, doors). These functions assess annual increases in maintenance costs based on information on the location of the unit with respect to the medium sea level, the technical characteristics (plastered or non plastered walls, dimensions, number of doors, etc.) and the availability of protection measures. The aggregate value of these estimates is based on detailed information on a relevant part of the ground floor units which have been revealed from inside.

Damages on buildings in the historic centre of Venice are caused by contact with salt water, which deteriorates bricks, plasters and doors. With regards to pavements, expert opinion indicates that, if properly maintained/rinsed with freshwater, any traditional material used for floors (marble, venetian floors, etc.) is not damaged, so for floors, only costs for cleaning with freshwater after each inundation are considered as maintenance costs.

Data on conditions of ground floor units dates back from 2001 from a comprehensive survey organized by the local authority. 2001 will thus need to be assumed as a baseline situation, for which the entity of existing protection measures and the technical characteristics have been recorded in the database.

What is the evaluation time frame?

- What is the lifespan of the measure with the longest lifetime?

the actual lifespan of adaptation measures, which should be assumed being of a value similar to those of buildings (approx., 50 years); has been chosen as a time frame. Thus as an initial time reference the time when the state of investments has been surveyed (2001), thus the end of the time frame has been set at 2050. A longer time frame would come with stronger assumptions, as it is to be expected, that types of uses will change with changing

conditions of flooding, and the city will adapt (as far as possible) transferring more sensitive uses like residences into higher floor levels and into higher areas within the city.

Which discount rate should be applied?

- Which discount rate is recommended by national guidelines for climate change adaptation measures (or public investments)?
- Is it a linear discount rate or any other type (i.e. declining, hyperbolic, etc.)
- (In addition, for testing the sensitivity of the results with regard to the discount rate(s) used, also apply a low and high discount rate (1% and 5%)).)

There are no rules for the application of discount rates in Italy, so only a sensitivity analysis will be used exploring results from the application of a lower and an upper bound of the discount rate.

to be defined, a testing with low and high discount rates seems pertinent. (TBC)

How to deal with data uncertainty?

- Can uncertainties related to the performance of the measures regarding certain evaluation criteria be described by a range (min-max), a triangular distribution (min, most likely, max) or any other kind of probability distribution?

Treating with a retrospective case, uncertainties are limited to variations between actual and average conditions. The cost assessment is based on expert knowledge; uncertainties related to the accuracy of these information are tackled indicating minimum and maximum values corresponding to lower and upper bounds of estimates.

Step 5 – Evaluation and Priorization (max 1500 words)

What is the ranking order of alternative adaptation options (measures, bundles of measures or pathways)?

- For cost-benefit analysis:
- What is the net-present value (discounted benefits – discounted costs) of the alternative options?
- What is the benefit-cost ratio?
- For cost effectiveness analysis:
- Which alternative achieves a defined objective at lowest costs?
- What is the cost-effectiveness ratio?

Table 6: Net present values for costs and benefits for Residences at present state of adaptation (2001-2050)

discount rate	1%	3%	5%
no SLR			
costs (NPV)	36.437.376		
benefits (NPV)	10.158.065	6.800.167	4.918.580
damages (NPV)	163.517.205	109.464.188	79.175.750
SLR +10 cm			
costs (NPV)	36.437.376		
benefits (NPV)	10.172.303	6.814.405	4.932.817
damages (NPV)	164.841.131	110.788.113	80.499.675
SLR +30 cm			
costs (NPV)	36.437.376		
benefits (NPV)	10.382.814	7.024.916	5.143.328
damages (NPV)	166.091.558	112.038.540	81.750.102

The results from modelling of the present state of adaptation show that costs for adaptation measures actually adopted (at 2001 values) largely exceeds the net present values of benefits to be expected over the period from 2001 to 2050 and are significantly lower than expected damages, both at present sea levels and under scenarios of sea level rise.

This apparent lack of correspondence between costs and benefits (measured in this case in terms of reduced maintenance costs for private buildings) might find explanations in dimensions which are difficult to be assessed in monetary terms, nevertheless are part of individual criteria for decisions on investments. Further to the economic benefits related to maintenance costs of buildings, mostly immaterial benefits need to be considered in relation to periodic inundation o residential and commercial units. First of all, these regard psychic stress related to having (parts) of the personal living space inundated; furthermore, time is required for undertaking the specific arrangements to protect mobile assets (household appliances etc.) which need to be taken in time. The early warning system put in place by the public authority is used for this scope, as it allows both residents and owners of commercial activities to prepare their units removing, as far as possible, sensitive objects from areas that can be reached by water[11]. Furthermore non monetary benefits comprise option values corresponding to the value attributed to the time needed for preparing the unit before a flood and of cleaning up (essentially rinsing floors with fresh water) after the end of the inundation. Actually only the economic value of the working time needed has been included in the assessment, but not the value attributed to foregone activities planned for the time actually needed for cleaning up.

