



Title: Report on pathways identification in case studies

Deliverable: 2.4

WP: WP2

Authors: Guittard Alice, Akinsete Ebun, Koundouri Phoebe et al.



This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101037424.

Deliverable Number and Name	D2.4 - Report on pathways identification in case studies
Work Package	WP2 – Systems Innovation Approach
Dissemination Level	Public
Author(s) and co-authors	AUEB: Guittard A., Koundouri P. Landis C.; ADDMA : Papageorgiou S., Stefas G.; AGRIS: Carboni G., Dettori M., Urracci G.; AKPT: Lalaj N., Alimerko S.; ATHENA: Akinsete E.; AUTH: Theodossiou N., Stavridis C.; BSUN: Mamut E.; CTBG: Zdravkov Y. , CUT: Nisiforou O., Charalambides A., DTU: Drews M.; EM: Ankjær Nielsen B., Hammer Lauridsen A.; IECE: Kasovska Georgieva S., Trajkovska S., Lika D.; INCDSB: Paraschiv M. LMU: Beck I., Böhnisch A., Ludwig R., Pérez-Ciria T.; METU: Hasan Hüseyin M.G., M. Uygurer P., Yucel M.; NECCA: Papadopoulou M.; NECCA: Grigoriadou E-T., Papadopoulou M. P., Roussos O.; NTUA: V. I. Chalastani, M. Chondros, V. K. Tsoukala ; PPA SA: Filippidis P. (external expert of PPA SA), Spyrou.; ULL: Cruz Perez, N., Rodriguez Alcantara J.S., Santamarta J.C.; UNEXE: Baker K.; UT: La Jeunesse I.; UTH: Adamos G., Laspidou C., Spyropoulou A.; VKU: Braun G., Zilker M.; VP: Arroyo Bovea M, Calduch Verduch D., Monterde Higuero N.; WRT: Howard R., Staddon H.;
Primary Contact and Email	aguittard@aueb.gr
Date Due	31/07/2024 (Final version) – 04/04/2025 (Revised version)
Date Submitted	04/04/2025 (Resubmitted)
File Name	ARSINOE – Report of pathways identification in case studies
Status	Final revised version
Reviewed by (internal)	Inna Petrenko
Suggested citation	Guittard A., Akinsete E., Koundouri P. et al. (2024) Report on pathways identification in case studies. ARSINOE Deliverable 2.4, H2020 grant no. 101037424

This deliverable contains original unpublished work except when indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both. Reproduction is authorised if the source is acknowledged.

This document has been prepared in the framework of the European project ARSINOE. This project has received funding from the European Union's Horizon 2020 innovation action programme under grant agreement no. 101037424.

The sole responsibility for the content of this publication lies with the authors. It does not necessarily represent the opinion of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.

Abbreviations

AL:	Albania
CAP:	Common Agricultural Policy
CC:	Climate Change
CS:	Case Study
CIW:	Climate Innovation Window
EU:	European Union
GR:	Greece
GHG:	Greenhouse Gases
IAS:	Invasive Alien Species
IP:	Innovation Pathway
LL:	Living Lab
NBS:	Nature-Based Solutions
NMK:	North Macedonia
PPMC:	Prespa Park Management Committee
TMS:	Transboundary Monitoring System
WFD:	Water Framework Directive
WGWM:	Working Group on Water Management
WS:	Workshop

TABLE OF CONTENTS

LIST OF FIGURES	6
LIST OF TABLES	8
EXECUTIVE SUMMARY	12
1.0 INTRODUCTION	14
2.0 METHODOLOGY	16
2.1 Theoretical Background: The Systems Innovation Approach	16
2.2 Combining the System Innovation Approach and the Climate Innovation Windows	17
2.3 ARSINOE innovation pathways development: a co-creation approach	18
2.3.1 A stakeholder-led process	19
2.3.2 STEP 1: Identifying main issues and challenges of the case study ...	22
2.3.3 STEP 2: Desired state to be achieved by the innovation pathways...	22
2.3.4 STEP 3: Co-design of a portfolio of innovations	25
2.3.4.1 Pre-identification of potential innovations.....	25
2.3.4.2 Co-Identification of Milestones	25
2.3.4.3 Outline Innovation pathways.....	27
2.3.5 STEP 4: Identify barriers and enablers	27
3.0 CASE STUDIES INNOVATION PATHWAYS	29
3.1 Case study 1: Athens.....	29
3.1.1 Problem statement.....	29
3.1.2 Future vision	29
3.1.3 Innovation pathway.....	29
3.1.4 Barriers and Enablers	33
3.2 Case study 2: Mediterranean ports	33
3.2.1 Problem statement.....	34
3.2.2 Future vision	34
3.2.3 Innovation pathways	34
3.2.4 Barriers and enablers	36
3.3 Case study 3: Main River.....	37
3.3.1 Problem statement.....	37
3.3.2 Future vision	38
3.3.3 Innovation pathway.....	39
3.3.4 Barriers and Enablers	44
3.4 Case study 4: Ohrid and Prespa lakes.....	45
3.4.1 Problem statement.....	45
3.4.2 Future vision	45
3.4.3 Innovation pathway.....	46
3.4.4 Barriers and enablers	49
3.5 Case study 5: Canary Islands.....	49
3.5.1 Problem statement.....	50
3.5.2 Future vision	50
3.5.3 Innovation pathway.....	50
3.5.4 Barriers and enablers.....	

3.6 Case study 6: South-West Black Sea	53
3.6.1 Romania	53
3.6.1.1 Problem statement	53
3.6.1.2 Vision	53
3.6.1.3 Innovation Pathway	54
3.6.1.4 Barriers and enablers	56
3.6.2 Bulgaria	57
3.6.2.1 Problem statement	57
3.6.2.2 Vision	57
3.6.2.3 Innovation Pathway	57
3.6.2.4 Barriers and enablers	61
3.6.3 Turkey	61
3.6.3.1 Problem statement	62
3.6.3.2 Vision	62
3.6.3.3 Innovation Pathway	62
3.6.3.4 Barriers and enablers	65
3.6.4 CS6 Regional level	65
3.6.4.1 Problem statement	65
3.6.4.2 Vision	65
3.6.4.3 Innovation Pathway	66
3.6.4.4 Barriers and enablers	73
3.7 Case study 7: Southern Denmark	74
3.7.1 Problem statement	74
3.7.2 Future vision	74
3.7.3 Innovation pathway	75
3.7.4 Barriers and enablers	77
3.8 Case study 8: Torbay & Devon County	78
3.8.1 Problem statement	78
3.8.2 Future vision	78
3.8.3 Innovation pathway	78
3.8.4 Barriers and enablers	82
3.9 Case study 9: Sardinia	82
3.9.1 Problem statement	82
3.9.2 Future vision	83
3.9.3 Innovation pathway	83
3.9.4 Barriers and enablers	85
3.10 Synthesis	86
3.10.1 Key fields in needs of innovation	87
3.10.2 Key barriers and enablers to support innovations for climate change adaptation	89
3.11 Recommendations	90
4.0 INNOVATION FOR CLIMATE CHANGE ADAPTATION AND RESILIENCE	92
4.1 Innovations to adapt to climate change risk	92
4.1.1 Technological innovations	92
4.1.2 Social and institutional innovations	94
4.2 Innovation Gaps	96
4.2.1 Water management sector	96
4.2.2 Community engagement / education	98

4.2.3 Environment / biodiversity.....	99
4.2.4 Soil management / agriculture	100
4.2.5 Energy	101
4.2.6 Climate change risk management.....	101
4.2.7 Fishery.....	102
4.2.8 Tourism.....	103
4.2.9 Governance and planning	103
4.2.10 Urban greening.....	104
5.0 CONCLUSION AND NEXT STEPS	105
REFERENCE.....	107
APPENDICES	108
APPENDIX 1: WORKSHOPS GUIDELINES	108
APPENDIX 2: PRE-IDENTIFICATION OF INNOVATIONS (OUTPUTS OF WS3) ...	129
APPENDIX 3: PESTLE FRAMEWORK	129
APPENDIX 4: CS3 INNOVATIONS	133
APPENDIX 5: OUTPUTS OF CS4 NATIONAL WORKSHOPS	137
APPENDIX 6: LIST OF INNOVATIONS TARGETED BY CSS IN THE ARSINOE INNOVATION PATHWAYS	148
APPENDIX 7: DETAILS OF BARRIERS AND ENABLERS IDENTIFIED FOR THE IMPLEMENTATION OF EACH INNOVATIONS COMPOSING THE CS INNOVATION PATHWAYS	164

List of Figures

Figure 1: SIA approach	16
Figure 2: ARSINOE overarching methodological framework.....	17
Figure 3:Methodological chart flow for the co-design of the innovation pathways –	18
Figure 4: Stakeholder mapping matrix.....	20
Figure 5: Example of a mental map developed in CS1.....	22
Figure 6: Characteristics of a future vision (source: De Vicente Lopez and Matti, 2016).....	23
Figure 7: envisioning a sustainable future: a preferable type of scenario	24
Figure 8: Backcasting and forecasting.....	26
Figure 9: Futures Radar (Source: De Vicente López & Matti, 2016)	27
Figure 10: Six areas of the Pestle analysis (source: https://pestleanalysis.com/what-is-pestle-analysis/)	28
Figure 11: CS1 - Athens - Innovation Pathway- Present-2030 * Green innovations: to be implemented within the frame of ARSINOE (WP5-CIW).....	31
Figure 12: CS1 - Athens - Innovation Pathway- 2030 -2050 *Red color: innovation gap	32
Figure 13: CS2 - Innovation pathway from present to 2030 *innovations in green: implemented within ARSINOE framework (CIW)	35
Figure 14: CS2 - Innovation pathway from 2030 to 2050	36
Figure 15: CS3 Innovation pathway for the water sector from present to 2025 - *needs of legal framework adaptation which would be innovative; innovation in red: haven't been tested / implemented elsewhere; innovation in green: implemented or supported by ARSINOE.....	41

