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1 Storm surge risk perception and resilience: a pilot study in the 2 German North Sea Coast

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8 Abstract

9 Resilience is defined as the capacity of a community to organise itself before, during and after a
10 dangerous/hazardous event in order to minimise the impacts. A conceptual framework is proposed to
11 assess the resilience of a community by understanding and integrating the institutional, legal and social
12 capacities to cope and recover from a natural hazardous event in order to minimize the impacts in the
13 short-term and to adapt to the risk in the long-term. A survey-based method and a specific resilience
14 questionnaire is proposed to explore the perception of stakeholders regarding the risk and emergency
15 management processes as well as psychological and social factors conditioning individual and community
16 preparedness. The method is applied in a pilot area (the Dithmarschen district in the German North Sea
17 Coast) for its validation before applying it to the entire Wadden Sea region, the pilot results being
18 presented in this work. Although some questions may need some type of adaptation to fit adequately to
19 other study sites, the conceptual and methodological framework could be applied worldwide. The study
20 area and its population are characterized by their continuous interaction with the ocean, with the
21 continuous transformation and reclamation of land for agricultural and other purposes, the constant
22 reshaping of the coastline and frequent coastal inundation by storm surge flooding. The assessment
23 allows identifying the main characteristics of the study area in terms of stakeholders' risk perception,
24 intention to prepare, individual and societal behavioural patterns, as well as their opinion regarding
25 authorities' decision-making on emergency and risk management. It also addresses potential improvement
26 in emergency and risk management in terms of multi-sector partnerships and additional adaptation
27 measures for the area. The deficiencies and incoherencies between society's and administration's
28 answers detected in the analysis point towards the challenges to deal with, in order to foster an adequate
29 community preparedness and adaptation to storm surge risk. Some of the results that the proposed
30 method permitted to obtain in the study area show (i) the need for a better information strategy to enhance
31 society's awareness and preparedness; (ii) the respondents' current proactive behaviour and preference
32 on participatory risk management options, despite fully participatory schemes are not yet set by the
33 authorities; (iii) the need for awareness campaigns regarding the relevance and benefits of the integrated
34 approach in potential partnerships, and (iv) the need for tailored and site-specific adaptation instruments
35 and measures due to the current society's disagreement with some of the options currently provided. The
36 results are useful to improve risk reduction initiatives by means of including society's opinions from the
37 beginning of the management process.

38 1. Introduction

39 Resilience is defined as the ability of a system, community or society exposed to hazards to resist, absorb,
40 accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the

41 preservation and restoration of its essential basic structures and functions (UN/ISDR, 2009). Cutter et al.
 42 (2008) defines resilience as the degree to which the community has the necessary resources and is
 43 capable of absorbing disturbance and reorganising into a fully functioning system. This refers to the
 44 capacity of a community to organise itself before, during and after the event in order to minimise the
 45 impacts (González-Riancho et al., 2014), and is directly linked to risk reduction, understood as the
 46 development and implementation of activities aimed at mitigation, preparedness, response and recovery
 47 (Mileti, 1999). The ability of a system, community or society, implies the recognition of both institutional
 48 and social/individual abilities. Resilience assessments focus on the changeable collective conditions
 49 improvable through learning and experience, such as risk preparedness within the communities, in
 50 contrast to the unchangeable conditions such as the age of the population (González-Riancho et al.,
 51 2014).

52 Accordingly, a resilient society is aware of the hazard, is prepared for its impacts and is able to recover.
 53 These capacities are referring to both institutional and social spheres of the community. In the field of
 54 resilience, some authors have focused on the institutional performance and preparedness (IOTWS, 2007;
 55 Birkmann et al., 2013; González-Riancho et al., 2014), while others focus on the preparedness and
 56 protective behaviour of the individuals (Fishbein and Ajzen, 1975; Rogers, 1983; Schwarzer, 1992; Paton
 57 2003, 2005, 2010; Becker et al., 2011, 2013; Lindell and Perry, 2012) or on how factors like risk perception
 58 may influence the behavioural adjustment and preparedness (Douglas and Wildawsky, 1982; Renn, 2008;
 59 Solberg et al., 2010; Birkmann et al., 2012a, 2012b). Table 1 presents a summary on the behavioural
 60 factors studied by several authors to predict preparedness and/or measure resilience. These factors had
 61 their origin in theories from health and social psychology, being applied and adapted afterwards to the
 62 natural hazards discipline.

63 The objective of this work is to propose a conceptual framework to assess the resilience of a community by
 64 understanding and integrating the institutional, legal and social capacities to cope and recover from a
 65 natural hazardous event in order to minimize the impacts in the short-term and to adapt to the risk in the
 66 long-term. By means of a proposed survey-based method we explore the perception of stakeholders
 67 regarding the risk and emergency management processes as well as psychological and social factors
 68 conditioning individual and community preparedness.

69 The proposed conceptual framework and method are applied for their validation in a small area
 70 (Dithmarschen district, Schleswig-Holstein) exposed to storm surge hazard on the German North Sea
 71 coast, the results of this pilot study being presented in this paper. From the methodological point of view,
 72 the validation of the newly developed framework is considered successful, so the survey will be further
 73 replicated along the whole trilateral Wadden Sea region, including the Netherlands and Denmark, in the
 74 framework of the ongoing FP7 ENHANCE Project (Enhancing risk management partnerships for
 75 catastrophic natural disasters in Europe, www.enhanceproject.eu). The project is aimed at developing and
 76 analysing new ways to enhance society's resilience to catastrophic natural hazard impacts, by providing
 77 new scenarios for selected hazard cases in close collaboration with stakeholders, and contribute to the
 78 development of new Multi-Sector Partnerships (MSPs) to reduce or redistribute risk.

79 Table 1. Review of previous works dealing with preparedness/protective behaviours [1], risk perception [2] and
 80 resilience [3].

Theory/framework	Predictor	Factors considered
Theory of Planned Behaviour / Reasoned Action (Fishbein and Ajzen, 1975)	[1]	Beliefs, attitudes, norms, and intentions

Cultural Theory of Risk (Douglas and Wildawsky, 1982)	[2]	Ways of life: Individualism vs. Communitarianism, Hierarchy vs. Egalitarianism
Protection Motivation Theory (Rogers, 1983)	[1]	Threat appraisal: perceived severity of a threatened event, and perceived probability of occurrence or perceived vulnerability of the individual. Coping appraisal: perceived response efficacy, perceived self-efficacy.
Health Action Process Approach (Schwarzer, 1992)	[1]	Threat appraisal: perceived severity of a threatened event, perceived vulnerability of the individual. Coping appraisal: perceived response efficacy, perceived self-efficacy, and individual and social outcome expectancies.
Social-cognitive preparation model (Paton, 2003)	[1]	Precursors: critical awareness, risk perception, hazard anxiety Intention formation: outcome expectancy, self efficacy, problem-focused coping, response efficacy, intention to prepare Linking intentions and preparedness: perceived responsibility, sense of community, timing of hazard activity, normative factors (trust, empowerment), response efficacy, adjustment/ adoption/ preparation
The preparedness process (Paton, 2005)	[1]	Precursors: critical awareness, risk perception, anxiety Development of intentions: outcome expectancy, self efficacy, action coping, intention to prepare Convert intention to action: preparation/action
Disaster Resilience of Place DROP model (Cutter et al., 2008)	[3]	Antecedent conditions: place-specific social, natural and built environment systems, including both inherent vulnerability and resilience. Event characteristics: frequency, duration, intensity, magnitude, and rate of onset Absorptive capacities: presence/absence of mitigating actions and coping responses (directly associated with antecedent conditions).
Risk governance (Renn, 2008)	[2]	Categories: personal manifestations and collective influences Factors: cultural background, social-political institutions, cognitive-affective factors, and heuristics of information processing
Tsunami resilient communities (IOTWS, 2009)	[3]	Governance, society and economy, coastal resource management, land use and structural design, risk knowledge, warning and evacuation, emergency response, and disaster recovery.
Social sustainability (Magis, 2010)	[3]	Resource development, community resources, active agents, collective action, strategic action, equity, impact, resource engagement
Adaptive capacity/ resilience model (Paton, 2010)	[3]	Individual level: negative outcome expectancy (denial/fatalism), positive outcome expectancy, action coping, self-efficacy, critical awareness. Community level: place attachment, sense of community, community participation, collective efficacy Societal/agency level: empowering settings, trust. Resilience/adaptive capacity: immediate impact (safeguard home/contents), impact (resources, self-reliance, psychological preparedness), response (community plans, collective action), recovery/rebuilding (collective action, inter-dependencies with civil agencies).
Community resilience framework (Becker et al., 2011)	[3]	Individual indicators: self-efficacy, outcome expectancy, critical awareness, action coping. Community indicators: community participation, articulating problems Institutional/societal indicators: community empowerment, trust
The Protective Action Decision Model (Lindell and Perry, 2012)	[1]	Source/message/receiver characteristics, channel access and preference, social/environmental cues. Pre-decision processes (exposure, attention, comprehension), stakeholders/ threat/protective action perceptions, protective action decision-making. Situational facilitators/impediments, behavioural response (information search, protective response, emotion-focused coping).
Embrace project (Birkmann et al., 2012a)	[2]	Interpretation of danger, understanding and knowledge of the cause, proximity, exposure, direct personal threat, personal experiences, people's priorities, experimental factors, environmental values.
Embrace project (Birkmann et al., 2012b)	[3]	Psychological, organizational and institutional, ecological and socio-ecological, critical infrastructure, and community-based

Community resilience framework (Becker et al., 2013)	[3]	Self-efficacy, critical awareness, positive/negative outcome expectancy, action coping, community participation, articulating problems, empowerment, social norms, trust, planning, personal responsibility, social responsibility, sense of community, leadership, collective efficacy, place attachment, experience, resourcing, psychological preparedness.
MOVE framework (Birkmann et al., 2013)	[3]	Capacity to anticipate: health and rescue human resources, residents risk awareness, insurance Capacity to cope: emergency plan, hospital beds, health human resources, rescue and firemen manpower Capacity to recover: development level, mean of subsistence, origin, education level, size of companies, female employment, etc.
Tsunami resilience (González-Riancho et al., 2014)	[3]	Coping capacity: information & awareness, warning & evacuation, emergency response Recovery capacity: disaster recovery

81

82 **2. Storm surge resilience assessment**

83 This section describes a conceptual framework to understand the factors affecting the resilience of a
84 community exposed to risks from natural hazards. The conceptual and methodological framework could be
85 applied worldwide, although some questions may need some adaptation to fit adequately to other risks
86 and study sites. The application to storm surge risks at the Dithmarschen district in the German North Sea
87 Coast is presented here. Moreover, the proposed methodology allows analyzing each of the relevant
88 factors to enhance disaster risk management and adaptation policies.