[11] It must be noted that insurances do not provide coverage for flood damage; the attempt of estimating potential losses of mobile assets is thus extremely complicated because of the lack of available data.

Table 7 Net present values for costs and benefits for private residences under the scenario of full impermeabilization (2001-2050)

discount rate		1%	3%	5%
no SLR				
costs (NPV)	351.684.738			
benefits (NPV)		107.812.419	72.173.438	52.203.247
damages (NPV)		65.862.851	44.090.917	31.891.082
SLR +10 cm				
costs (NPV)	351.684.738			
benefits (NPV)		108.594.451	72.955.470	52.985.279
damages (NPV)		66.418.982	44.647.048	32.447.213
SLR +30 cm				
costs (NPV)	351.684.738			
benefits (NPV)		109.206.965	73.567.984	53.597.793
damages (NPV)		67.267.406	45.495.472	33.295.637

With regards to commercial units, further to the material losses, the economic losses due to the interruption of economic activities needs to be taken into account, although not entirely to be attributed to the inundation of the unit itself, but also due to problems in reaching the unit because of flooding of the public space. In 2002 an attempt of quantifying losses by commercial units used scenarios in which continuous low level flooding and single high level events could be avoided, yielding a present value between 1 and 1.7 Billion Euros considering loss of activity, merchandise and time for rearranging and clearing up (Sgobbi, 2003, internal report).

The actual discrepancy between benefits and damages is based largely on the fact that actually only a relatively small number of units is protected by measures. (insert % of units protected); thus the value of investment in private adaptation measures refers to a relatively small number of interventions.

The decision of not adopting protection measures can be seen on the one side, in the relatively low level of economic benefits of the measures produce for the individual investor. On the other hand side, public investment in the early warning system and the private experiences with flooding events have created some routine which facilitates dealing with inundations and preventing additional damages.

Assuming that private actors decide on their investments in an economically rationale manner, the fact that actually relatively few investments in protection measures have been made, can be sought in the individual judgement that the total of monetary and non-monetary benefits that can be obtained from the investment does not equal the costs, or perhaps in the lack of private resources for the necessary investments.

Also considering the relation between investment costs and net present values of expected benefits under a hypothesis of the most expensive and comprehensive protection measure (*vasca*) adopted in all units, still a substantial disproportion is visible, with investment costs exceeding calculated benefits by more than three times. This holds even under a scenario of substantial sea level rise (+ 30 cm until 2050 with a consequent increase of level and frequencies of inundations). Under this scenario with a maximum range of protection measures in place, still some residual damages must be expected, although at a significantly lower rate.

The Scenario simulation based on the assumption of small measures (punctual insulation measures like barriers and pumps, etc. offers a slightly better relationship between investment costs and benefits (see Table 3), although costs from damages remain consistent.

Table 8: Net present values for costs and benefits for residences under the scenario small adaptation measures (2001-2050)

discount rate		1%	3%	5%
no SLR				
costs (NPV)	39.967.298			
benefits (NPV)		62.149.435	41.605.025	30.093.030
damages (NPV)		111.525.836	74.659.330	54.001.300
SLR +10 cm				
costs (NPV)	39.967.298			
benefits (NPV)		62.445.346	41.900.936	30.388.941
damages (NPV)		112.568.087	75.701.581	55.043.551
SLR +30 cm				
costs (NPV)	39.967.298			
benefits (NPV)		62.702.910	42.158.500	30.646.505
damages (NPV)		113.771.461	76.904.956	56.246.925

A third scenario simulating the adoption of the actually most diffuse protection measure which consists of raising floor levels inside the unit yields very low benefits in terms of avoided maintenance costs, as it does not protect walls from salt water intrusion. Nevertheless, it avoids the inside of the unit being flooded, protecting thus, further to inner doors and the floors themselves, household appliances, furniture etc. which have not been considered in this assessment as these can easily be protected by specific arrangements to be taken in the moment of flood warnings.

discount rate		1%	3%	5%
no SLR				
costs (NPV)	80.186.830			
benefits (NPV)		17.539.564	11.741.603	8.492.734
damages (NPV)		156.135.707	104.522.752	75.601.596
SLR +10 cm				
costs (NPV)	80.186.830			
benefits (NPV)		17.350.264	11.552.303	8.303.434
damages (NPV)		157.663.169	106.050.214	77.129.058
SLR +30 cm				
costs (NPV)	80.186.830			
benefits (NPV)		17.455.617	11.657.656	8.408.787
damages (NPV)		159.018.755	107.405.800	78.484.643

Table 9: : Net present values for costs and benefits for Residences under the scenario of only floor level raising (2001-2050)

What are the main lessons learnt from your case study?