Figure 16: CS3 Innovation pathway for the water sector from 2030 to 2050 - *needs of legal framework adaptation which would be innovative; innovation in red: haven't been tested / implemented elsewhere; innovation in green: implemented or supported by ARSINOE	42
Figure 17: CS3 Innovation pathway for land use / soil management, public awareness and education, water and biodiversity -*innovation in red: haven't been tested / implemented elsewhere.	43
Figure 18: CS4 - Innovation pathway from present to 2030 * in green: innovation to be tested within the framework of ARSINOE project; in red: innovation gap (not yet developed or implemented elsewhere) * in purple: innovation to be implemented only in Greece	47
Figure 19: CS4 - Innovation pathway from 2030 to 2045 * in green: innovation to be tested within the framework of ARSINOE project; in red: innovation gap (not yet developed or implemented elsewhere)	48
Figure 20: CS5 - Innovation pathway * in red: innovation gap (do not exist yet or not implemented elsewhere); in green: innovation funded under ARSINOE framework (CIW).....	51
Figure 21: CS6 Romania Innovation Pathway from present to 2040 *in red: innovation gap (not yet developed or identified); in violet innovation coming from Danubius-RI; in green: innovation to be implemented within the ARSINOE framework	55
Figure 22: CS6 Romania Innovation Pathway from 2040 to 2050 *in red: innovation gap (not yet developed or identified); in violet innovation coming from Danubius-RI; in green: innovation to be implemented within the ARSINOE framework	56
Figure 23: CS6 Bulgaria Innovation pathway period present to 2030 *in red: innovation gap (innovation not yet developed or not yet identified); in green: innovation funded under ARSINOE framework (CIW)	59
Figure 24: CS6 Bulgaria Innovation pathway period 2030 - 2045 *in red: innovation gap (innovation not yet developed or not yet identified).....	60
Figure 25: CS6 Türkiye innovation pathway from present to 2030 *in red: innovation not yet fully developed or does not yet exist (innovation gap); in green: innovation implemented within ARSINOE framework.....	63
Figure 26: CS6 Türkiye innovation pathway from 2030 to 2045 *in red: innovation not yet fully developed or does not yet exist (innovation gap).....	65
Figure 27: CS6 Regional level - Innovation pathway from present to 2030 for “monitoring / data collection” and “Machine Learning trajectories	67
Figure 28: CS6 Regional level - Innovation pathway from 2030 to 2045 for “monitoring / data collection” and “Machine Learning trajectories * in red: innovation gaps.....	68
Figure 29: CS6 Regional level - Innovation pathway from present to 2030 for “community inclusion” trajectories * in red: innovation gaps	69
Figure 30: CS6 Regional level - Innovation pathway from 2030 to 2045 for “community inclusion” trajectories * in red: innovation gaps	70
Figure 31: CS6 Regional level - Innovation pathway from present to 2030 for “internal cooperation” trajectories * in red: innovation gaps	71
Figure 32: CS6 Regional level - Innovation pathway from 2030 to 2045 for “internal cooperation” trajectories * in red: innovation gaps	72
Figure 33: CS7 Innovation pathway from 2024-2025 *in red innovation gap (not yet developed or need further development)	75
Figure 34: CS7 Innovation pathway from present to 2030 *in red innovation gap (not yet developed or need further development)	76
Figure 35: CS7 Innovation pathway from 2030 to 2050 *in red innovation gap (not yet developed or need further development)	77
Figure 36: CS8 - Cross-sector innovation pathway present to 2025 * in red: innovation gap; in green: innovation funded by ARSINOE framework.....	79

Figure 37: CS8 - Cross-sector innovation pathway 2025 to 2040 * in red: innovation gap.....	80
Figure 38: CS8 - innovation pathway for water / infrastructure / biodiversity / community * in red: innovation gap	81
Figure 39: CS9 - Innovation pathway present to 2030 * in red: innovation gap; in green: innovation funded by ARSINOE framework.....	84
Figure 40: CS9 - Innovation pathway from 2040 to 2050 * in red: innovation gap; in green: innovations funded by ARSINOE framework.....	85
Figure 41: Targeted areas of intervention depending on climate change risks	88
Figure 42: Example of a mental mapping exercise with local stakeholders in a workshop (H2020 COASTAL project).....	112
Figure 43: Example of a refined mind map post workshop (H2020 COASTAL project).....	113

List of Tables

Table 1: Main stage of the SIA	16
Table 2: Athens case studies (adapted from ARSINOE Del. 2.1).....	20
Table 3: Innovation gaps in the field of "water management"	97
Table 4: Innovation gaps in the field of "community engagement / education"	98
Table 5: Innovation gaps in the field of "environment / biodiversity"	99
Table 6: Innovation gaps in the field of "soil management / agriculture"	100
Table 7: Innovation gaps in the field of "energy"	101
Table 8: Innovation gaps in the field of "climate change risks management"	102
Table 9: Innovation gaps in the field of "fishery"	103
Table 10: Innovation gaps in the field of "tourism"	103
Table 11: Innovation gaps in the field of "governance and planning".....	104
Table 12: Innovation gaps in the field of "Urban greening"	104
Table 13: The PESTLE framework.....	130
Table 14: Technological innovations in the field of water management targeted in ARSINOE CS Innovation pathways.....	148
Table 15: Social and institutional innovations in the field of water management targeted in ARSINOE CS Innovation pathways.....	150
Table 16: Technological innovations in the field of "Community engagement and education" targeted in ARSINOE CS Innovation pathways	152
Table 17: Social and institutional innovations in the field of "Community engagement and education" targeted in ARSINOE CS Innovation pathways.....	153
Table 18: Technological innovations in the field of "Environment and biodiversity" targeted in ARSINOE CS Innovation pathways.....	153
Table 19: Social and institutional innovations in the field of "Environment and biodiversity" targeted in ARSINOE CS Innovation pathways	154
Table 20: Technological innovations in the field of "soil management and agriculture" targeted in ARSINOE CS Innovation pathways	155
Table 21: Technological innovations in the field of "energy" targeted in ARSINOE CS Innovation pathways.....	157
Table 22: Social and institutional innovations in the field of "energy" targeted in ARSINOE CS Innovation pathways.....	157
Table 23: Technological innovations in the field of "CC risk management" targeted in ARSINOE CS Innovation pathways.....	158
Table 24: Social and institutional innovations in the field of "CC risk management" targeted in ARSINOE	

CS Innovation pathways.....	159
Table 25: Technological innovations in the field of “Fishery” targeted in ARSINOE CS Innovation pathways.....	159
Table 26: Social and institutional innovations in the field of “fishery” targeted in ARSINOE CS Innovation pathways.....	160
Table 27: Technological innovations in the field of “tourism” targeted in ARSINOE CS Innovation pathways.....	160
Table 28: Social and institutional innovations in the field of “tourism” targeted in ARSINOE CS Innovation pathways.....	160
Table 29: Social and institutional innovations in the field of “governance and planning” targeted in ARSINOE CS Innovation pathways	161
Table 30: Technological innovations in the field of “port and shipping” targeted in ARSINOE CS2 Innovation pathway	161
Table 31: Decision-support tools in the field of “port and shipping” targeted in ARSINOE CS2 Innovation pathway	162
Table 32: Technological innovations in the field of “urban greening” targeted in ARSINOE CS Innovation pathways.....	162
Table 33: Social and institutional innovations in the field of “urban greening” targeted in ARSINOE CS Innovation pathways.....	163
Table 34: CS1- Identification of barriers and enablers for innovation related to Water.....	164
Table 35: CS1- Identification of barriers and enablers for innovation related to the Energy theme	170
Table 36:CS1- Identification of barriers and enablers for innovation related to theme Urban Greening	170
Table 37: CS1- Identification of barriers and enablers for innovation related to theme Heat risk management.....	173
Table 38: CS1 - Identification of barriers and enablers for innovation related to theme 5, namely Awareness/Social (Health)	177
Table 39: CS2 - Identification of barriers and enablers for innovation related to theme Port Operations/ Logistics / Infrastructure	179
Table 40: CS2 - Identification of barriers and enablers for innovation related to theme Green Port (Environment / Emissions).....	181
Table 41:CS2 - Identification of barriers and enablers for innovation related to theme Green Port (Environment / Energy).....	181
Table 42: CS2 - Identification of barriers and enablers for innovation related to theme Finance	182
Table 43: CS2 - Identification of barriers and enablers for innovation related to theme Risk management	182
Table 44: CS3 - Identification of barriers and enablers for innovation related to theme LAND USE / SOIL	182
Table 45: CS3 - Identification of barriers and enablers for innovation related to theme 1 WATER/WATER BALANCE	186
Table 46: CS3 - Identification of barriers and enablers for innovation related to theme Public awareness and education	212
Table 47: CS4 - Identification of barriers and enablers for innovation related to sector 1: Water Supply- Environmental Monitoring -	216
Table 48: CS4 - Identification of barriers and enablers for innovation related to theme / sector 2: Forest & Wetland Protection	219
Table 49: CS4 - Identification of barriers and enablers for innovation related to theme / sector 3: Fishery	221
Table 50: CS4 - Identification of barriers and enablers for innovation related to sector 4: Agriculture	221

Table 51: CS4 - Identification of barriers and enablers for innovation related to sector 5: Tourism & Cultural Heritage.....	222
Table 52: CS4 - Identification of barriers and enablers for innovation related to sector 6: Education-Social Cohesion-Social Awareness & Economy.....	224
Table 53: CS4 -Identification of barriers and enablers for innovation related to sector 7 Institutional-Legal Framework-Policy	225
Table 54: CS4 - Identification of barriers and enablers for innovation related to sector 9: Infrastructure/Renewable Energy	226
Table 55: CS5 - Identification of barriers and enablers for innovation related to theme 'Water'	227
Table 56: CS5 - Identification of barriers and enablers for innovation related to theme 'Primary sector'	228
Table 57: CS5 - Identification of barriers and enablers for innovation related to theme 'Research, Education and Technology'	229
Table 58:CS5 - Identification of barriers and enablers for innovation related to theme 'Tourism'	230
Table 59: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector: Water quality - Monitoring and data management	231
Table 60: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 2: Aquaculture and Fisheries	232
Table 61: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 3: Agriculture	233
Table 62: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 4: Citizen science.....	234
Table 63: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 5: Political initiative.....	234
Table 64: Bulgaria PESTLE analysis: Innovations code names for theme A 'Sustainability'	235
Table 65: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector A. Sustainability.....	235
Table 66: Bulgaria PESTLE analysis: Innovations code names for theme B High level of awareness	237
Table 67: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector B. High level of awareness	238
Table 68: Bulgaria PESTLE analysis: Innovations code names for theme C Integrated approach	238
Table 69: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector C. Integrated Approach.....	239
Table 70: Bulgaria PESTLE analysis: Innovations code names for theme D Activated Civil Society.....	239
Table 71: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector D. Activated Civil Society.....	240
Table 72: CS6 Türkiye - Identification of barriers and enablers for innovation related to monitoring ...	241
Table 73: CS6 Türkiye - Identification of barriers and enablers for innovation related to waste management.....	242
Table 74: CS6 Türkiye - Identification of barriers and enablers for innovation related to cultural/historical heritage	244
Table 75: CS6 Türkiye - Identification of barriers and enablers for innovation related to fish farms	245
Table 76: CS6 Türkiye - Identification of barriers and enablers for innovation related to catch fisheries	245
Table 77: CS6 regional level: PESTLE analysis: Innovations code names for theme A Monitoring / Data collection.....	247
Table 78: CS6 regional level - Identification of barriers and enablers for innovation related to Monitoring and Data Collection.....	248
Table 79: CS6 regional level: PESTLE analysis: Innovations code names for theme B AI/Machine learning	