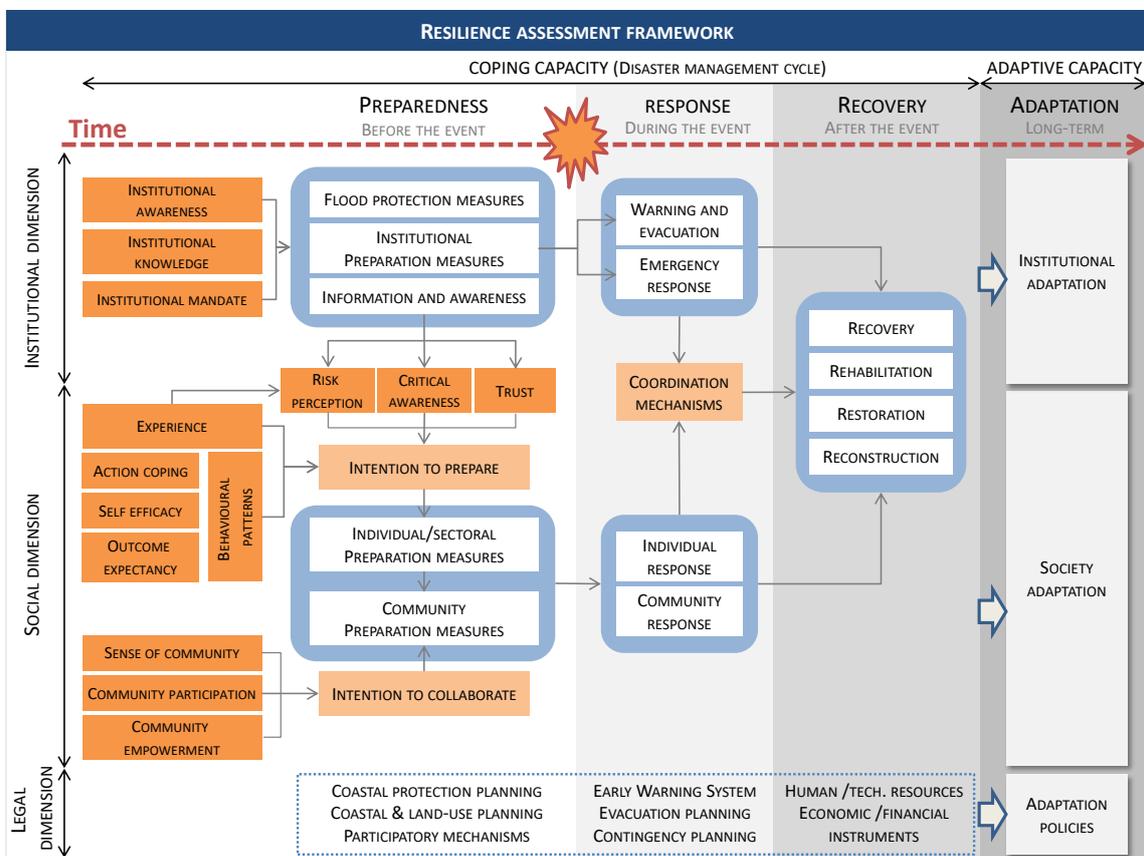
89 **2.1. A framework for assessing resilience**

90 A conceptual framework is proposed to assess the resilience of a community by understanding its short-
91 term coping capacity and long-term adaptive capacity, the former referring to the emergency/disaster
92 management cycle, i.e. preparedness, response and recovery phases, while the latter refers to the
93 adjustments in the human-natural system needed to respond properly to the existing threat. Figure 1
94 conceptualizes and summarizes all the aspects considered in the storm surge resilience assessment
95 presented here and that will be explained in this section.

96 Preparedness is defined as the knowledge and capacities developed by governments, professional
97 response and recovery organizations, communities and individuals to effectively anticipate, respond to,
98 and recover from the impacts of likely, imminent or current hazard events or conditions (UNISDR, 2009).
99 The performance in this phase will determine the success in the subsequent emergency and recovery
100 phases. Therefore, it must be based on a sound risk analysis as well as supported by formal institutional,
101 legal and budgetary capacities. Accordingly, to better understand the organizational capacity of a
102 community, institutional, social and legal dimensions should be considered since a failure or a
103 shortage/deficit of a specific ability in one of them could turn the risk management and/or the emergency
104 process partially ineffective or invalid for the worst case.

105 The institutional adaptation to the storm surge risk implies the improvement of every task included in the
106 disaster management cycle (IOTWS, 2009; González-Riancho et al., 2014), such as flood protection
107 measures, vertical and horizontal coordination, public information and awareness, early warning system,
108 evacuation planning, emergency protocols, contingency planning, etc., as well as a range of recovery
109 options. Most of the tasks of the institutional adaptation are requirements defined in obligatory documents
110 (which are included in the legal dimension in this framework). The institutional awareness and knowledge
111 regarding the storm surge risk as well as the existing mandatory conditions to manage it will affect the
112 level of implementation of each step.

113 The social adaptation, however, is voluntary and more complex to understand due to existing society's
 114 values, risk cultures, perceptions and dynamics. The voluntarism associated to a society's behaviour make
 115 necessary to analyze its potential adaptation to the storm surge risk in terms of "intentions", which are
 116 understood as the cognitive representation of a person's readiness to perform a given behaviour, and
 117 considered to be the immediate antecedent of behaviour (Ajzen, 1991). Besides the individual protective
 118 behaviour as predictor of preparedness, developing community participation to achieve community goals is
 119 considered essential for effective disaster management (Perry & Lindell, 2003; Wisner et al., 2003;
 120 UN/ISDR, 2005; Paton, 2006; US IOTWS, 2007; Basolo et al., 2009; Solberg et al., 2010). It is therefore
 121 important to understand the capacity of the society to work in a collaborative way and if this networking
 122 and the results obtained from it are supported by coordination and empowerment mechanisms promoted
 123 by the authorities (Becker et al., 2011). The intention to prepare at both individual and collective levels is
 124 determined here through the analysis of the behavioural conditioning factors presented in the conceptual
 125 framework (orange boxes), which are inspired by the work carried out by Paton (2003, 2005, 2010),
 126 Becker et al. (2011, 2013) and Birkmann et al. (2012a).



127

128 Figure 1. Resilience conceptual framework applied to understand the coping and adaptive capacities through time and
 129 dimensions (institutional, social and legal), and to design the questionnaire accordingly. The various preparedness,
 130 response and recovery steps to be accomplished by the institutions and society, as well as policy instruments required
 131 for it, are shown in blue boxes. Orange boxes represent the factors conditioning the action-taking by both institutions
 132 and society.

133 The fulfilment of both social and institutional requirements is essential to enhance society's resilience to
 134 catastrophic storm surge events. The close collaboration between governmental authorities, sectoral
 135 stakeholders and the community, for example through new MSPs to reduce or redistribute risk, is
 136 proposed in this framework to be a needed step towards improved risk management options. This

137 institutional-social coupled assessment, similarly applied by Becker et al. (2011), is complemented by the
138 legal dimension in order to incorporate policy requirements and instruments conditioning the adaptation.
139 These policies are the basis above all for most tasks included in the institutional dimension. The
140 deficiencies detected in the analysis will point towards the challenges to deal with to foster an adequate
141 community adaptation to storm surge risk.

142 To summarize, the framework shows the linkages between the institutional, social and legal dimensions
143 within risk management to enhance community preparedness, emergency management and long-term
144 adaptation. It provides an appraisal through time (short-term vs. long-term) and analyzes psychological
145 and social factors conditioning individual and collective preparedness.

146 **2.2. Methodology and resilience questionnaire**

147 Based on the conceptual framework presented in Fig. 1, a questionnaire has been designed to assess the
148 storm surge resilience (Table 2). To understand the capacity of the community to organize itself before,
149 during and after a potential event in order to minimize the impacts, an analysis of the opinion of various
150 stakeholders on several topics must be carried out. The entire questionnaire and its questions are clearly
151 linked to the information the coastal manager obtains to improve risk management, and it can be easily
152 adapted to analyze the risk perception and resilience of a community regarding other type of hazards.

153 The perceived institutional preparedness can be explored through the analysis of the current hazard
154 mitigation measures and emergency management phases, the availability of storm surge risk information
155 (hazard probability, potential impacts, responsible authorities on risk management, etc.) and its
156 consideration in the decision-making process. The individual as well as the sectoral preparedness can be
157 understood through the analysis of stakeholders' potential intention to prepare and the currently
158 undertaken preparation measures; while the community preparedness can be studied through the analysis
159 of the sense of community and community involvement levels. Finally, the feasibility of coordination
160 mechanisms (partnerships) and various potential policy options allows connecting potential institutional
161 measures and social acceptance to understand their expected degree of success and implementation
162 challenges.

163 It is important to conduct the survey in both institutional and social spheres since incoherencies between
164 authorities' and society's perceptions are automatically identified as a critical issue for resilience
165 enhancement measures (González-Riancho et al., 2014). Accordingly, the questionnaire aims to
166 understand the perceived (1) institutional and social preparedness, and (2) feasibility of coordination
167 mechanisms and policy options. This allows identifying potential misunderstandings between those who
168 make the rules and those whose life and activities are regulated based on them. This lack of coordination
169 may generate potential failures in risk and emergency management.

170 Following the recommendations provided by EC (2002) to conduct an integrated stocktaking of
171 stakeholders, the identification of survey participants should analyse which major actors and institutions in
172 the exposed area influence or are affected by the risk management of their coastal zone. The inventory
173 should consider all administrative levels and economic sectors; analyse interests and concerns of citizens,
174 nongovernmental organisations (NGOs) and the business sector; and identify relevant inter-regional
175 organisations and cooperation structures.

Table 2. Questionnaire applied, including for each question the resilience criteria and the output information for the formulation of risk management measures.