As a conclusion of the results of these simulations and taking into account that damages resulting from the flooding of public spaces in terms of difficulties in movements, it can must be concluded that private flood adaptation measures for buildings can considerably reduce damages, but will are not able to avoid them totally; especially with regards to non-monetary damages. Private adaptation comes, furthermore under most of the options with a considerable level of investment cost which may not be affordable for all households. The fact that some measures are employed despite a low cost-benefit rate, furthermore points to the fact that values not taken into consideration, especially the damages and losses in life quality and stress play an important role in private decisions.

6. Implementation Analysis

The aim of this section is to establish whether adaptation measures can be implemented in the real world context of case studies, and what the key obstacles and opportunities are in doing so. To ensure the answers provided in this section are comprehensive and in line with WP2 and WP7, a checklist is provided below with the main factors that all case holders need to consider in their answers If relevant to the implementation of your case study.

Checklist

When answering the main questions below ensure you consider each factor listed in the checklist below that might have had a role in the implementation of your case study work. Write in the table how important each factor has been to the implementation of your BASE work and adaptation in general at your case study; where 1 = unimportant, 2 = slightly important, 3 = Important, 4 = Very important, and 5 = Critical). The checklist might not be all-inclusive, so feel free to discuss other factors that are not listed.

Key factors:	Rank from 1 – 5
i. **Knowledge and information about climate adaptation**	

ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	5
iv. **Local and regional context** (e.g. culture, history, geography, environment, economy)	5
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	1
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	1
vii. **Resources** (e.g. financial, human)	5
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	1
ix. **Other** (specify _____)	

Summary Information (based on your answers to the questions below)

a) Specify sectors covered (e.g. coast, city, agriculture):
Urban area interested by coastal flooding
b) Specify adaptation measures covered (e.g. altering cultivation practices, building defences; explain why they were chosen):
Spontaneous individual adaptation measures
c) Specify climate change impacts covered (e.g. flooding, heat stress, sea level rise):
Coastal flooding / sea level rise
d) Specify main results of activities (e.g. changes, outputs):
Individual decisions for adopting flood proofing measures are only partially based on economic considerations (cost benefit analysis does not yield relevant economic benefits) but psychological issues need to be considered. Treating a retrospective case study, no changes have been registered during the BASE project.

Questions

Answer these six questions giving specific evidence and examples where possible. In principle all implementation activities should be included, i.e. adaptation activities supported by BASE partners as well as those by other actors. If it is possible to inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW. The measures covered can be extensive and/or particular to a case study. They can include for example, the development of plans and strategies, vulnerability/risk assessments, economic assessments such as CBA, MCA, the development of participatory processes/public dialogue, through to the implementation of actual measures including physical measures such as engineering developments and land use change, incentives/subsidies for behavioural change, etc. This list is not all-inclusive and is merely a guide. Your own case study may have very different measures. However, **you must be clear what measures you are refereeing to when answering these questions.**

1. How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! *Note:* Retrospective case studies will not answer this question, but have to update their answer to question 1 E of this document on the history of adaptation at their case study. (Approximately 500 words) Venice is a retrospective case study

2. *What and who drives (or enables) the adoption and implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words);*

The adaptation approach assessed follows only individual decisions made by single actors. Dealing with existing flooding, financial **resources** from public subsidies for building renovation for private households have been used for implementing private flood proofing measures. The measures considered in the assessment have, for the time being, not been put in relation to climate change. Increasing flood frequencies and peak levels are addressed, so far as a specific local phenomena, connected to local transformation (mainly natural and men-made subsidence and transformations of the hydrodynamic equilibrium of the lagoon) The measures analyzed just represent an individual, non policy driven initiatives. They nevertheless anticipate potential forms of adaptation to a typical climate impact in coastal cities. **Knowledge** about climate change has had no influence so far on the decision of applying the measures and the design of measures. Science driven projections of sea level rise have not been received so far in the local policy debate, if not referring for the protection the MOSE project will be able to provide in case of increasing sea levels and consequently increasing levels of high water.

Whereas individual strategies for flood proofing the dwellings have been developed as a local practice, using standard measures, the Mose project which is actually under construction (see chapter 3 on participation for an account of the policy processes), has been evaluated by an international team of experts in a period when climate change was not yet discussed as a particular issue. The approval of **international** experts was used as a legitimation for the project chosen for realization, actually Climate Change adaptation is used as an additional ex-post justification of the investment.