.....	253
Table 80: CS6 regional level - Identification of barriers and enablers for innovation related to AI/Machine Learning.....	254
Table 81: CS6 regional level - CS6 regional level: PESTLE analysis: Innovations code names for theme C Community inclusion	255
Table 82: CS6 regional level - Identification of barriers and enablers for innovation related to Community Inclusion	255
Table 83: CS6 regional level - CS6 regional level: PESTLE analysis: Innovations code names for theme D international cooperation.....	258
Table 84: CS6 regional level - Identification of barriers and enablers for innovation related to International Cooperation	258
Table 85:CS7 - Identification of barriers and enablers for innovation related to Citizen/civil society....	259
Table 86: CS7 - Identification of barriers and enablers for innovation related to Public Authority (Esbjerg Municipality, national government, etc.).	261
Table 87: CS7 - Identification of barriers and enablers for innovation related to Private sector (industry, enterprises and investors).	263
Table 88: CS7 - Identification of barriers and enablers for innovation related to Utility sector (water, wastewater, electricity, district heating).	264
Table 89: CS7 - Identification of barriers and enablers for innovation related to Knowledge institutions.	265
Table 90: CS8 - Identification of barriers and enablers for innovation related to the Cross-Sector (Health, community, biodiversity, infrastructure, water and flooding)	266
Table 91: CS8 - Identification of barriers and enablers for innovation related to Cross-sector (Infrastructure, water and flooding).....	270
Table 92: CS8 - Identification of barriers and enablers for innovation related to Cross-sector (Infrastructure, community)	271
Table 93: CS8 - Identification of barriers and enablers for innovation related to Cross-sector (Infrastructure, water and flooding, community).....	274
Table 94: CS8 - Identification of barriers and enablers for innovation related to Community	276
Table 95: CS8 - Identification of barriers and enablers for innovation related to Biodiversity.....	280
Table 96: CS9 - Identification of barriers and enablers for innovation related to theme 1: sustainable agriculture.....	281
Table 97: CS9 - Identification of barriers and enablers for innovation related to theme 2: local food chain	283
Table 98: CS9- Identification of barriers and enablers for innovation related to theme 3: water and energy	285

EXECUTIVE SUMMARY

D2.4 reports on the activities performed within the task 2.4 “forecasting innovation pathways co-creation”. Over the course of past 2 years and half, stakeholders from the quadruple helix (stakeholders representing academia, the private sector, public authorities, and the civil society) in the 9 case studies of ARSINOE were engaged in Living Labs, through a series of workshops following a systems innovation approach in order to 1) agree upon the key climate change challenge to address as part of ARSINOE, 2) co-develop a sustainable vision for their region 3) co-design a portfolio of actions to support the achievement of the vision in the form of an innovation pathways.

This deliverable follows WP2 deliverable 2.1 which presented the stakeholder engagement strategy: how local stakeholder were selected to participate in the co-design process of ARSINOE Living labs and WP6 deliverable 6.5 which introduce the System Innovation Approach followed to co-design the innovation pathways. It reports on the innovation pathways (IPs) developed in each ARSINOE case studies, reiterating the problem to be solved in each case study, the vision to be achieved and the potential barriers and enablers, assessed with the PESTLE framework, to take into consideration during the implementation process.

Regarding the results, the case studies’ portfolio of innovations described in the IPs provide an overview of the type of innovations to be mobilized and the key field of interventions to support climate change adaptation and resilience in European regions. Innovations are primarily needed to better manage water and soil and support the agriculture sector to adapt to new farming conditions. Driving the farming sector and cities towards sustainability will also require innovations in the energy sector to increase the adoption of renewable energies and reduce the overall sectoral energy consumption, thereby mitigating climate change. As changes in the water regime are expected to negatively impact local biodiversity, innovative practices to manage natural ecosystems are essential. Finally, social innovative practices to facilitate community engagement and raise awareness on climate change impacts, adaptation and resilience practices are needed. Additional innovations are critically important for risk management and impacts on infrastructures (better assess, predict, prevent and protect against the risk). Most innovations targeted within the ARSINOE innovation pathways are already available in the market, nonetheless gaps remain in many fields which should be the focus of future research and innovation agendas.

The report also highlights the enablers and barriers for the implementation of climate change adaptation innovations in the ARSINOE European regions. Utilizing the PESTLE framework, political, economic, social, technological, legal, and environmental factors, as enablers or barriers influencing the implementation of innovation pathways for climate adaptation, were identified. It highlights the difficulties in the ARSINOE case studies representing different EU regions, to harmonize policies across governance levels. Legal barriers include delays in adapting frameworks to climate conditions, while concerns about data privacy might hinder AI-related technological innovations. Economic challenges are often marked by insufficient funding and private sector reluctance to invest due to uncertainty, though incentives and long-term savings are encouraging factors. Social barriers stem from societal resistance to change and lack of awareness, which can be countered by strengthening environmental education, awareness campaigns, and community networks. Technological barriers include limited access to knowledge and data issues, while local innovation hubs could serve as promising enablers. Environmental barriers involve insufficient data for technological support, while climate change impacts are more and more seen as enablers by driving a sense of urgency for adaptation policies.

The main conclusion of this work was that strengthen climate policy frameworks, adopting a systemic approach, mobilizing the wide range of solutions already at hand, ensuring the workforce is properly trained, engaging the wider public and fostering collaboration across sectors and actors, and having the

necessary financial support are key recommendations coming out of the ARSINOE Living Labs to lead the path towards climate change adaptation and resilience in Europe.

1.0 Introduction

ARSINOE project is shaping the pathways to resilience, in 9 European regions, by bringing together Systems Innovation Approach (SIA) and Climate Innovation Window (CIW) with the purpose of building an ecosystem for climate change adaptation solutions. Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing technologies from the CIW pool of solutions providers, or technologies from external solution providers to form an innovation package for resilience to climate change.

Adaptation to climate change refers to all approaches taken to adjust, prepare for, and accommodate new conditions that are created by changing climates. Adaptations may be cultural and societal, or financial solutions, for example families deciding to purchase flood, fire, or windstorm insurance. For natural-resource managers, adaptation strategies also include actions taken to assist natural resources (species, habitats, forest plantations, watersheds) in accommodating new conditions imposed by climate, but also facing socio-economic impacts brought about by a worsening climate migration crisis. As climate change is complex and interconnected with other global challenges, such as food security, water scarcity, biodiversity depletion and environmental degradation, it is insufficient to use traditional approaches to innovation that focus on one aspect of the problem.

Systems Innovation Approach (SIA) addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system “as a whole” and on the variety of actors, instead of focusing on specific functions or individual/sectoral benefits. SIA analyses the challenges, recognizes the opportunities and designs solutions. Within the ARSINOE project, the SIA is applied to support the 9 CSA in co-identifying a portfolio of innovations in a form of innovation pathways able to support local regions in their resilience and adaptation strategy to climate change.

This deliverable reports on Task 2.4, “co-development of innovation pathways at case study level”, as part of the elaboration of ARSINOE innovation packages (T6.4), one of the 5 main outputs of the project. It builds on Deliverable 2.1 and 6.5., and contributes to:

- Objective 1: Facilitate a fundamental transformation of economic, social and financial systems that will trigger exponential change in decarbonization rates and strengthen climate resilience through a Systems Innovation Approach that will deliver integrated inclusive and coordinated interventions in economic, financial, political and social systems and along whole value chains.
- Objective 2: Support recovery from the COVID-19 crisis and climate resilience through the implementation of the EU Next Generation Fund Recovery and Resilience Plans (RRP's) in a co-integrated way, by taking into account the 1) country-specific recommendations derived from the EC Semester Process, 2) the weaknesses on SDG's identified in the Sustainable Development Report at national level and 3) the European Green Deal Policies
- Objective 6: To facilitate knowledge transfer and exploitation for start-ups and SMEs, trigger industry-academy-SME collaborations and eventually enable the establishment of a Climate Adaptation innovation ecosystem by implementing an Innovation Bazaar Contracting Scheme.

The innovation pathways, co-designed by local stakeholders involved in the ARSINOE Living Labs, identify a portfolio of key innovations (technological, social and institutional) in various sectors (i.e. water and risk management, agriculture, tourism, urban planning, etc....) to be implemented over the next 25 years to ensure European regions are fully adapted and resilient to future climate conditions by 2050. It aims at guiding policy makers in terms of short- and long-term investment and decision making.

Following an introductory part (part 1 of the deliverable), part 2 presents the methodological steps followed in each case study to co-develop climate change adaptation and resilience innovation pathways for European regions; Part 3 showcases the

innovation pathway for each case study including the CS's problem statement and the future vision. It concludes with a synthesis on the key fields of intervention for strategic climate change adaptation pathways, barriers and enablers to implement case studies' innovation pathways, and generic recommendations for implementing effective adaptation strategies; Part 4 provides an analysis of the innovations needed for climate adaptation and mitigation as identified in ARSINOE innovation pathways, per field (water management; community engagement and education; environment and biodiversity; soil management and agriculture; energy; climate change risk management; fishery; tourism; governance and planning; urban greening) and per type of innovation (technological and social). This chapter also highlights the innovation gaps: where further research and development are required to fulfill the needs of ARSINOE European regions.

2.0 Methodology

2.1 Theoretical Background: The Systems Innovation Approach

As already presented in D2.1 and D6.5, System Innovation Approach (SIA – figure 1) is a methodological framework which enables systemic change based on the co-identification of an interconnected set of innovations, where each influences the other; with innovation both in the parts of the system and in the ways in which they interconnect (Mulgan and Leadbeater, 2013). SIA is rooted in system thinking (Meadows, 2008), and its implementation within the context of the research draws on transition management methodology (Roorda et al. 2014; Loorbach, 2007) in order to deal with persistent problems and facilitate sustainability transition. The emphasis is on the functions of the cross-sectoral system “as a whole” and on the variety of actors that are part of the system, instead of just focusing on specific functions or individual/sectoral benefits. It is based on a highly participatory process where stakeholders are actively engaged in Living Labs setting, resulting in the co-identification of a combination of actions to drive the desired transition in a form of a portfolio of connected projects across technologies, governance, finance, social innovations. In this context Living Labs act as open

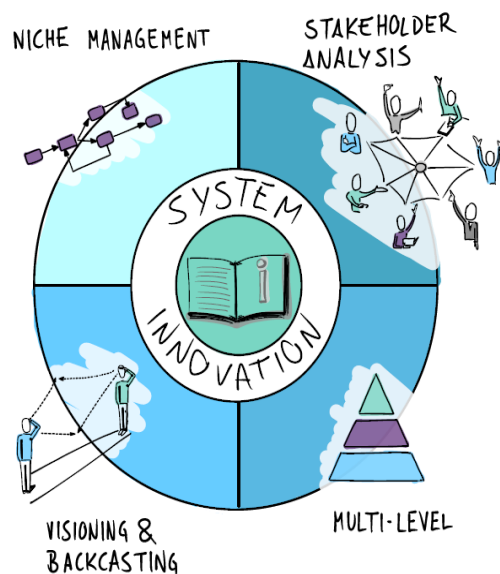


Figure 1: SIA approach

innovation spaces which foster co-creation with users and the end-result is expected to better solve stakeholder needs.