Resilience criteria	Question about:	Output information for the formulation of risk management measures. Knowledge about:	
Risk information and institutional preparedness	Expected impacts	Q1. The impacts that could be generated in case of storm surge flooding.	The need for improving the risk communication strategy based on the degree of awareness on potential impacts and the disagreements/incoherencies between the answers
	Information & knowledge	Q2. The storm surge-related information provided by the responsible authorities.	The need for improving the risk communication strategy to increase risk awareness and fulfil society's expectations.
	Knowledge-based decision-making	Q3. The extent the storm surge risk is considered in the decision-making.	The need for integrating risk knowledge within sectoral decision-making and sectoral interests within risk management. Additionally the need for better information about it if already happens.
	Flood protection measures	Q4. The effectiveness of the currently applied flood protection measures.	The need for fostering society's knowledge, awareness and acceptance of the various flood protection options.
	Preparedness and recovery options	Q5. The availability of preparedness and recovery options for storm surge flooding.	The need for implementing specific options in the area if they do not exist yet or the need for better information about them if they already exist.
	Warning	Q6. The type of warning currently being issued in case of a storm surge event.	The need for enhancing society's knowledge about warning mechanisms, or the need for establishing new ones based on society's suggestions.
	Responsible authorities	Q7. The responsible authorities for the various processes within storm surge risk management.	The need for clarifying the roles of each institution within risk management, so that society knows what to expect and how to behave in case of emergency.
Sectoral and community preparedness	Critical awareness	Q8. The main problems the stakeholders worry about.	The significance of society's perception of risks in the context of daily life issues, and the need for increased awareness to foster society's intention to prepare.
	Trust	Q9. The extent stakeholders trust the institutions, mechanisms and structures related to storm surge management.	The need for increased society's trust on the management system and authorities in order to facilitate the adoption of protective behaviours.
	Experience	Q10. The experience with major storm surge flooding events.	The extent life experiences may influence society's risk perception and intention to prepare.
	Risk perception	Q11. The risk perception of stakeholders regarding their public/private sector and living/working activities.	The society's threat feelings as a predictor of intention to prepare.
	Intentional patterns	Q12. The level of involvement that the stakeholders think their sector should have within risk management.	The sectors / stakeholders willingness and attitude towards participative management approaches and the preferred type of participation extent.
	Behavioural patterns	Q13. The current proactive/reactive behaviour of the various sectors and stakeholders and the extent it is considered by the authorities.	The society's current preparedness behaviour and its acceptance and internalization by the authorities. It includes the concepts of outcome expectancy, self-efficacy and action coping as predictors of intention.
	Preparation measures	Q14. The accomplishment of different preparation measures and the main constraints faced by stakeholders.	The need for institutional support to enhance and facilitate the adoption of site-specific and plausible measures.
	Community participation	Q15. The level of participation and involvement of community members and sectors within risk management.	The need for enhancing sense of community and institutional support for community participation.
Coordination mechanisms and policy options	Active stakeholders	Q16. The stakeholders/persons currently having an active role in storm surge protection within the community.	The relevant stakeholders that could help encouraging a participative approach in the preparedness of the community.
	Partnerships structure	Q17. The involvement of several listed stakeholders in a potential partnership for risk reduction.	The need for raising awareness about the relevance of integrated approaches in risk management, involving public and private sectors and civil society organizations.
	Partnerships benefits	Q18. The main benefits that these partnerships could bring.	The perceived benefits in risk management to foster the partnerships.
	Partnerships difficulties	Q19. The main foreseen challenges/difficulties that these partnerships could face.	The perceived difficulties to anticipate them and propose preventive solutions.
Potential risk reduction measures	Q20. The adequacy of various economic instruments, measures and policy options.	The potential level of acceptance of the various measures by society and consequent prioritization of measures, as well as the need for raising awareness on benefits and disadvantages.	

177 The questionnaire includes three types of questions: scoring, selection and open-ended. Most of them are
 178 composed of various items (subquestions), which may be analyzed separately or aggregated by question.

179 Different types of questions require different aggregation methods (Table 3). Based on OECD (2008), for
 180 the *scoring questions* the item value is calculated through a weighted arithmetic mean of the number of
 181 responses. To ensure the results from 3-scores and 5-scores questions are comparable, item values are
 182 normalized through the minimum–maximum method obtaining an identical range [0,1] where the minimum
 183 is the lowest possible score and the maximum the highest one. Normalized item values are then
 184 aggregated to build the question value. The *selection questions* are analyzed through the selection ratio,
 185 which directly provides a value in the range [0,1], or qualitatively where appropriate. *Open-ended*
 186 *questions* are analyzed qualitatively. Once we have all the question results normalized [0,1], an Equal
 187 Intervals classification is carried out to obtain 5 classes (Very Low, Low, Medium, High, Very High).

188 Table 3. Aggregation methods by type of question (Q= question, N/A= No answer/I don't know). (*) *the score weighting*
 189 *of those questions implying denial (e.g. "no information", "not available", etc.) includes the null weight for the lowest*
 190 *category.*

Type of question		Questions	Aggregation method
Scores	5 scores	1, 4, 9, 15, 20	<u>Item value</u> : scores weighted arithmetic mean. Min-Max normalization. <u>Score Weights</u> : <ul style="list-style-type: none"> • <i>Non-denial scoring (Q1, Q4, Q9): from 1 to 5, N/A=0</i> • <i>Denial scoring* (Q15, Q20): from 0 to 4, N/A=0.</i> <u>Question value</u> : mean value of the normalized items.
	3 scores	2, 3, 5, 17	<u>Item value</u> : scores weighted arithmetic mean. Min-Max normalization. <u>Score Weights</u> : <ul style="list-style-type: none"> • <i>Non-denial scoring (Q17): from 1 to 3, N/A=0.</i> • <i>Denial scoring* (Q2, Q3, Q5): from 0 to 2, N/A=0.</i> <u>Question value</u> : mean value of the normalized items.
Selection	1 option	10, 12, 13	Item/question value: selection ratio.
	Many options	6, 8, 11	<u>Item value</u> : selection ratio. <u>Question value</u> : arithmetic mean of selection ratios.
		7, 14, 18, 19	Item/question value: qualitative analysis.
Open-ended question		16	Qualitative analysis.

191 Based on the above-described methodological considerations, the application of the proposed resilience
 192 questionnaire and method to the pilot case is presented in Section 3.

193

194 3. Application to the case study: the German North Sea coast

195 Storm surge risk management is an important issue in the whole trilateral Wadden Sea region, which
 196 includes seaward the bordering North Sea and landward the frequently affected administrative units of
 197 municipalities/counties/provinces in all three countries (the Netherlands, Germany and Denmark). In
 198 general, this region can be characterized as a rural area, the only single small- and medium-sized towns
 199 being Esbjerg (DK), Emden, Wilhelmshaven, Bremerhaven (GE), Leeuwarden and Groningen (NL).

200 The German North Sea coast and its population are characterized by their continuous interaction with the
 201 ocean. The coastal area has been reclaimed and transformed for agricultural and settlement purposes by
 202 the population, while the sea has been constantly reshaping the coastline and flooding settled marshlands.
 203 This continuous human-nature interaction has resulted into a unique landscape and cultural-historical
 204 heritage in the area where, according to Bauer et al. (2001), until today the local population feels strong
 205 bonds to the region and its history.

206 The district¹ of Dithmarschen in Schleswig-Holstein (SH) is located on the German North Sea coast and
207 presents the typical rural structures of the communities in the Wadden Sea region. It is embraced by the
208 Eider estuary to the north, the Elbe estuary to the south, and the Kiel Canal to both the east and
209 southeast. It is a rather flat countryside that was once full of fens and swamps and has a maximum north-
210 south length of 54 km and an east-west length of 41 km. It has 1,428 km² and hosts about 133,000
211 inhabitants according to the census of 2011², which represents less than 1% of the population in about 9%
212 of the total area of the state of SH. The population density is of 94 inhabitants per km², considerably lower
213 than the state's average of 179³.

214 The Dithmarschen economy consists mainly of agriculture, tourism, and energy. Dithmarschen has an
215 outstanding soil quality, which can easily be cultivated, and a favourable climate. The forms of agricultural
216 operations include extensive and intensive farming of grain crops and vegetables (Bauer et al., 2001). The
217 touristic infrastructure predominates in Büsum and Friedrichskoog communities, the industry is mainly
218 based in Brunsbüttel community being fostered by the Kiel Canal connecting the North Sea with the Baltic
219 Sea, and there are numerous wind parks shaping the Dithmarschen coastal scenery.

220 According to Bauer et al. (2001), as a result of the development patterns the contemporary cultural
221 landscape of the Dithmarschen marshes can be divided into three sections seawards: (i) the old sea
222 marsh which was enclosed in dykes in the High Middle Ages, with its substantial village mounds, (ii) the
223 low-lying Sietland, which was made arable in the Middle Ages, with its elongated linear settlements, and
224 (iii) the new sea marsh with its modern dyke constructions.

225 The resilience assessment presented in this document has been carried out on the 19 coastal
226 communities of Dithmarschen. In total, these coastal communities have a population of around 33,300
227 inhabitants along a 70 km long coastal stretch. The 4 most populated communities (Büsum, Meldorf,
228 Friedrichskoog and Brunsbüttel) host the 81% of the coastal population, which reflects the low population
229 density along most of the study area.

230 **3.1. Storm surge flooding and disaster risk management**

231 The region is exposed to different hazards. For centuries storm surges and sea level rise represent the
232 major threat to coastal settlements and agricultural land, forcing the inhabitants to adopt several coastal
233 protection measures and strategies. Some of the most relevant storm surge events are presented in Table
234 4. The most famous one is probably the Grote Mandränke or 'Great Drowning' of 1362 which devastated
235 the entire Wadden Sea region with estimated 100,000 casualties, the disappearance of villages and
236 islands and the reshape of the entire coastline, such as the first embayment of the Dollart bay (NLWKN,
237 2007). The last disastrous event was in February 1962, which caused 340 casualties in the German North
238 Sea coast and Hamburg. The flooded area in Dithmarschen due to the last 4 events of this Table 4 is
239 shown in Fig. 2, together with the current coastal protection dyke line. Additional risks are related to heavy
240 storm and rainfall events with subsequent flooding events in the hinterland, which increase the risks of
241 high discharge rates and raise the challenge of draining the land in the low-lying areas behind the dikes.