The relation to **public policies** for urban flood proofing (raising public floor levels) and protection works (MOSE) still under construction, could not be identified, as the realization of measures was observed for a period where both works were not yet started.
Aiming at flood proofing, there are no direct potential mitigation effects. Measures eventually may go along with throughout restoration works which then might also entail increases in energy efficiency as co-benefits and climate change mitigation measures, but these are separated and in no way accounted for in the economic assessment. The fact that flood proofing measures are implemented alongside with other restauration works does eventually produce small economic advantages in terms of reduced overall costs, but no permanent **co-benefits.**
Living with periodic flooding is part of the Venetian life in the historic center and the islands of the lagoons. Inhabitants usually have a good record of flood levels interesting their premise and have routines for dealing with the inconveniences created by the events, including knowledge of convenient paths for moving in the city etc. Those inhabitants who lived in the city during the Acqua Alta of 1966, conserve a precise memory of the events and the damages provoked then. This which occured the 4th of November 1966 with a flood level which was not reached again since, represents a somehow disruptive

experience both for flood protection policies and the public experience. It provoked the flooding of practically the entire urban area, and some crevasse flood protection dams of a lagoon island (Pellestrina) towards the open sea, which led to the complete evacuation of this island situated

3. *What obstacles were encountered during the adoption or implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words*)

(not sure how to interpret this for this case study)

4. If any obstacles were overcome, how was this achieved? (Approximately 500 words)

   (See above)

5. *What are the future prospects of the climate change adaptation activities in the case study? (Approximately 200 – 500 words)*

   Although peak flood levels measured in the past years show an upwards trend, the flood level of the emblematic event of 1966 has not been reached again until now. It nevertheless is treated as sort of informal "security level" or threshold, above which flood protection is deemed less essential. Nevertheless, protection levels realized in recent years often exceed this threshold levels if technically feasible.

   The economic assessment shows that with increasing sea levels, the residual damages are increasing, and critical limits for the efficiency of private, building based measures for adaptation could be reached soon, although it is not clear how these limits will be defined, partly also because of socio economic transformations, especially the increasing transformation of the private dwellings into tourist accommodation which will accelerate the rate of uptake of the most expensive (and efficient) among the flood proofing measures, as tourists lack the local knowledge and experience, Venetians use for dealing with local flood risk.

6. *What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (Approximately 200 – 500 words).*

   The case study has observed an existing strategy and private decisions for investments. The analysis of the economic performance of measures suggests that the prevention of physical damage is not the only rationale used for investment decisions in households; probably the psychological effect of being protected plays a major role that has not been quantified in this study.

Policy

- Is there a recognition of wider sustainability issues in adaptation? (resource efficiency, links to mitigation, social-cultural aspects, conflicts/tensions, Intergenerational aspects)
- Has international/national climate change adaptation policy contributed to the understanding, and how has it contributed?
- What is the role of slow trends vs experienced or feared extreme events, vs science in driving planning and action for adaptation?
- What role does the context (geography, political history, cultural background,...) play in the initiation and implementation of CC adaptation?
- Has adaptation policy(ies) (at EU/ national/regional level?) played a role in creating the drivers for adaptation (at local level) ? How? Is the measure aligned to the EU Adaptation Strategy, national adaptation strategies, and other sector policies ? Does the measure affect other sectors or agents in terms of their adaptive capacity? How policy coherence and integration is ensured ?
- Do the actors perceive the need for coherence in policy/action? (across sectors/within sectors over levels EU->local)? What coordinating mechanisms exist/are being created ?
- Is there competition between authorities based on competence/budget/conflicting interests? Why and how does it arise/manifest: is it because of the legal structure or institutional arrangements? What consequences does it have? Whose competences are critical? Are sufficient resources available for the planning of adaptation? Which are the most important resources? What resources are lacking?
- Is CC adaptation an add on to planning and activities that are in place or progressing in any case, or is it a dominant driver of the activities in the case? Is that part of a larger adaptation strategy (national, regional, local), or part of a policy appraisal tool (such as impact assessment, strategic environmental assessment, etc.....) ? Or further, an implementation measure from a sectoral policy?

1. Development of new tools for adaptation planning and implementation

(Please describe the development and use of new tools for climate change adaptation planning and implementation which you have used under BASE research project and report on their SWOT analysis and overall feedback. Máx 2000 words)

(not pertinent, the case study uses an ad-hoc assessment strategy developed on the basis of the information available)

New tool(s) developed and used during BASE:

1) _____
2) _____
3) _____
4) _____

Description for each New tool (Máx 50 words/each):

Swot Analysis:

Strenghts	**Weaknesses**
Opportunities	**Threats**

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See list of project documentation and academic literature to be consulted.

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