ARSINOE Living Labs are structured around 3 key workshops (Table 1) in each case study: to effectively tackle the climate change challenges identified in workshop 1 and reach the vision co-designed in workshop 2, stakeholders will co-develop innovation pathways (workshop 3)

Further details on the implementation approach followed within the ARSINOE can be found in Deliverable 6.5 (La Jeunesse et al., 2023)

Table 1: Main stage of the SIA

Stage	purpose	ARSINOE implementation phase
1. Defining the scope	Systems boundaries (spatial, temporal or conceptual), setting focus/objectives	Workshop 1 (WS1)
2.Mapping	Mapping of the system including stakeholders, issues, and challenges	Workshop 1
3. Problem Definition	Isolation and challenge statement validation	Workshop 2 (WS2)
4.Envisioning	Outlining the desired future state/goal	Workshop 2
5.Backcasting	Identification of intermediary milestones and innovations working backwards from the Vision	Workshop 3 (WS3)

6. Building

Elaboration of the Innovation pathways and identification of supporting actions

Workshop 3

WP2 provided guidelines, trainings and continuous support (regular meetings with case study leaders) throughout the whole process. Prior to each workshop a training (face to face and/or online) was delivered by the WP2 team along specific guidelines detailing how to conduct the workshop. Workshop guidelines can be found in appendix 2. Pre and post workshop meetings took place to support workshop preparation, debrief and processing of the workshop outputs.

2.2 Combining the System Innovation Approach and the Climate Innovation Windows

The SIA addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system as a whole and on the variety of actors. The Climate Innovation Window (CIW) is the EU reference innovations marketplace for climate adaptation technologies. ARSINOE shapes the pathways to resilience by bringing together SIA and CIW, to build an ecosystem for climate change adaptation solutions (Figure 2). Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing CIW innovation, or solution proposed by new providers (or a combination) according to their needs. This methodology is applicable to any region dealing with complex, multi-facet challenges, its building blocks are transferable and re-usable; they can be re-adapted and updated. In this way, the user (region) gets an innovation portfolio including already tested and validated innovative solutions (expanding the market for CIW); new technology providers with solutions tested within a specific ARSINOE region get the opportunity to be validated and become CIW members, while the society (citizens, stakeholders) benefits as a whole.

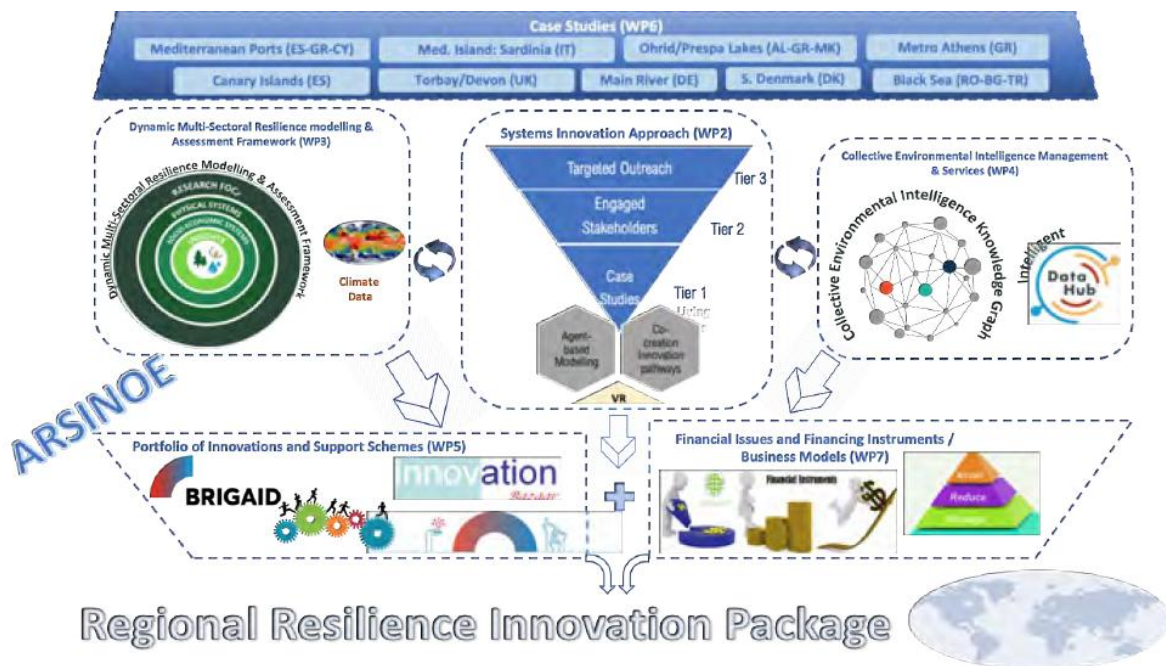


Figure 2: ARSINOE overarching methodological framework

ARSINOE applies a three-tier, approach: (a) using SIA it integrates participatory approach with multi-faceted technological, digital, business, social and environmental aspects for the development of innovation pathways for climate adaptation and resilience in the 9 ARSINOE regions; (b) it links with the CIW by matching end-users/regions with innovators who can provide solutions answering the needs identified within the stakeholder engagement process (SIA) (c) it fosters ecosystem sustainability and growth with cross-fertilization and replication across regions and scales, at European level and beyond, using specific business models, exploitation and outreach actions.

The ARSINOE approach is showcased in nine widely varied demonstrators, as a proof-of-concept with regards to its applicability, replicability, potential and efficacy. (ARSINOE D2.1)

2.3 ARSINOE innovation pathways development: a co-creation approach

Innovation Pathways refer to a trajectory of change that led from the present state of the system to the desired future state where chronological milestones are underpinned by concrete actions and associated innovations.

Figure 3 below illustrates the building blocks of the innovation pathway (IP) co-design process detailed in the following sub-chapters.

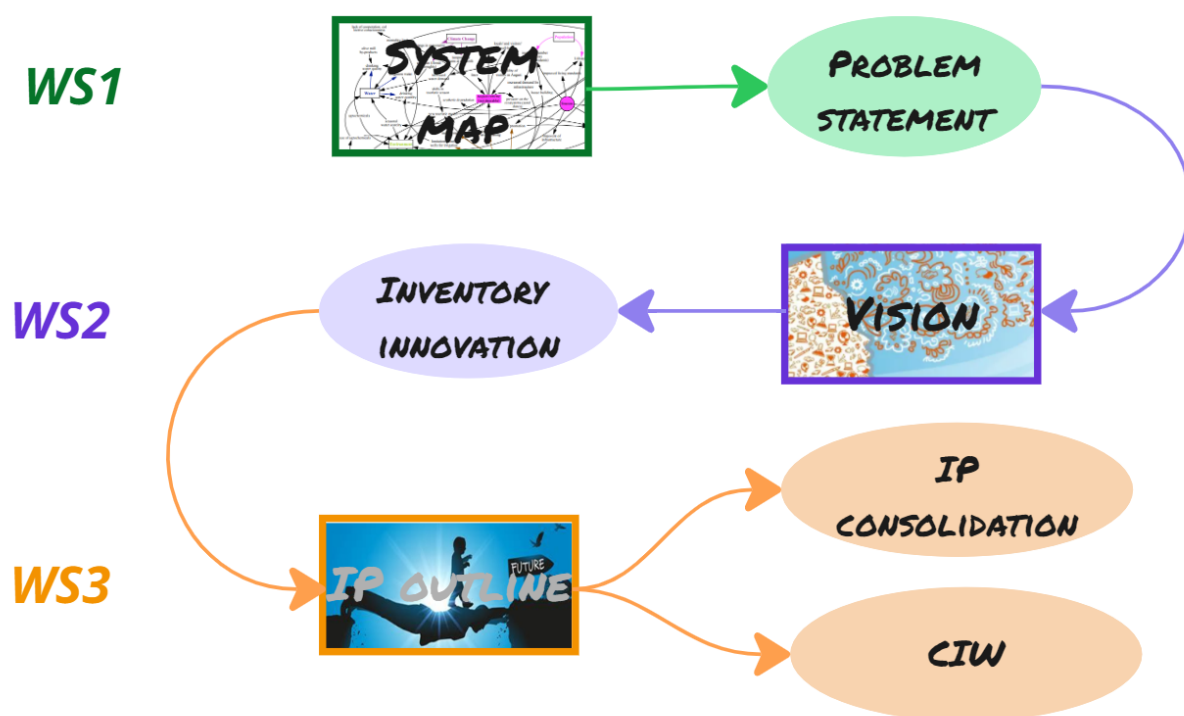


Figure 3: Methodological chart flow for the co-design of the innovation pathways – *Square* = activity conducted with stakeholders in a participatory workshop – *Circle*: activity conducted by the research team in between workshops (can include the participation of stakeholders) – IP= Innovation Pathways - CIW = Climate Innovation Windows

2.3.1 A stakeholder-led process

The SIA has been implemented using Living Labs (LLs). LL are a participatory research tool often used in planning, product design and innovation which brings together a collective of key stakeholders **to explore a focal issue**. LLs act as **open innovation spaces which foster co-creation** with users; the result is expected to better address stakeholder needs. They bring together a core group of stakeholders from public and private sectors, academia and civil society, representing key sectors impacting or impacted by the challenge addressed within the LL or having the capacity to change the system towards resilience and sustainability. The ARSINOE LL are composed of approximately **12-15 stakeholders**, engaged in a series of participatory workshops (Table 1) to exchange system knowledge, co-develop a shared sustainable vision, and co-design pathways able to support the transition towards sustainability and climate resilience. This systemic co-creation approach integrates research and innovation processes in real life communities and settings, building on the stakeholders' experience to work through a cycle of observation, reflection, and innovation.