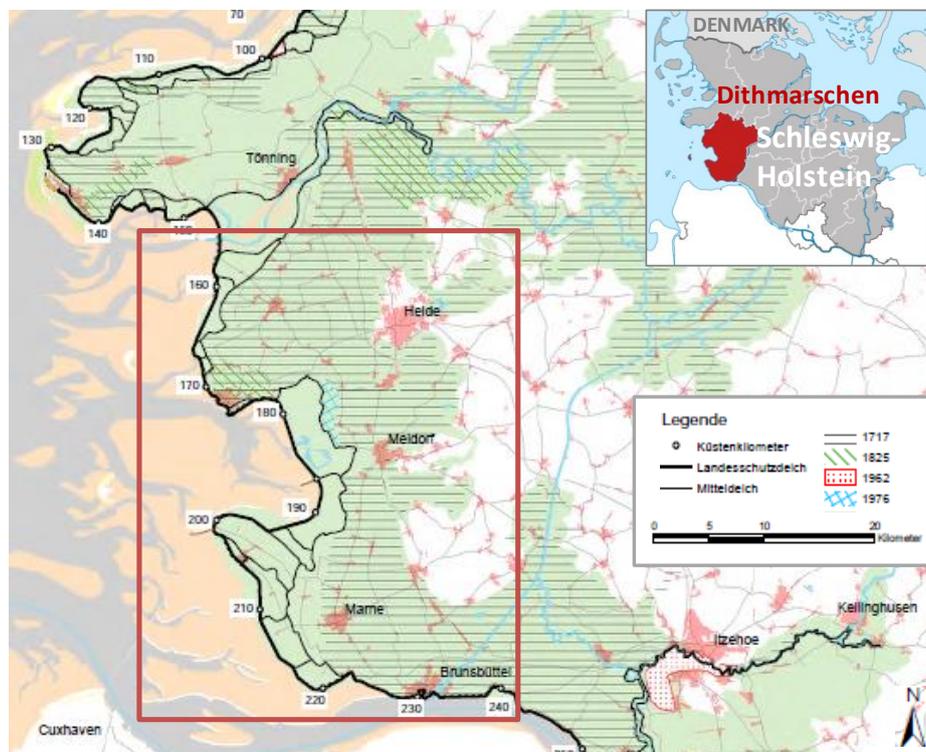
¹ Federal States (*Länder*) in Germany are divided into districts (*Kreis*) and communities (*Gemeinde*), districts being grouped in counties (*Amt*).

² "[Statistikamt Nord – Bevölkerung der Gemeinden in Schleswig-Holstein 4. Quartal 2012 \[XLS-Datei\] \(Fortschreibung auf Basis des Zensus 2011\)](#)". [Statistisches Amt für Hamburg und Schleswig-Holstein](#) (in German). 25 July 2013.

³ www.dithmarschen.de

242 Table 4. Summary of important historic storm surge events at the German North Sea Coast (extract from NLWKN
 243 2007). The flooded area in Dithmarschen due to the last 4 events is shown in Figure 2.

Date	Description	Countries/ areas affected	Number of casualties
16/01/1219	<i>1st Marcellus flood.</i> Huge flooding in the River Elbe area and elsewhere; first historically transmitted eye-witness account.	German North Sea Coast	36,000
16/01/1362	<i>2nd Marcellus flood/ "Grote Mandrenke".</i> First embayment of the Dollart bay between northern Netherlands and Germany; destruction of a huge part of North Frisia.	North Frisia	100,000
11/10/1634	<i>2nd "Mandrenke".</i> Island of "Strand" destroyed, remnants of Strand are Nordstrand and Pellworm islands.	Germany, North Frisia	8,000
24-25/12/1717	<i>Christmas flood.</i> Highest and most disastrous storm surge event of its time.	Netherlands, Germany and Denmark	11,150
3-4/02/1825	Many dyke breaches and heavy losses of dunes on islands; marked the highest storm surge level (e.g. in Hamburg) until 1962.	German North Sea Coast	800
16-17/02/1962	<i>February Flood 1962/ 2nd Julian flood.</i> Heavy storms flood in the North Sea coast, mainly Hamburg.	German North Sea Coast and Hamburg	340
3/01/1976	Highest storm surge level at many tidal gauges, dyke breaches along the coast of SH and the Elbe river.	German North Sea Coast	0



244
 245 Figure 2. Current coastal protection and historical flooded areas for the storm surge events of 1717, 1826, 1962 and
 246 1976 in Dithmarschen. The black lines show the main and secondary dyke lines (source: modified from Generalplan
 247 Küstenschutz des Landes Schleswig-Holstein, MELUR 2012)

248 The disastrous storm surge events triggered large changes in coastal protection strategies over the
 249 centuries (dwelling mounds, ring dykes, closed dyke lines, etc.). Simultaneously with the process of
 250 continuous enhancement of protection facilities, an increase in population and the amount of goods and
 251 values in this region has been documented. In this regard institutional arrangements, responsibilities and
 252 distributions of mandates played an important role in risk management over centuries and resulted in the
 253 currently applied, comprehensive risk management of storm surge risks along the German North Sea
 254 coast.

255 As an introduction to the coastal management of the study area and in order to better understand the
 256 results presented in this work, some basic information about laws, responsibilities, funding and the
 257 distribution of mandates and tasks in the study area is summarized here. The Basic Constitutional Law of
 258 the Federal Republic of Germany identifies coastal protection as an issue of concurrent legislation⁴, and
 259 assigns the Federal States the responsibility for it. According to NLWKN (2007) the public funding for
 260 coastal protection is distributed between the German Government (70% of the costs) and the federal
 261 states (30%) for the main dyke line (NLWKN 2007). Maintenance of dykes and other coastal protection
 262 facilities are paid by the federal state in Schleswig-Holstein. Regarding private investments and insurance,
 263 storm surge damages have not been insurable in Germany until recently, being officially and explicitly
 264 excluded from both building insurance (VGB, 2008) and home content insurance (AStB, 2008). In SH, the
 265 organizational structure and distribution of competencies among authorities/associations involved in
 266 coastal protection, shown in Table 5, reflects the embedded risk culture of the study area, based on a
 267 modified coastal landscape, the land reclamation patterns and related need for drainage, the storm surge
 268 hazard and the coastal protection dykes.

269 Table 5. Organizational structure and distribution of competencies among authorities/associations involved in coastal
 270 protection and emergency management in Schleswig-Holstein (German North Sea coast).

Institution	Mandate
Ministry of Energy Transition, Agriculture, Environment and Rural Areas (<i>Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume, MELUR</i>)	Strategic planning of coastal protection issues. In 2012 the State Governmental Master Plan for Coastal Risk Management in SH (<i>MELUR, 2012</i>) was updated in order to consider new projections of climate change and sea level rise and to implement the EU-Floods Directive (Hofstede, 2014)
Agency for Coastal Protection, National Parks and Ocean Protection (<i>Landesbetrieb Küstenschutz, Nationalpark und Meeresschutz, LKN</i>)	Guidance and supervision of construction and maintenance of coastal protection facilities
Water Boards and Land Associations (<i>Landesverband Wasser - und Bodenverbände, LVB</i>)	Dike maintenance (guided and supervised by LKN; MLR, 2001), pumping station operation, water, sanitation, wind/water protection and irrigation, and take additional tasks of nature conservation.
Main Dyke and Sluice Association (<i>Deich- und Hauptsielverein, DHSV</i>)	Maintenance of water resources and dikes, operation and maintenance of pumping stations, implementation of the EU Water Framework Directives, nature conservation and landscape management, sewage treatment plants and coordination of several Dykes Associations at the local level.
Federal Maritime and Hydrographic Agency (<i>Bundesamt für Seeschifffahrt und Hydrographie, BSH</i>) in connection with the German Weather Service (<i>Deutsche Wetterdienst, DWD</i>)	Issuing and publishing the flood warnings in case of a storm surge event through the radio, internet (www.bsh.de) and TV. If evacuation of vulnerable areas is necessary, the warning is issued by radio or television, loudspeakers also being used for announcements of local police or fire department, together with sirens in some regions
Federal Agency for Technical Relief (<i>Technisches Hilfswerk, THW</i>) from the Ministry of Interior	Emergency operations, supported by partners such as the fire departments, the Red Cross, the Federal Police and the Army

271

272 In view of the long-lasting historic experience in managing risks along the coast and the continuous
 273 interaction between the population and the ocean, the experience on coastal protection and hazard
 274 mitigation measures is recognized in the study area; devastation incidents were at the order of the time.
 275 Performance of preparedness, response and recovery phases as well as the perception of society on
 276 storm surge risk issues have not been found documented and became an issue in rather recent time.

⁴ Concurrent legislation means that the Federal States have the power of legislation processes as long as the State does not make use of its (superordinate) right of legislation on the issue.

277 **3.2. Stakeholder sample**

278 Following the EC (2002) guidelines to stock take the main actors, the following types of stakeholder were
 279 identified in Dithmarschen, including those involved in management processes and those whose activities
 280 could be potentially affected by the storm surge impacts:

- 281 • Main socioeconomic sectors: agriculture, tourism, industry, culture and environment.
- 282 • Relevant administrative actors: coastal protection, emergency management, local administration.
- 283 • Relevant non-administrative actors: NGOs, business sector.
- 284 • Administrative levels: national, state (*Länder*), county (*Amt*), district (*Kreis*), community
 285 (*Gemeinde*).

286 Several interviews with experts on the storm surge hazard and emergency management and/or in the
 287 socio-economy of the study area, helped to develop an inventory of stakeholders in Dithmarschen. 43
 288 stakeholders were identified due to their representativeness and relevance in the region and contacted by
 289 phone and/or email. The objective and method of the study was personally explained to each of them and
 290 access to the online survey was then provided. The questionnaire, which was available to be filled in for
 291 one month (March 2014), was answered by 16 stakeholders. The type, spatial scope and sector of the
 292 interviewed stakeholders are shown in Table 6. The statistical sample could be considered small, but is
 293 still representative of the study area since it includes all types of stakeholder, administrative levels and
 294 sectors. At the next stage individual citizens will be also included in the analysis, since the validated
 295 method will be replicated along the whole trilateral Wadden Sea region in the framework of the ongoing
 296 FP7 ENHANCE Project.

297 Table 6. Stakeholders interviewed in Dithmarschen categorized by type of stakeholder, scope and sector (scope:
 298 N=national, S=state, D=district, C=county, CM=community). The name of the organizations is not provided due to
 299 questionnaire-related confidentiality conditions.