Stakeholders were identified and selected following a system mapping analysis using a influence/interest matrix (Figure 4) where stakeholders are categorized based on their influence in the system and interest in joining the research-led effort to tackle the focused challenge. The results of the stakeholder mapping for each ARSINOE case study can be found in ARSINOE Deliverable 2.1. Such approach allows for the identification of stakeholders to whom the work is most relevant and who are most likely to be engaged in the research process. While it is advantageous to utilize the LLs as an opportunity to engage influential decision-makers, the examination of 'Interest' also allows for the identification of those stakeholders who will invest time and effort into supporting the research process (Brugha and Varvasovszky, 2000; Mendelow, 1981).

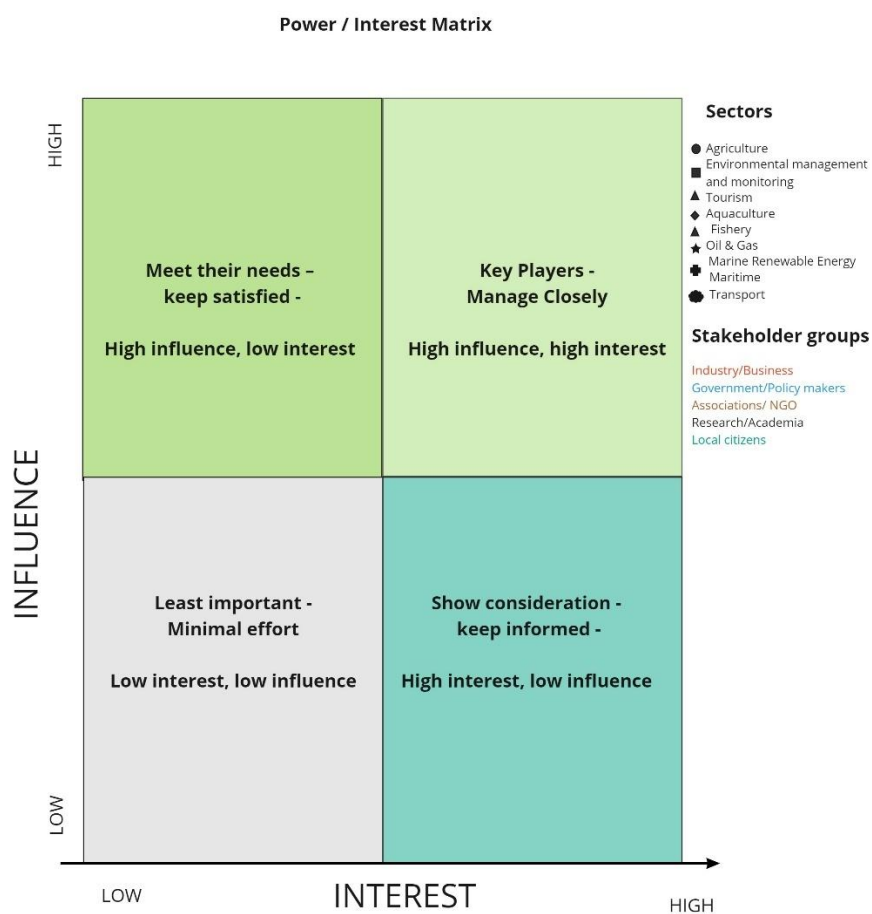


Figure 4: Stakeholder mapping matrix

LL were implemented in the 9 ARSINOE case studies, each of them focusing on a specific climate change challenge (Table 2).

Table 2: Athens case studies (adapted from ARSINOE Del. 2.1)

ARSINOE Case study	Local sub-groups	Lab focus	Innovation pathways
CS1 - Athens	None	Mitigating urban heat through nature-based solutions	One Innovation pathways for the municipality of Athens
CS2 – Mediterranean Ports (Three local living labs plus one International Working Group for all ports.)	Valencia	Impact of climate change on ports infrastructures and operations.	One common pathway developed for all three ports
	Cyprus		

	Piraeus		
CS3 – Main River	None	Water-energy-food nexus	One innovation pathway for climate adaptation and resilience in the main river basin
CS4 – Orhid/Prespa Lakes (High disparity in terms of political systems and in languages; three working groups to prepare a common living lab)	North Macedonia	water scarcity in relation to agriculture, tourism & heritage	One common pathway for the three countries to support climate adaptation and resilience of the Orhid and Prespa lakes
	Albania	water scarcity in relation to agriculture & energy	
	Greece	water scarcity in relation to agriculture & biodiversity.	
CS5 – Canary Islands	None	Water-Food nexus	One innovation pathway for climate adaptation and resilience in the Canary Islands
CS6 – Black Sea (Three local working group and one international living lab)	International	Integrated water resources management from source to sea with a focus on the environmental aspects of water management	One international pathway to support climate adaptation and resilience of the South-West Black Sea region. One pathway per country to tackle the local issues regarding climate adaptation and resilience.
	Bulgaria (Ropotami reserve)	Fresh water pollution and water scarcity	
	Romania (Danube region)	Fresh water pollution and water scarcity in the Delta	
	Turkey (Bosphorus region)	Socioeconomic changes in the sea of Marmara and southwest black sea	
CS7 – Southern Denmark	None	Emergency preparedness plan in flooding extremes	One innovation pathway for climate adaptation and resilience in the coastal municipalities of Southern Denmark
CS8 – Torbay & Devon county	None	Cascading effects on infrastructures during flooding	One innovation pathway for climate adaptation and resilience in the Torbay and Devon county
CS9 - Sardinia	None	Transforming the food production system based on durum wheat	One innovation pathway for climate adaptation and resilience in Sardinia

2.3.2 STEP 1: Identifying main issues and challenges of the case study

Within the first round of workshops, stakeholders were engaged in an open discussion, aimed at identifying the main issues, opportunities, obstacles and solutions in the context of climate change impacts (present and future) in their region by co-creating a mental map (see WS1 guideline in Appendix 1). The mental mapping refers to the graphical representation of the issues brought forward by the workshop participants, linking the elements mentioned (see example in Figure 5). Causality between key variables is an important aspect of the mental maps (sometimes referred to as ‘mind maps’). Through this cognitive exercise, different representations of the system based on stakeholder background, experiences, knowledge, and perceptions of the environment, were heard, discussed and integrated to build a comprehensive graphical representation (a map) of the system the Living Lab focuses on. The result is a common understanding of the different elements of the system and key interactions across sectors and ecosystems where main issues and challenges are highlighted.

Figure 5: Example of a mental map developed in CS1

Deliverable 6.5 includes detailed information on the mental map developed in each case study.

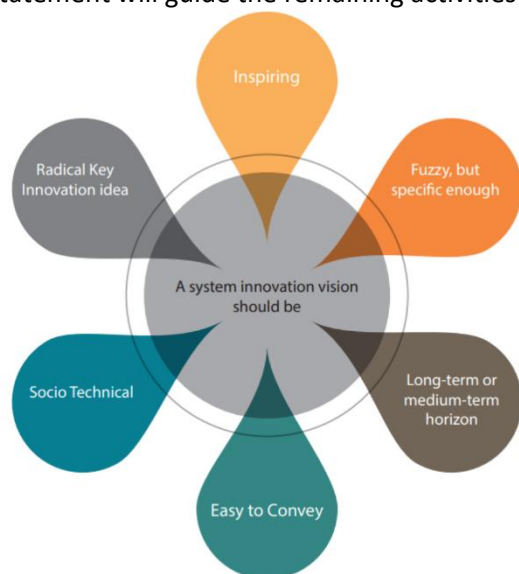
2.3.3 STEP 2: Desired state to be achieved by the innovation pathways

Step two (in WS2) built upon the outputs of workshop 1 where main sustainability challenges and needs for climate change adaptation were isolated, acknowledged and understood by all participants across sectors and stakeholder groups. Following workshop 1, a thorough analysis of the mental map co-developed with stakeholders enabled the formulation of a **problem statement** by the research team. The problem statement often takes the form of a question and makes explicit the specific challenge(s) the LL will focus on within the frame of climate adaptation and resilience. For example, a problem

statement could be:

“How do we ensure efficient water management and local food security while reducing pollution and maintaining local ecosystem health?”

The problem statement was presented to the stakeholder in WS2, with time to comment and react on the proposed formulation and proceed with the validation of the final statement. The problem statement will guide the remaining activities of the LL.



Once Living Lab participants agreed on the problem to be solved during the second round of LL participatory workshops, stakeholders were asked to develop a **common vision** describing a desirable sustainable future (how they would like their region look like in 2050') where the problem at stake would have been effectively tackled (see WS2 guideline in Appendix 1).

The scope and main goals of the innovation pathways are then defined by engaging participants in a visioning exercise (De Vicente Lopez et Matti, 2016). The purpose here was to build a shared positive vision of the future (horizon 2050) across sectors and stakeholder groups (academia, business, policy makers, civil society) describing a horizon where the region has succeeded in adapting to climate change impacts.

Figure 6: Characteristics of a future vision (source: De Vicente Lopez and Matti, 2016)

The Future Narrative, a qualitative storyline, should convey the potential to inspire participants, as well as mobilize individuals outside the process (Roorda et. al., 2012). It should explore the state of key drivers in the context of the envisioned future, building a storyline around them (Volkery et. al., 2008; Foran et al., 2013).

To conduct this exercise, stakeholders were split in smaller groups (4-5 participants) where stakeholders representing different sectors and groups were asked to co-design a common vision for the future of their case study, based on climate change adaptation measures. Participants were encouraged to consider the long-term systemic transitions, and not to be confined by the status quo or the way things are at present. Visionary images ought to be conceptually rich enough to be meaningful, credible and feasible enough to be useful (De Vicente Lopez and Matti, 2016), this is not a predictive exercise but a preferable scenario as a means to provide a sense of direction, a goal to be achieved by the innovation pathways, as well as the ambitions to get there (Figure 7).