No.	Type	Scope					Sector
		N	S	D	C	CM	
1	Administration			x			Administration
2	Authority, Administration			x			Emergency
3	Authority				x		Environment
4	Authority, Administration				x	x	Coastal protection, emergency, tourism
5	Public agency					x	Tourism
6	Authority		x				Coastal protection
7	Authority	x					Emergency
8	Authority				x		Emergency, Environment
9	Authority			x	x	x	Emergency
10	Cultural			x			Emergency
11	Authority					x	Emergency
12	NGO			x			Emergency
13	Business/ socioeconomic activity			x			Tourism
14	Business/ socioeconomic activity					x	Tourism
15	Business/ socioeconomic activity			x			Agriculture and farming
16	Business/ socioeconomic activity	x		x			Administration, industry, water supply

300

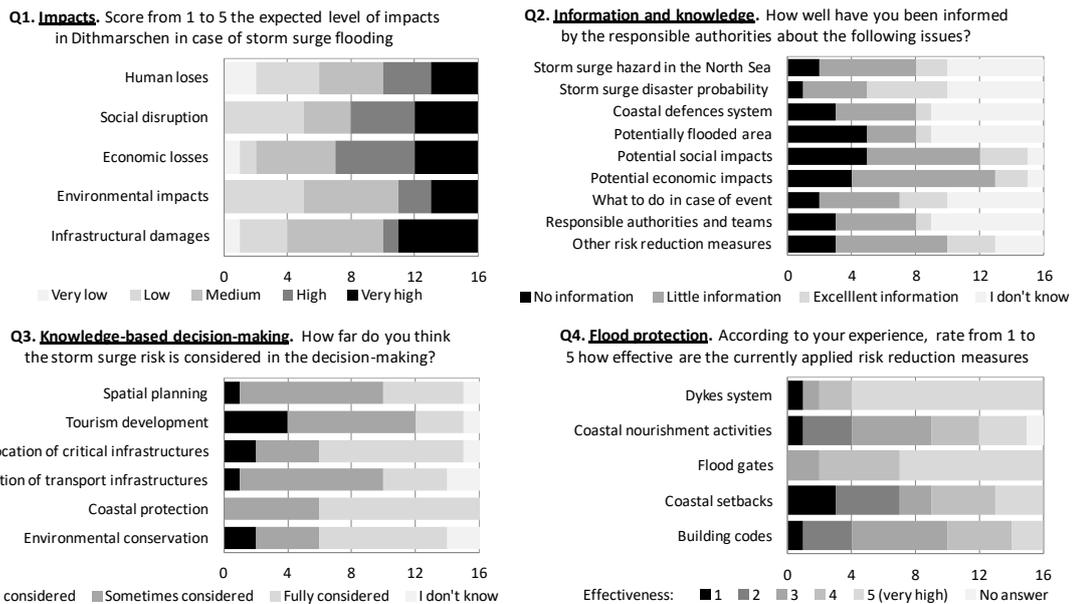
301 **3.3. Storm surge risk perception and resilience in Dithmarschen: results from the** 302 **pilot study**

303 This section presents the results obtained in the pilot study area which are organized according to the
304 structure presented in Table 3, which includes (1) risk information and institutional preparedness, (2)
305 sectoral and community preparedness, and (3) coordination and policy options. Results are supported by
306 the pertinent references and methodological background needed to understand the main conclusions
307 obtained.

308 **3.3.1. Risk information and institutional preparedness**

309 According to Patton (2005), risk communication based on information provision alone will fail to engage
310 people in ways that facilitate their ability to make decisions. Instead, personalizing hazard information and
311 disseminating it in ways that involve engaging people in debate encourages people to interact with and to
312 interpret information relative to its implications for themselves, their family and the activities they deem
313 important (Paton and Johnston, 2006). In this survey, the first group of questions dealt with the knowledge
314 of the stakeholders about the storm surge hazard, such as potential impacts, what to do in case of an
315 event, responsible authorities, flood protection and preparedness/recovery options. The availability, quality
316 and use of the existing storm surge risk information in sectoral planning were analyzed together with the
317 perception of the stakeholders regarding the institutional preparedness.

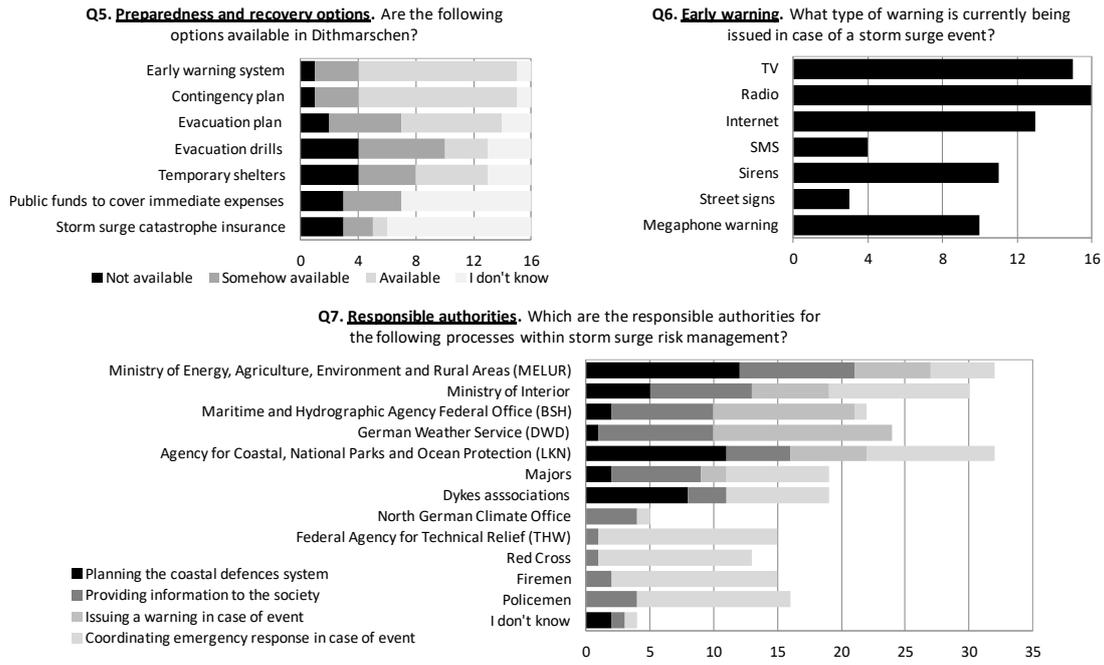
318 The major **expected impacts (Q1, Fig. 3)** in Dithmarschen are on the infrastructural, economic and social
319 dimensions, while human losses and environmental impacts are secondarily positioned by the
320 stakeholders. To understand the degree to which knowledge and awareness could translate into
321 preparedness behaviour (Johnston et al., 2005), the stakeholders were asked about the **availability of**
322 **storm surge risk information (Q2, Fig. 3)**. Almost half of the respondents don't know if there is available
323 information for each of the issues. About half stated that no/little information is available, this percentage
324 increasing for the potential socio/economic impacts and for risk reduction measures. Very low rates were
325 given to the "Excellent information" category, which indicates a lack of appropriate information on the topic
326 being provided to stakeholders (and consequently also to the local population) to better cope with the
327 hazard. The question **on knowledge-based decision-making (Q3, Fig. 3)** aimed to evaluate the extent
328 the risk information is considered in the sectoral planning in the study area. More than half of the
329 respondents (10-12) think it is fully considered in coastal protection planning but not in spatial planning,
330 tourism development and location of transport infrastructures. These results suggest that there is a lack of
331 risk knowledge-based sectoral planning which could imply a higher amount of people and infrastructures in
332 flood-prone areas. Being asked to rate the effectiveness of the currently applied **flood protection**
333 **measures (Q4, Fig. 3)**, most of the stakeholders have agreed on the high effectiveness of hard protection
334 measures, i.e. dykes system and flood gates (13-14 rated them with high/very high effectiveness).
335 However, soft protection and spatial planning measures, i.e. coastal nourishment, building codes and
336 coastal setbacks, receive lower effectiveness values. This result shows the higher credibility on
337 engineering measures prevailing in the study area.



338

339 Figure 3. Results about availability of information and institutional preparedness (questions 1-4). Q1: expected impacts,
 340 Q2: available information/knowledge, Q3: knowledge-based decision-making, Q4: flood protection measures.

341 Regarding the **preparedness and recovery options (Q5, Fig. 4)** available in Dithmarschen, 14
 342 respondents guaranteed that an early warning system and contingency plans are fully/somewhat available.
 343 For evacuation plans, drills and temporary shelters that certainty decreases resulting in contradictory
 344 responses that should be considered for better information strategies. Most of the respondents (14-15) do
 345 not know if economic instruments are available to deal with the risk. These results show a lack of clear
 346 information about preparedness and recovery options provided to the public, which could hinder the
 347 community preparedness options. Focusing on the storm surge **early warning system (Q6, Fig. 4)**, the
 348 interviewed stakeholders effectively identified the available official warning mechanisms, with radio, TV
 349 and internet being the most known ones, followed by sirens and loudspeakers, and then by street signs
 350 and SMS. Some stakeholders suggested additional warning systems such as Facebook/Twitter (social
 351 media), sirens in those places where it is currently not available and firemen-related warning. Regarding
 352 the **responsible authorities within storm surge management (Q7, Fig. 4)**, as several answers were
 353 possible the stakeholders identified those authorities they think are involved in each process, and not only
 354 the responsible ones. MELUR and LKN are identified as the main responsible authorities for planning the
 355 coastal defences system, although the Dykes Association, Ministry of Interior, BSH, DWD, and majors are
 356 also linked to this task. Every presented authority is expected by the stakeholders to provide information to
 357 the society, the DWD and the North German Climate Office (*Norddeutsches Klimabüro, a science*
 358 *information office of HZG*), involved in dissemination of information to the public, not being particularly
 359 highlighted compared to the others. The DWD and the BSH are identified as those in charge of issuing a
 360 warning, although MELUR, Ministry of Interior, LKN and Majors are also identified. Emergency
 361 coordination is assigned to the Ministry of Interior, THW, firemen, police, etc., but also to LKN, MELUR,
 362 Dykes association and Majors. The conclusion obtained from this question is that the different tasks within
 363 storm surge risk management are not completely understood nowadays and that should be clarified to the
 364 stakeholders and presumably as well to the society in general.