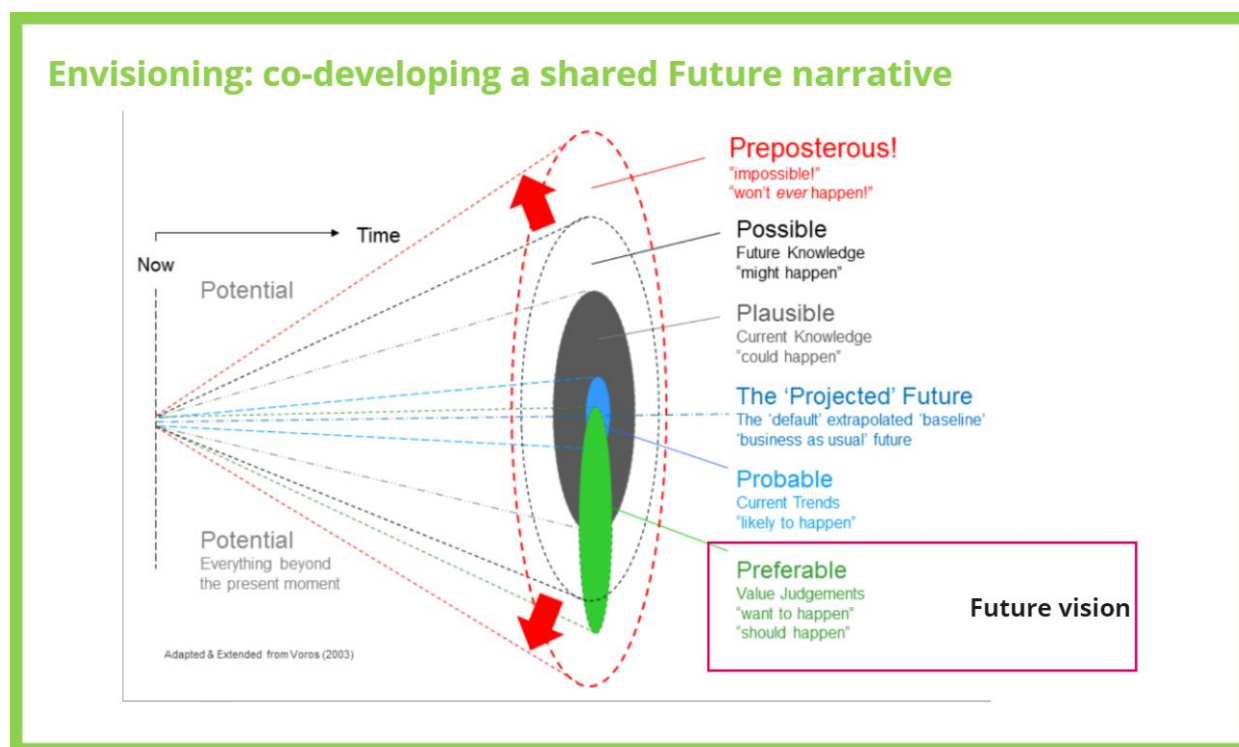


Figure 7: envisioning a sustainable future: a preferable type of scenario

To guide the discussion and help stakeholders to envision a sustainable future, the research team of each Living Lab identified, prior to workshop 2, a series of “guiding principles” (words or short phrases) to serve as inspirational building blocks with which to develop their Future Narrative. These Guiding Principles were extracted from case study’s relevant Sustainable Development Goals targets to anchor the innovation pathways in the international sustainability agenda.

Example of “guiding principles”

SDG Target 2.4: Ensure **sustainable food production systems** and implement **resilient agricultural practices** that increase productivity and production, that help **maintain ecosystems**, that **strengthen capacity for adaptation** to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

SDG Target 6.4: **Increase water-use efficiency** across all sectors and ensure **sustainable withdrawals** and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

Extracted Guiding Principles: **sustainable food production systems / resilient agricultural practices / maintain ecosystems / strengthen capacity for adaptation / Increase water-use efficiency / sustainable withdrawals**

The visions developed in the sub-groups were then merged into one single vision acknowledged and validated by all the stakeholders engaged in the Living Lab either within workshop 2 (if the time allowed it) or during the next round of workshops.

2.3.4 STEP 3: Co-design of a portfolio of innovations

2.3.4.1 Pre-identification of potential innovations

The innovation pathway serves as a roadmap to the desired future state of a case study. Thus, it is necessary to analyse the vision to identify the different sectors and fields that require the implementation of innovations.

Once the main sectors / field that necessitate intervention had been identified, the case study leaders were asked to make an inventory of potential existing innovations that could support the achievement of the vision. A template for identifying innovation was developed by WP2 lead team (see Appendix 2). Various sources of information were mobilised:

- Innovation(s) raised during the discussions with local stakeholders during the previous workshop
- Existing innovations references in online database (e.g. the Climate Innovation Window¹ from BRIGAD Connect (WP5 leader); Climate adapt²; the MEMA Accelerator³)

The case study leaders were also asked to directly involve their Living Lab members in the completion of the list of potential innovations prior to the 3rd round of the workshop (see full list of CSs innovations in ARSINOE Deliverable 6.6).

2.3.4.2 Co-Identification of Milestones

The co-design of the innovation pathways with local stakeholders started during the 3rd round of the living lab workshops with a ‘backcasting’ exercise to co-identify essential Milestones (MS) - intermediary objectives to be achieved between the present and the 2050 vision (see workshop 3 guideline Appendix 1). Unlike conventional means of planning for the future such as ‘Forecasting’, **Backcasting** guides the development process from an envisioned future; retracing required steps and actions back to the present day (Figure 8). As such, Backcasting is a method to collectively create pathways to an envisioned future, taking the future as starting point and going step-by-step back in time. The choice to start from the envisioned future is essential to enable the formulation of future-oriented strategies that go beyond “business as usual” solutions and are not constrained by vested interests and stakes.

¹ <https://www.climateinnovationwindow.eu/>

² <https://climate-adapt.eea.europa.eu/en/about>

³ <http://maritime-accelerator.org/?cmid=927e257e-e598-4318-b3a9-0587732b5782>

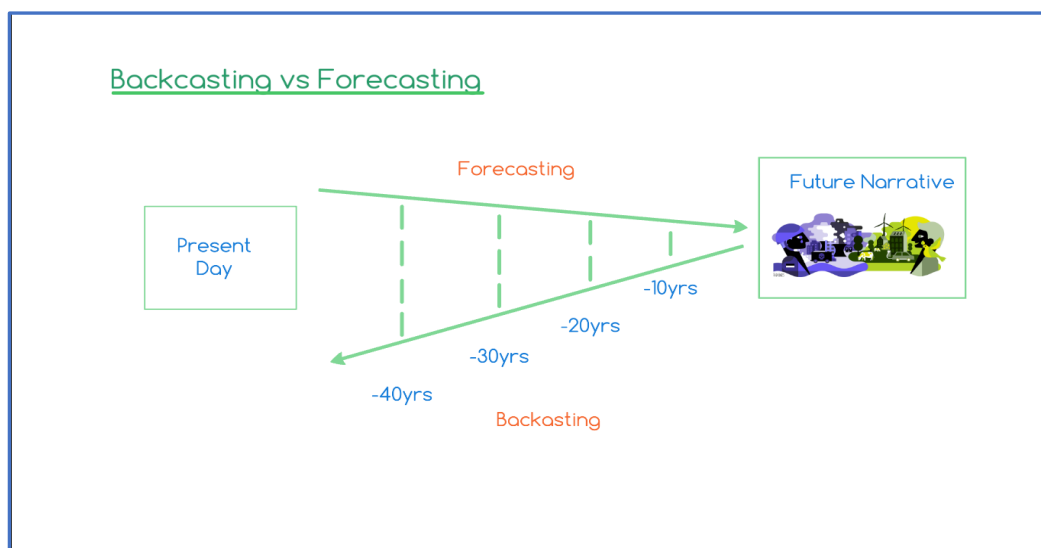
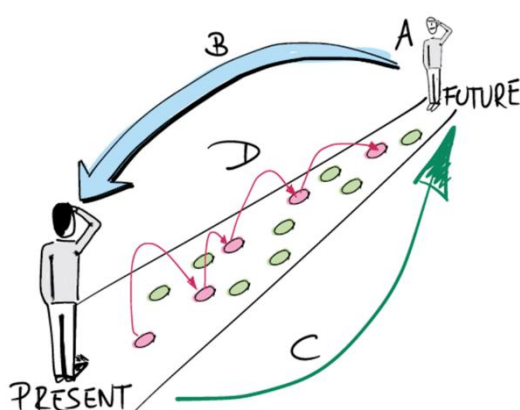


Figure 8: Backcasting and forecasting

The use of backcasting is a central method of SIA and sits within a wider Transition Management (TM) methodology. It is a participatory methodology that is used primarily in the field of sustainability and governance in order to deal with persistent problems to



facilitate sustainable change (van der Brugge and Rotmans, 2007). TM aims at influencing the direction and pace of societal change dynamics in the context of contributing to sustainability by creating space for new ways of organizing, doing and thinking, eventually bringing about a desired transition (Loorbach, 2007). These transitions, refer to processes of change that transform the way societal systems meet societal needs; they are fundamental shifts in structures, mind-sets and practices, involving stakeholders from many different domains and scale-levels (Roorda and Akinsete, 2013). A core strength of the TM methodology is that it allows for

the extensive consideration of social transformations within societal transitions, as opposed to the transformative impact of technology which tends to be overestimated by traditional methods particularly associated with forecasting. Vanderbilt T (2015) highlights the fact that 1960's visions of the 'future office space' was able to capture technological developments such as fax machines, however one glaring omission remained – the absence of women. Thus 'social progress', a historical weakness of futurism as a discipline, is addressed within the TM process (Tetlock, 2005; Samuel, 2009). Furthermore, the flexibility of the process makes it applicable across various sectors such as the transport, energy supply, healthcare, agricultural, or water management (van der Brugge and Rotmans, 2007; de Haan et. al., 2016).

Stakeholders were asked to work backwards in identifying key milestones under each sector/field (long-, mid- and short-term actions) that would need to have taken place to achieve the sustainable future described in the vision. To facilitate that exercise, the workshop facilitators were encouraged to use the 'Future Radar' tool and sticky notes (Figure 10), to start moving backwards towards the present time and identify what changes should have happened to reach the desired future. Changes could be: new knowledge, financial arrangements, new technologies, new political or economic frameworks, significant changes in actor configuration, cultural and formal conventions, changes in routines, rules,

culture, infrastructure, etc.

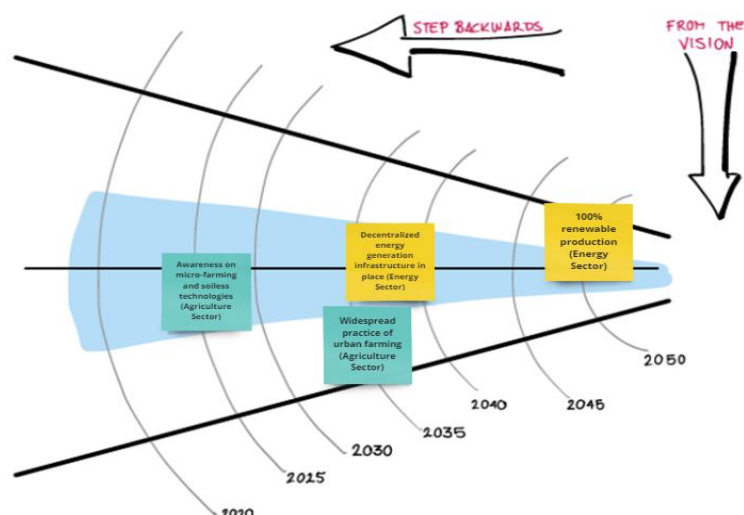


Figure 9: Futures Radar (Source: De Vicente López & Matti, 2016)

2.3.4.3 Outline Innovation pathways

Once the necessary MS have been identified and agreed upon, the final step is to identify the necessary innovations (technological, social, political...) to support each MS, starting from the list of innovations created prior to the workshops. One innovation can support multiple MS as well as multiple innovations might be needed to reach one MS. Additional innovations, not pre-identified might emerge during the workshop discussion.

Due to time constraint, not every Living Lab managed to complete the outline innovation pathways within the workshop. Therefore, in many cases, stakeholders were further engaged post-workshop to pursue the co-design process of the innovation pathways. Depending on the capacity of Living Lab leaders and availability of their stakeholders, different means of engagement were applied:

- A template (appendix 2) to be completed online
- Online meeting with some or all stakeholders involved in the Living Labs
- Dedicated time as part of an on-site ARSINOE event

2.3.5 STEP 4: Identify barriers and enablers

Finally, barriers that could obstruct and/or hinder the implementation of the innovation pathways but also enabling conditions that would support it (e.g. existence of human, financial, political, technological resources: Human, Financial, Political, and Technological but also the decline of undesirable activities or behaviors) have to be identified.

For this exercise, the PESTLE framework was used (see template in appendix 3). The PESTLE framework is a strategic analytical tool used to identify and analyze the

key external factors that can impact an organization or a project Christodoulou, A., & Cullinane, K. (2019). PESTLE stands for Political, Economic, Social, Technological, Legal, and Environmental factors (Figure 10).

P	Political	Political factors are government, trade and tax policies, general political issues, changes in leadership, regulation, and political trends.	
E	Economic	Economic factors may include inflation, interest rates, exchange rates, economic growth and unemployment levels.	
S	Social	Social factors are cultural trends and patterns in society. They may include lifestyle trends, age distribution, and consumer behavior.	
T	Technological	Technological factors may include technological advancements and developments, innovation and scientific breakthroughs.	
E	Environmental	Environmental factors may include climate change, environmental regulations, waste management policies and consumer environmental awareness.	
L	Legal	Legal factors may include labor and consumer laws, market and import/export regulations, health and safety policies and guidelines	

Figure 10: Six areas of the Pestle framework (source: <https://pestleanalysis.com/what-is-pestle-analysis/>)

By examining these six categories, organizations can gain a comprehensive understanding of the macro-environmental elements that could influence (positively or negatively) their operations and strategic decisions such as the development and implementation of an innovative solution. Political factors include government policies, stability, and regulations; Economic factors encompass economic growth, inflation, and exchange rates; Social factors involve demographic trends, cultural norms, and consumer behavior; Technological factors cover advancements, innovation, and technological infrastructure; Legal factors pertain to laws, regulations, and legal frameworks; and Environmental factors focus on ecological and environmental aspects like climate change and sustainability. Each of these factors implies certain changes, risks and opportunities.

The PESTLE framework well complements the SIA approach as a practical and easy tool to conduct a comprehensive mapping of barriers and enablers through a thematic factor analysis.

ARSINOE case study lead team conducted the analysis, based on their expertise and awareness of the local context, on the knowledge harnessed within the Living Labs. When necessary, case study lead teams further interacted with local stakeholders through focus group discussion, one and one meeting, or online questionnaires to complete, review and validate the analysis.

3.0 Case studies innovation pathways

This chapter presents the outcomes of the ARSINOE SIA, presenting the 1) problem statement co-defined, the vision co-developed, and the innovation pathway co-designed by local stakeholders in each Living Lab case study.

3.1 Case study 1: Athens

The mean annual temperature of Athens has increased steadily since 1970, by 1.3 °C between 1970 and 2011, while the mean summer temperature increases even more sharply, by almost 1 °C per decade. The urban heat island becomes increasingly intensive (up to 8 °C has been recorded), along with the heat waves which are more frequent, intense, and prolonged. The recent climatic projections foresee further increase of the maximum summer temperature by 2 °C for the period 2031 to 2050. The climate change impact, combined with the anthropogenic activities in a densely populated area, suffering from lack of sufficient urban green areas, also affected by the wildfires of its peri-urban forests over the last years, result in an alarming situation for Athens, with direct environmental and socio-economic impacts. The need for action to protect the most vulnerable part of the population during heat waves, such as the elderly, and the children, with immediate response actions, as well as to plan and improve the city's preparedness and adaptation capacity are acknowledged priorities of the city's administration. (ARSINOE D6.5)

Therefor the innovation pathway developed within the Athens case study aimed at creating a portfolio of innovations enabling the city of Athens to adapt and be resilient to extreme heat by 2050.

3.1.1 Problem statement

Athens is becoming increasingly hot with significant impacts on health, society and the local economy. What is our vision for dealing together with this imminent and invisible threat?

3.1.2 Future vision

Athens is a green and cool city! It has established a strategic management of urban nature, integrating green and blue infrastructure to enhance the city's biodiversity and resilience to extreme heat. The management of urban nature ranks high in the city's priorities, implemented with commitment, continuity, and vision. Athens has a revitalized and vibrant city center, with sustainable mobility and no air or noise pollution. Urban green areas, green and blue corridors are developed and integrated into the city's cultural routes. Athens actively promotes Green Architecture to cool the city: it is abundant with urban gardens, planted rooms, green roofs, vertical gardens and green buildings. Innovative solutions are fully explored, learning from international experience and mobilizing green funding. Athens is an example of inclusion and equity, its citizens are active and well-informed, and there is social welfare for all, especially the vulnerable; the city knows where they are and responds swiftly to protect them.

3.1.3 Innovation pathway

To become resilient to extreme heat, innovations are needed in key sectors within the city, namely water, energy, urban development, risk management as well as in terms of social awareness about the potential impacts of heat on health. Stakeholders essentially targeted technological innovations, focusing on the current decade (present to 2030). Beyond

2030, there will be a need for additional innovations, not yet identified, to reach the targets set by 2040 and 2050, particularly in the energy sector.

No intermediary milestones were identified for “risk management” and social awareness beyond 2030. Three innovations selected through the Open Tender for Innovations will be tested within the framework of the ARSINOE project: Kausal Platform”, “Singular Ribbon”, and “Tiny Forest” (highlighted in green in the Innovation pathway

sectors	innovations							MS (Milestone) 2030
Water	Rain Gardens	RESILIO adaptive rooftops (Roofs for water harvesting)		RichWater	LooPi®: vertical ecosystem® or vertECO®			30 % of irrigation water covered by alternative water resources (other than water from the public mains)
	SolarDew							50 % of public spaces with potable water supply
	Really cooling water bodies in cities		Water art – fountain – cooling measure		The Refreshing Waters (Cooling Station 2.0)			Increase blue infrastructure to cool the city; at least 10 new items, e.g. fountains created
Energy	LeafSkin® Vertical gardens	Colorful low-emissivity paints for space heating and cooling energy savings						increase energy efficiency in the building sector by 10%
	Establishment of Energy Poverty Office at Municipal level							Reduce energy poverty by 20%
Urban Greening	Pocket parks	LeafSkin®: Vertical gardens (CIW)		Tiny Forest in Athens: forests are planted, maintained and monitored with the help of local volunteers, businesses and schools	Green Corridors	Citizens' Accessibility to Green Urban Areas (15-minutes city concept)**		Meet the 3–30–300 Rule for Greener, Healthier and more Resilient cities by 2030
	Urban Biodiversity assessment framework	A Square Meter for Butterflies: enhance green roofs in order to increase their value for biodiversity	SingularRibbon: vegetal awnings, that is, tensioned sails covered with vegetation			Live Tree Check: smart application to Check up on trees, look after them and create your own tree collection		
Heat Risk management	Citizens' Accessibility to Green Urban Areas (15-minutes city concept)**	QoAir: A blockchain-based system for heatwave management in urban areas	Modeling future population's vulnerability to heat waves	AST2.0 (Climate Resilient Cities Toolbox); Climate Adapt Platform		WED: Environmental Analytics for All from Space		Built up the knowledge base relevant to extreme heat
	UHI and Heat-related parameters along the Hadrian Aqueduct: under ARSINOE			Thermal Assessment Tool (REACH OUT, H2020)	Extreme Heat Resilience Alliance	Bitagreen: Tool to access data, simulate, identify strategy for CC mitigation	CityClimateX A decision-making tool for public and private space planning and redevelopment in terms of thermal comfort, urban heat islands and air quality	Heat Stress Tool for Athens
Awareness / Social (Health)	Helpline & Early Warning Messaging System		I-REACT (Improving Resilience to Emergencies through Advanced Cyber Technologies)		EXTREMA Global: smart app to inform about solutions to tackle extreme urban heat			Vulnerable groups protection ensured
	Municipality's website dedicated to extreme heat				RESpring EDUPark:			Increase awareness re extreme heat

Figure 11: CS1 - Athens - Innovation Pathway- Present-2030 * **Green innovations**: to be implemented within the frame of ARSINOE (WP5-CIW)

sectors	innovations	MS 2040	innovations	MS 2050
Water	Continue the exploitation of water from alternative sources (other than the public mains)	50% of irrigation water covered by alternative water resources (other than water from the public mains)		
		100 % of public spaces with potable water supply		
		Increase blue infrastructure to cool the city; at least 20 new items, e.g. fountains created. At least one river uncovered by 2040		
Energy	Thermal Assessment Tool (REACH OUT, H2020)	increase energy efficiency in the building sector by 40%	INNOVATION GAP	increase energy efficiency in the building sector by 80%
	INNOVATION GAP	Reduce energy poverty by 50%	INNOVATION GAP	Reduce energy poverty by 80%
Urban Greening	continue implementation of previous innovations	Green space/inhabitant > 5 m ²	continue implementation of previous innovations	Green space/inhabitant > 10 m ²
Heat Risk management				
Awareness / Social (Health)				

Figure 12: CS1 - Athens - Innovation Pathway- 2030 -2050

*Red color: innovation gap



3.1.4 Barriers and Enablers

Water Sector: The introduction and adoption of innovative solutions present significant enablers and barriers within the Case Study #1 for the city of Athens. Politically, the topic is high in the agenda, there is available budget through national or European initiatives, however given the high urbanization during the 1960 & 1970 changing the urban development practices and patterns required time, engagement, and sensitization of stakeholders as well as significant financial resources to produce significant impact and results. The society is ready to welcome such course, as well as the technological level available. However, changes are needed at legal level to be able to adopt such new ways to mitigate the extreme climate conditions within the city.

Energy Sector: With regards to the energy sector, a key point identified is the “resistance to change”, the established status quo seems quite difficult to be surpassed, while also changes in the legislative framework are also necessary. Moreover, despite the political agenda being in favour of new agreements on climate and energy issues, a lot of effort is still required to be adopted at large scale. Technologically, access to new technologies is there, but costly budget and wide knowledge is still missing from the puzzle to be able to produce tangible results, despite the positive environmental impact presented.