365

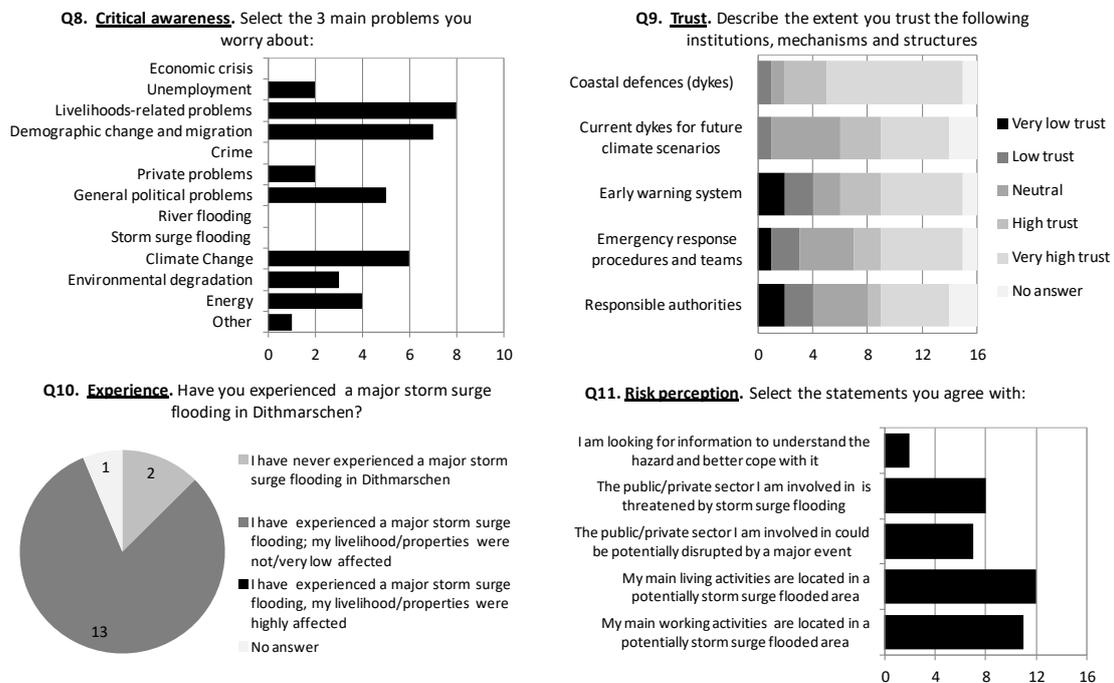
366 Figure 4. Results about availability of information and institutional preparedness (questions 5- 7). Q5: preparedness and
 367 recovery options, Q6: early warning, Q7: responsible authorities (several answers possible).

368 3.3.2. Sectoral and community preparedness

369 This second group of questions dealt with the sectoral and community preparedness for storm surge risks,
 370 including several factors conditioning behavioural patterns, protective behaviours as well as community
 371 interaction.

372 Risk perception has been long considered a protective behaviour predictor in health and natural hazards
 373 literature (Douglas and Wildawsky, 1982; Lindell and Perry, 2000; Sjöberg, 2004; Renn, 2008; Birkmann et
 374 al., 2012a). The extent risk is perceived in the society is conditioned by previous experiences (Birkmann et
 375 al., 2012a; Becker et al., 2013) as well as on the information provided by the authorities regarding the
 376 hazard itself, the potential impacts and the risk reduction options applied and/or promoted. The information
 377 provided will affect the extent the hazard is a salient topic within the society's discourse as well as the
 378 extent the society trusts the information itself, the responsible institutions and the measures applied.
 379 Dalton (2001), Patton (2003, 2005, 2010) and Becker et al. (2011, 2013), among others, identified the
 380 critical awareness as a conditioning factor for the perception of risk and the intention to act. The critical
 381 awareness describes the extent to which people think and talk about a specific source of adversity or
 382 hazard within their environment (Paton, 2003), reflects how important this problem is compared to others
 383 and provides an insight about the intention to develop a protective behaviour. The storm surge **critical**
 384 **awareness (Q8, Fig. 5)** has been found very low according to the answers obtained. The three main
 385 problems affecting the stakeholders in Dithmarschen are livelihood-related difficulties, demographic
 386 change and migration, and climate change. Not a single stakeholder selected storm surge or river flooding
 387 as a problem they worry about, which suggests that storm surge is not considered an urgent problem. It
 388 could be discussed that daily problems as livelihood-related issues, for example, are most likely to be
 389 highlighted; however, climate change appears as the third most important problem for the stakeholders,
 390 which may be related to the effectiveness of climate change awareness campaigns worldwide and the lack
 391 of them for storm surge hazard in particular. The fact of not considering storm surge as an urgent problem
 392 may be the cause for the prevalence of temporary short-term protection measures to cope with it.

393 Research has found that people are more likely to adopt protective measures if they trust the source that is
 394 providing the information, as well as to be supportive of civic agencies if they trust the way to manage risk
 395 and they think they are competent (Paton 2003, 2010; Paton et al., 2006; Basolo et al., 2009; Becker et al.,
 396 2011). The question about **trust (Q9, Fig. 5)** shows higher trust levels in coastal engineering measures
 397 than in other type of measures, mechanisms and authorities. The trust in coastal defences is definitely
 398 proved with 13 respondents assigning very high and high trust, although lower trust is given to the same
 399 coastal defences for future climate scenarios. Regarding **experience (Q10, Fig. 5)**, the stakeholders are
 400 familiar with major storm surge events although not with storm surge disasters. No one experienced a
 401 disastrous event although most of them have experienced a major storm surge event with minor impacts.
 402 The answers to the **risk perception (Q11, Fig. 5)** question show that storm surge risk is perceived in
 403 Dithmarschen, since 11-12 respondents feel personally threatened as their living/working activities are
 404 located in a potentially flooded area. About half of the survey participants feel that his/her sector is
 405 threatened and that it could be potentially disrupted. In spite of the perceived risk, only 2 stakeholders are
 406 looking for information to better cope with the storm surge hazard. However, according to Paton (2005) the
 407 intention to seek information does not directly lead to protective behaviours as does the intention to
 408 prepare.

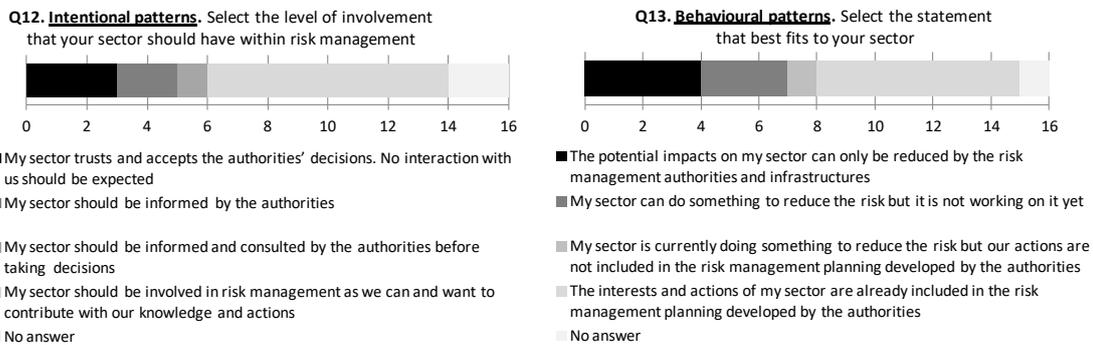


409

410 Figure 5. Results about sectoral and community preparedness (questions 8-11). Q8: critical awareness, Q9: trust, Q10:
 411 experience, Q11: risk perception.

412 The question on **intentional patterns (Q12, Fig. 6)** deals with the level of involvement the stakeholders
 413 think their sector should have within risk management. Half of the respondents suggest a more
 414 participative and integrated approach in storm surge risk management as they believe they can actively
 415 contribute with their knowledge and actions. The 68% prefers a participatory risk management, although
 416 with different involvement levels. The question on **behavioural patterns (Q13, Fig. 6)** includes on the one
 417 hand the concepts of outcome expectancy, self-efficacy and action coping applied by previous authors as
 418 predictors of intention formation (Paton, 2005, 2010; Becker et al., 2011; Becker et al., 2013). On the other
 419 hand it assesses whether the authorities are considering in some way the actions taken by the
 420 stakeholders to reduce the risk. Outcome expectancy refers to the perceptions of whether personal actions

421 will effectively mitigate or reduce a problem, self-efficacy to the beliefs regarding personal capacity to act
 422 effectively, and action coping (or “problem-focused coping” as per Paton, 2003) to the predisposition to
 423 choose action directed at changing a situation (Paton, 2003). The answers to this question show that 4
 424 respondents believe they cannot do anything to reduce the risk as this totally depends on the authorities’
 425 actions and infrastructures. This attitude has been psychologically described as *fatalism* by several
 426 authors in disaster research (McClure et al., 1999; Asgary and Willis, 1997; Flynn et al. 1999, Paton, 2010;
 427 Şimşekoğlu, 2013). When people perceive others as being responsible for their safety, they are less likely
 428 to convert intentions to actions (Ballantyne et al., 2000). Besides, the dissemination of information on
 429 structural mitigation to the public has been found to lead to a reduction in levels of household and personal
 430 preparedness and a transfer of responsibility for safety to civic authorities (Paton et al., 2000). The
 431 perceived high effectiveness (Q4) and the high trust (Q9) associated to the dyke system call attention to a
 432 possible safety feeling among the society. However, a proactive behaviour in risk reduction is detected in
 433 the 75% of responses to this question. Half of the stakeholders are already working on risk reduction, the
 434 actions and interests of 7 of them being already considered by the risk management authorities. 3
 435 respondents are already aware that their sector can do something to reduce the risk, although not working
 436 on it yet.

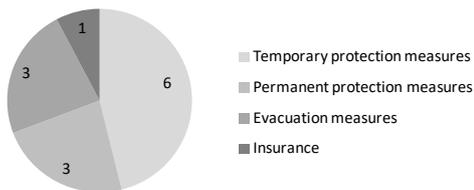


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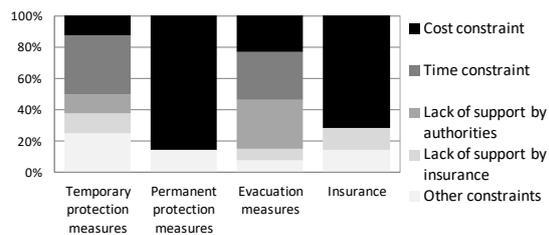
438 Figure 6. Results about sectoral and community preparedness (questions 12-13). Q12: Intentional patterns, Q13:
 439 behavioural patterns.

440 In order to move from intentions and behavioural patterns to implemented protective behaviours, the
 441 stakeholders were asked about the type of **preparation measures (Q14, Fig. 7)** being already undertaken
 442 by them together with the main constraints faced (or potentially faced) to accomplish them, the latter
 443 aspect being related to the situational facilitators/impediments proposed by Lindell and Perry (2012). The
 444 preparation measures undertaken by the stakeholders - from agriculture & farming, industry, emergency
 445 and administration sectors - are mainly temporary (6), such as sandbag storage, time being the main
 446 constraint faced to accomplish it. Very few undertake permanent structural protection, evacuation
 447 measures or have their belongings covered against flooding by insurance. Besides cost/time constraints,
 448 the stakeholders identify a lack of support by authorities and insurance to accomplish temporary protection
 449 and evacuation measures as well as to insure their belongings.

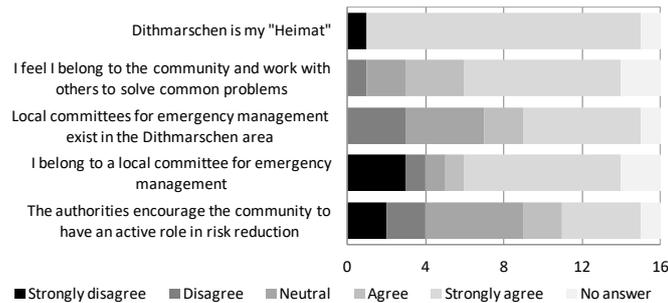
Q14a. Preparation measures. Please identify the measures you already undertake



Q14b. Preparation measures. Select the main constraints to accomplish the following measures



Q15. Community participation. Rate from 1 to 5 the extent you agree with each of the following statements



450

451 Figure 7. Results about sectoral and community preparedness (questions 14-15). Q14: preparation measures (several
452 answers possible), Q15: community participation.

453 The enhancement of community resilience depends on the promotion of mitigation and preparedness
454 behaviours and the implementation of collaboration and empowerment mechanisms to connect local
455 communities with disaster risk management agencies. Based on this idea, the question on **community**
456 **participation (Q15, Fig. 7)** includes queries about the feelings of the respondent concerning the study
457 area (using the German concept of *Heimat*) and the local community, to then ask about the existence of
458 emergency management local committees, his/her involvement in them and their acceptance and support
459 by the authorities. Ratter and Gee (2012) confirmed the concept of *Heimat* as a multi-faceted and highly
460 relevant term in the German context and explicitly along the North Sea coast for approaching place values,
461 sense of place and attachment to place. The concept links place to social relations through a strong
462 emotional component related to the perceived intangible place values or "spirit of place". Their results
463 demonstrated that this feeling of belonging has inherent qualities to foster the people to act as well as to
464 strengthen participative processes. The answers to Q15 show that there is a sense of community in the
465 study area, since 14 respondents feel home and place-attached (Dithmarschen is my *Heimat*) and 11 work
466 with others to solve common problems. Around the half stated that local committees for emergency
467 management exist and they belong to one of them. However, more than half stated that the authorities are
468 not encouraging enough the community to have an active role in risk management, more support from
469 authorities being therefore expected.

470 The stakeholders identified by the respondents as active in storm surge management in Dithmarschen
471 **(Q16)** are the authorities at the various administrative levels, the Main Dyke and Sluice Association and
472 local Dykes Associations, the Trade Ministry, the Coastal, Natural Parks, and Ocean Protection Agency
473 (LKN), the Water Boards and Land Associations (LVB), the fire brigades, and the farmers. These
474 stakeholders should be considered in potential participatory approaches and partnerships, and all of them
475 having been contacted for carrying out this questionnaire.

476 3.3.3. Coordination and policy options

477 The third and final group of questions dealt with the potential coordination mechanisms along with policy
478 and economic options to foster the adaptation to the storm surge hazard in Dithmarschen.

479 One of the main lessons in the aftermath of hurricane Katrina 2005 or the tsunami of 2004 and seen in
480 other coastal hazards is that single-sector development planning cannot solve the complexity of problems
481 posed by natural hazards nor build resilience to them (US IOTWS, 2007). Partnerships involving the public
482 and private sectors and civil society organizations are currently seen as a way of sharing responsibilities to
483 significantly improve disaster risk management and an increased support and understanding of the chosen
484 direction and solutions (Swart et al., 2014; OECD, 2010; UN/ISDR, 2005). Most of the stakeholders
485 interviewed (14-15 out of 16), when asked about the **structure of a potential partnership to deal with**
486 **risk management (Q17, Fig. 8)**, highly agreed on the involvement of those stakeholders related to the
487 emergency (i.e. THW, Red Cross, Fire brigade, etc.) and coastal protection (LKN, Dykes association). The
488 highest disagreements are related to the involvement of sectoral stakeholders (such as the
489 agriculture/livestock, tourism and industry private sectors), the environmental stakeholders (Wadden Sea
490 National Park and environmental conservation organizations) and NGOs. The involvement of authorities
491 (ministries, mayors and communities) also counts with some disagreement. The main conclusion arising
492 here is that if MSPs are to be fostered in the region, previous awareness campaigns about the relevance
493 of this integrated approach should be promoted.

494 The stakeholders were asked to identify the 3 main benefits and challenges from potential partnerships,
495 this allowing rank/prioritize the provided options. The main **expected benefits from a potential**
496 **partnership (Q18, Fig. 8)** are the increased collaboration and responsibility-sharing between
497 stakeholders, and the gain of knowledge in risk management. Long-term planning, increased budget
498 available, and the involvement of the society are considered next. These are followed by increased
499 discussion about risk management, risk sharing and, finally, the involvement of sectoral objectives in
500 management. The main **expected difficulties to be faced by a potential partnership (Q19, Fig. 8)** are
501 related to people's time and commitment, and the effective implementation of the decisions potentially
502 taken. Budget, guidance and knowledge are also challenges to be considered. These are followed by
503 collaboration and empowerment issues. The identified and ranked challenges are essential information to
504 design and manage the partnership in such way that these problems are minimized.

505 The last question dealt with potential **policy options or economic instruments that could be applied in**
506 **the region to adapt to the storm surge risk (Q20, Fig. 9)**. The stakeholders were asked to rate the
507 extent they agree with the adequacy of the following measures to Dithmarschen: land use taxes/dykes
508 taxes⁵, tax exemption⁶, grants/subsidies⁷, incentives/compensation⁸, public contracts⁹, service
509 concessions¹⁰, insurance¹¹, and catastrophe bonds¹². Around the half of the respondents rated very
510 inadequate/inadequate all of the measures. Land use taxes are considered very inadequate by most (10)

⁵ Flood prone land owners finance coastal protection

⁶ Tax exemption for private investment in permanent flood protection

⁷ Grants/ subsidies as financial support for private investment in permanent flood protection

⁸ Incentives/compensation for giving up land

⁹ Public contracts to perform a particular task that benefit the community funded by government funds

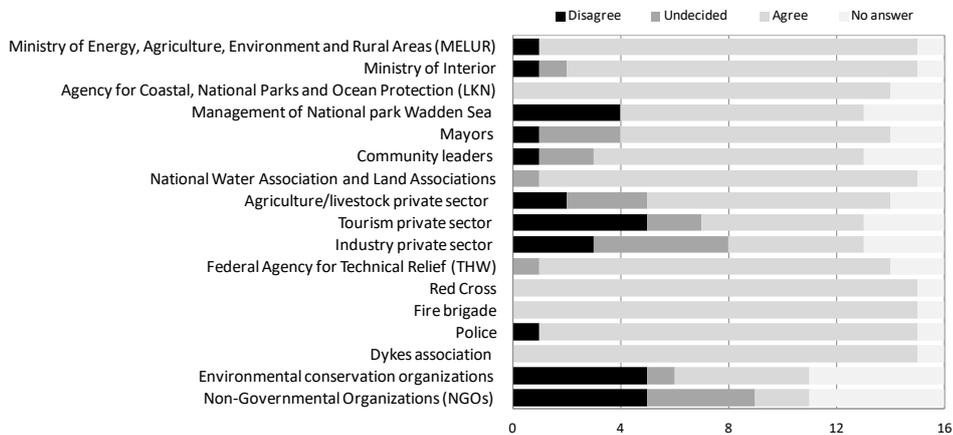
¹⁰ Service concessions to have the exclusive right to operate, maintain and carry out the investment in a public utility for a given number of years, this including the right to charge the final users of the product

¹¹ Insurance financing losses caused by storm surge events

¹² Disaster risks are securitized in the financial markets, the investor receiving a return if a catastrophe does not occur during the contract, but sacrificing interest or part of the principal if the event does occur

511 of the stakeholders. The options that received some acceptance (adequate/very adequate), even with low
 512 percentages, were grants/subsidies and insurance, followed by tax exemptions. The lowest acceptance
 513 was detected for service concessions and catastrophe bonds. Potential economic instruments and
 514 adaptation options should consider the current disagreement with some of the presented options, in order
 515 to design tailored and site-specific measures.

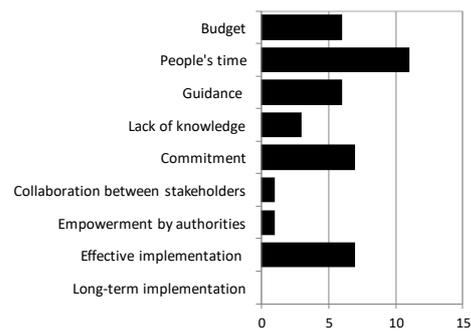
Q17. Partnerships structure. To which extent do you agree or disagree with the involvement of the following stakeholders in a potential partnership?



Q18. Partnerships benefits. According to your experience, select the 3 main benefits that these partnerships could bring



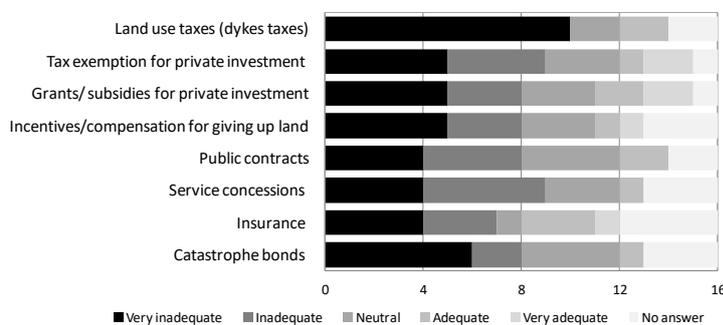
Q19. Partnerships challenges. According to your experience, select the 3 main challenges/difficulties that these partnerships could face



516

517 Figure 8. Results about coordination and policy options (question 17, 18 and 19). Q17: partnerships structure, Q18:
 518 partnership benefits, Q19: partnership challenges (Q18 and Q19: only 3 options possible).

Q20. Policy options. According to your expectations, rate from 1 to 5 the adequacy of the following measures to Dithmarschen



519

520 Figure 9. Results about coordination and policy options (question 20). Q20: policy options

521 **3.3.4. Summary of major findings: the risk culture of the pilot study**

522 The assessment carried out permitted to identify the main characteristics of the study area in terms of
 523 stakeholders' risk perception, individual/collective intention to prepare and behavioural patterns, as well as
 524 their opinion regarding the authorities' decision-making. This provided a very useful insight about the risk
 525 culture of the area, defined by Douglas and Wildawsky (1982) as the predominance in society of individual
 526 or collective approaches and the preference for hierarchies or egalitarianism. The main findings of the
 527 analysis, presented below, allow understanding the site-specific institutional, sectoral and community
 528 preparedness in Dithmarschen and the options for enhancing its resilience.

529 Based on the aggregation methods presented in Table 3 the following standardized values [0-1] by
 530 question have been obtained for the study area (Table 7). To better understand in what topics the risk
 531 management efforts should focus on, the question values are classified in 5 classes from very low to very
 532 high. The optimum result is the Very High class except in question 1 where it is the Very Low class since
 533 this question analyses the expected impacts.

534 Table 7. Resilience assessment results by question

Resilience question	Type of question	Question value (0-1)	Class
Q1. Expected impacts	Scoring (5)	0,67	High
Q2. Information and knowledge	Scoring (3)	0,32	Medium
Q3. Knowledge-based decision-making	Scoring (3)	0,61	High
Q4. Flood protection effectiveness	Scoring (5)	0,73	High
Q5. Preparedness and recovery options	Scoring (3)	0,35	Medium
Q6. Early warning	Selection (any)	0,92	Very High
Q7. Responsible authorities	Selection (any)	Qualitative	Low
Q8. Critical awareness	Selection (3)	0	Very low
Q9. Trust	Scoring (5)	0,69	High
Q10. Experience	Selection (1)	0,58	Medium
Q11. Risk perception	Selection (any)	0,50	Medium
Q12. Intentional patterns	Selection (1)	0,66	High
Q13. Behavioural patterns	Selection (1)	0,64	High
Q14. Preparation measures	Selection (any)	Qualitative	Medium
Q15. Community participation	Scoring (5)	0,67	High
Q16. Active stakeholders	Open-ended	Qualitative	Not applicable
Q17. Partnerships structure	Scoring (3)	Qualitative	Low
Q18. Partnership benefits	Selection (3)	Qualitative	Not applicable
Q19. Partnership challenges	Selection (3)	Qualitative	Not applicable
Q20. Adequacy of policy options	Scoring (5)	0,26	Low

535

536 The specific results obtained for each item within each question have been presented in the previous
 537 section and are summarized next.

538 High storm surge impacts are expected in Dithmarschen, the higher damages being related to the
 539 infrastructural and socio-economic dimensions. To some extent there is some storm surge risk-related
 540 information available but it is not enough for raising awareness in the society and for a better
 541 preparedness. The information that should be improved concerns (i) the potential impacts of a major storm
 542 surge event, (ii) preparedness/recovery options, (iii) responsible authorities of the different tasks within
 543 storm surge risk management, and (iv) the consideration of storm surge risk in sectoral planning. Warning
 544 mechanisms are known by the stakeholders, some new additional having been suggested.

545 A clear reflect of the risk culture of the area is shown by a higher credibility and trust levels on engineering-
546 based protection measures, than on soft protection and spatial planning measures, as well as on
547 authorities and teams. The stakeholders have some experience with major storm surge events, and storm
548 surge risk is indeed perceived in Dithmarschen, as the 75% of the respondents feel personally threatened
549 as their living/working activities are located at a potentially flooded area; and around the half feels that
550 his/her sector is threatened and that it could be potentially disrupted. Nevertheless, few stakeholders are
551 looking for information to better cope with the storm surge hazard.

552 Despite the experience and the risk perception, storm surge is not considered an urgent/important problem
553 by the stakeholders. It could be discussed that only daily problems such as livelihood-related difficulties or
554 demographic change and migration are highlighted; however, climate change appears as the third most
555 important problem for the stakeholders, which suggests the important role and effectiveness of climate
556 change awareness campaigns worldwide and the lack of them for storm surge hazard in particular. The
557 fact of not considering storm surges as an urgent problem may be the cause for the prevalence of
558 temporary short-term protection measures to cope with it. Besides cost/time constraints, a lack of
559 authorities and insurance support to accomplish temporary protection and evacuation measures, as well
560 as insurance support could be identified as an important obstacle in order to increase resilience against
561 storm surges in Dithmarschen.

562 Most of the respondents prefers a participatory risk management and shows a proactive behaviour in risk
563 reduction (68% and 75%, respectively), though fully participatory schemes are not yet established by the
564 authorities. Most of the stakeholders work with others to solve common problems, although more support
565 from authorities is expected in terms of community participation and involvement. However, a lack of
566 awareness about the relevance/usefulness of the integrated approach and the vertical and horizontal
567 coordination, i.e. various administrative levels and various sectors respectively, is recognized when asked
568 about the structure of this potential partnership. There is a high consensus on the involvement of those
569 stakeholders related to the emergency and coastal protection in a potential partnership. The highest
570 disagreements are related to the involvement of sectoral stakeholders (such as the agriculture/livestock,
571 tourism and industry private sectors), the environmental stakeholders and the NGOs. The involvement of
572 authorities also counts with some disagreement. Therefore, if Multi-Sector-Partnerships are to be fostered
573 in the region, previous awareness campaigns should be promoted regarding the relevance of the
574 mentioned integrated approach. Several stakeholders have been identified as already active on risk
575 reduction, which should be definitely considered in potential participatory approaches and partnerships.

576 Finally, regarding potential policy options and economic instruments to cope with the storm surge, about
577 half of the respondents rated very inadequate/inadequate all of the measures that were offered as
578 answers. Strong disagreement of the involved stakeholders with currently discussed and proposed
579 measures and instruments highlights the need for tailored and site-specific potential economic instruments
580 and adaptation measures for Dithmarschen. This need represent a major future challenge in storm surge
581 management.

582 It should be noted that the detailed analysis of contradictory answers and disagreements between types of
583 stakeholders, despite its relevance for the study and its significance in sectoral cooperation for storm surge
584 risk management, is not presented in this paper due to statistical limitations related to the size of the
585 sample in this pilot case. Once the study is applied to the entire Wadden Sea region and a statistically
586 confident sample is collected, conclusions will be provided. This larger study will include a few reverse-

587 coded questions to facilitate checking whether respondents read the questions with diligence or simply
588 rush through without regard for the subject matter.

589

590 **4. Conclusions**

591 A resilient society is aware of the hazard, is prepared for its impacts and is able to recover from negative
592 impacts, these capacities referring to both institutional and social spheres of the community. A conceptual
593 and methodological framework is proposed to understand the factors affecting the resilience of a
594 community exposed to risks from natural hazards. The framework shows the linkages between the
595 institutional, social and legal dimensions within risk management to enhance community preparedness,
596 emergency management and long-term adaptation. The proposed survey-based method and the specific
597 resilience questionnaire allows exploring the perception of stakeholders regarding the risk and emergency
598 management processes as well as psychological and social factors conditioning individual and community
599 preparedness.

600 Both framework and questionnaire could be applied worldwide, although some questions may need some
601 adaptation to fit adequately to other risks and study sites. The application to storm surge risks at the
602 Dithmarschen district in the German North Sea Coast has been presented here.

603 The assessment carried out in the pilot case permitted to identify the main characteristics of the study area
604 in terms of stakeholders' risk perception, individual/collective intention to prepare and behavioural patterns,
605 as well as their opinion regarding the authorities' decision-making. This provided a very useful insight
606 about the risk culture of the area to guide future site-specific options for enhancing its resilience.

607 Both institutional and social preparedness are analyzed since a failure or a shortage/deficit of a specific
608 ability in one of them could turn the risk management and/or the emergency process partially ineffective or
609 invalid for the worst case. The deficiencies and the incoherencies between society's and administration's
610 answers detected in the analysis point towards the challenges to tackle in order to foster an adequate
611 community preparedness and adaptation to storm surge risk. As an example, some of the results obtained
612 from the pilot study in Dithmarschen analyzed in this work show (i) the need for a better information
613 strategy in some specific topics in order to enhance society's awareness and preparedness; (ii) the
614 respondents' current proactive behaviour and preference on participatory risk management options,
615 despite fully participatory schemes are not yet set by the authorities; (iii) the need for awareness
616 campaigns regarding the relevance and benefits of the integrated approach in potential partnerships, and
617 (iv) the need for tailored and site-specific adaptation instruments and measures due to the current
618 disagreement of society with some of the options provided. This type of results is very useful to improve
619 risk reduction initiatives by means of including society's opinions from the beginning of the management
620 process.

621 The various conclusions on the risk culture, perception and preparedness of the study area validate the
622 usefulness of the questionnaire to enhance community resilience and risk reduction. The conceptual
623 framework and method presented will be replicated along the region of the Wadden Sea, including the
624 Dutch, German and Danish North Sea coast, in the framework of the ongoing FP7 ENHANCE Project. This
625 study will therefore rely on a much larger sample size providing a highly confident statistical analysis. The
626 first results of this larger study, based on collaborative work with stakeholders in the Wadden Sea region,
627 demonstrate that dealing with risks involves more than the simple quantitative process of identifying,
628 quantifying, or monetarily assessing risks and their potential impacts on society (Gerkenmeier et al.

629 2015). Risk management is a societal process which takes place within a particular socio-cultural context
630 and there is constant need for negotiation and mediation between different interests and options. The
631 presented framework is capable of assessing the current state of storm surge risk management including
632 different perspectives, concerns and rationalities of partner responsibilities within the risk management
633 process.

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638

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