Urban Greening: Potentially one of the most mature themes of all presented herewith, the conditions at all levels seem ripe and ready to incorporate new solutions, change practices and implement greening practices on an urban scale. There is a significant swift from people and their political leaders towards urban greening. Additionally economic accelerators, availability of funds, and technological enablers combine to drive significant change and positive results at urban and peri-urban scale.

Heat Risk Management: The theme of heat risk management has lately begun to be recognised as a priority theme by citizens as well as on a political level. Significant barriers, including the need for funding, technological infrastructure, and legislative framework must be taken into consideration. However, the latest climate conditions at the urban level (extreme heat waves, prolonged high temperatures throughout the day and night), lead to a more prone acceptance at political and social level.

Awareness / Social (Health): Another theme that has increased as a priority at the city level: despite the existing framework, established practices, and the favouritism by the political stakeholders, some social resistance persists and needs to be further addressed for more meaningful outcomes. Economically, a lack of resources is partially mitigated through funding programmes and existing mechanisms by organisations, however increased actions are necessary due to the critical importance of this issue. Finally, technological developments offer significant opportunities at every level for improvements in this theme and need to be further utilized.

Details of CS1 the barriers and enablers identified for each sector / theme of the CS1 innovation pathways can be found in appendix 7.

3.2 Case study 2: Mediterranean ports

CS2 includes 3 Mediterranean seaports, namely the seaports of Piraeus (Greece), Limassol (Cyprus), and Valencia (Spain). The Piraeus seaport is one of the leading European seaports (second maritime cluster globally) in terms of coastal shipping, cruise and containerized cargo. The Port is involved in 14 EU-funded projects related to its intention and target to become a “green” and financially independent seaport. The seaport of Valencia is Spain’s leading Mediterranean port in terms of commercial traffic,

and it is also the maritime gateway for various commercial activities to and from the entire Iberian Peninsula. The seaport of Limassol handles 90% of the export and import volume of Cyprus and a lively Cyprus passenger traffic, including cruise ships and ferry connections with Greece, Israel, Egypt, and Lebanon.

CS2 focuses on climate change impacts on ports' operations and infrastructures. The innovation pathway developed aimed at ports adaptation and resilience to future extreme weather conditions. In particular, CS2 seeks to (i) conduct a vulnerability assessment for seaports since it is a prerequisite for enhancing resilience and developing adaptation actions; (ii) identify adaptation priority actions and (iii) design tailored adaptation pathways for the seaports considered. Ultimately, the conclusions will be translated into transformative interventions to enhance the resilience of seaports. The purpose of this case study is to incorporate existing mechanisms and tools developed by the port authorities while actively engaging stakeholders and incorporating financial instruments throughout the process.

3.2.1 Problem statement

Seaports play a crucial role in the worldwide economy, enabling global trade while fostering development, employment and connectivity. However, they are vulnerable to a range of factors due to their location, infrastructure condition, operational dependencies and climate change. Since the impacts of climate change become eminent (e.g., heatwaves, increased wind/waves, extreme events, storm surge), both seaports' infrastructure and operations, as well as the adjacent communities are further jeopardized (seaport closure, seaport congestion, delays, energy efficiency issues, pollution, increase of accidents, damage in goods etc.).

3.2.2 Future vision

"By 2050, Mediterranean Ports will be leaders in sustainable and resilient port operations and infrastructure, setting an example for the Mediterranean region and beyond. These ports will prioritize attracting investments and create growth, invest in smart trading solutions, end-to-end logistics, efficient port management, and sustainable technologies to maximize resilience while remaining competitive and profitable. Mediterranean ports will be Smart, Green, Blue, climate neutral and climate-resilient, with increased efficiency. They will be hubs for business ecosystems, innovation, culture and education, serving as models for the development of green ports and fostering a culture of upskilling and re-skilling to adapt to changing technological and environmental challenges. These ports will prioritize risk management strategies that enable them to adapt to the effects of climate change and remain operational during adverse weather conditions. They will take the appropriate measures for securing safety and improving the port-city interaction and ensuring the security of the supply chain and the resilience of the entire value chain, including nearby municipalities and communities. By collaborating with stakeholders and partners, Mediterranean ports will achieve operational excellence, serving as examples of sustainability and resilience to other ports around the world."

3.2.3 Innovation pathways

Workshops took place in each of the port for the first and second round of Living Lab workshops and were mainly focused on identifying vulnerabilities. The third workshop, focused on the co-design of the innovation pathway was common to all three ports. An innovation pathway applicable to all three Mediterranean ports was co-designed. The key sectors targeted were the port operations, infrastructure and logistics. The main challenge was how to reduce energy consumption and

atmospheric emissions, as well as how to cope with increased temperature and heatwaves. Stakeholders also looked at the financial and the risk management aspects, targeting technological innovations. The AE4RIA matrix developed within the framework of ARSINOE WP7 is also expected to support the ports to name the most relevant financial mechanisms for the implementation of the targeted innovations.

Three innovations were selected through the ARSINE open tender, to be tested in 3 MED ports - EmbioAirBELD in the port of Limassol, CLEVER Tool in the port of Valencia, Diorama LET-Ports in PPA (highlighted in green in the Innovation pathway).

Sectors	Innovations				MS 2030
Port Operations/ Logistics / Infrastructure	Road4Water: road harvesting technology		ALONGROUTE: Ultra-precise, AI-based marine weather forecasts for weather routing software solutions to achieve greater		1. Crucial Infrastructure and technological solutions defined
	EmbioAirBELD: detect and mitigate sources of air pollution (ARSINOE implementation)	CLEVER TOOL (NOW SYSTEMS): Climatic event registry logger applied in Valencia Port (ARSINOE implementation)	SACIP-Valencia (METEOGRID): Climate Alert and Information System for Port Infrastructures		2. 80% Logistic Chain climate Resilience in Case of extreme weather events
	No innovation necessary to reach this MS → Management planning at the port level				3. 30% Extension of Cruise Section (Pireaus)
Green Port (Environment / Emissions)	IoT CO2 cities Monitoring (Everimpact) combines satellite images and measurements, IoT sensors, and AI for accurate measurement of GHG emissions	AirNode and Libelium sensors (AirNode and Libelium Consortium):Air Quality Station The Air Quality Station to monitor key pollution parameters through Artificial Intelligence.	DIORAMA LET-Ports (WaitR) monitoring GHG emissions through remote satellite sensing and images analysis. (ARSINOE implementation)	Solumar provides new air and gas filtering solutions to directly cut all emissions and collected Black Carbon and CO2 into reusable Carbon powder	1. Reduce Emissions by 30%
Green Port (Environment / Energy)	Obrec (BReakwater for the Energy Conversion) - multifunctional device, which combines harbor protection and energy production.		Rhoé Rhoé optimization software for sustainable mobility solutions		1. Renewable Energy Production covering 50% of Port Needs
	no innovation needed per se				2. Set Targets Beyond Requirements
Finance	AE4RIA metrix Models and Metrics to measure and report sustainability performance at various scales/levels- National/Subnational/Companies)				1. Explore Funding Sources for Infrastructure / Climate Change Adaptation Plans
					2.Develop Business model for early port operations according to environmental issues/ climate change
Smart Port and Policies	Infosequa:Timely and systematic generation of actionable warnings and risk indicators fort risk-centered drought management and adaptation strategies. (ARSINOE implementation)				1. Digitalization of operations and automation of B.P.F.
	no innovation needed per se				2. Upskilling and Reskilling Programs are Initiated

Figure 13: CS2 - Innovation pathway from present to 2030 *innovations in green: implemented within ARSINOE framework (CIW)

Sectors	Innovations		MS 2040	Innovations	MS 2050
Green Port (Emissions / Emissions)	REELEASE: recycling and upcycling of marine waste.	Marine Hound: Autonomous emissions sniffer system able to detect the use of illegal non-compliant fuel	1. Reduce Emissions by 50%	Navisense: track port activities with AIS and calculate emissions and show optimisation potential.	1. Net Zero Port
			2. Marine Waste Recycling and Upcycling		
Green Port (Environment / Energy)			1. Renewable Energy Production covering 100% of Port Needs	Bufferblock: stormwater drainage and buffering in the urban area. .	1. 100% Energy Self Sufficient and Efficient
	Quantum Marineworks: optimize vessel journey for energy & cost savings***.		2. Reduce Raw Materials Use by 30%		
Finance	no innovation needed per se		1. Secure External Funding	no innovation needed per se	1. Successfully Leverage Private Capital to Fund Climate Projects
	BID2BOARD Digitalizing Marine TechnicalService.		2. Implement Business Models		
Smart Port and Policies	SenZ2: Monitoring water system infrastructures in real time		1.Strategies/ Pathways for Climate Adaptation Developed	3c for Cities: risk analysis for storm damages, .	1. Proven Working Strategies for CC Adaptation
	no innovation needed per se		2. Mandatory Implementation Penalties	no innovation needed per se	2. 100% OF Personnel trained
	no innovation needed per se		3. Align to State Plans & Change of Legislation for State Aid		
	no innovation needed per se		4. Launch Vocational Education Programmes		
	no innovation needed per se		5. Stakeholder and Communities of Practice Engaged		

Figure 14: CS2 - Innovation pathway from 2030 to 2050

3.2.4 Barriers and enablers

A significant political barrier identified is the lack of long-term political commitment, which can hinder the progress and implementation of green and blue port initiatives. High upfront costs are noted as a primary economic barrier, posing financial challenges for the initial investment required for green / blue technologies and infrastructure. The 3 MED Ports (PPA, Port of Limassol and Port of Valencia) also stated the importance of placing environmental EU regulations by the national governments that will favor systematic monitoring and reduce the GHG emissions in MED ports. On the positive side, EU funding programs, such as the CEF Energy on Mission Adaptation, offer financial assistance to support green port projects. Pricing mechanisms that incentivize green practices could also be an important enabler, however lack of initial / adequate capital for applying innovative / advanced technologies are also identified as economic barrier. A social barrier identified is the wrong perception of public awareness or miss-conception in relation to the environmental impacts of port operations. This can lead to insufficient public support towards port authorities while trying to implement green or blue initiatives. To counter this, public education campaigns promoting renewable energy and sustainability, and the benefits of applying/adopting new measures and initiatives and the importance of decreasing GHGs emissions are considered social enablers, helping to raise awareness and garner public support for green innovations. On the technological aspect, the lack of technology and the insufficient infrastructure regarding the storage of renewable energy is a

major technological barrier, limiting the efficient use and integration of renewable energy sources in seaport operations. The lack of standardized/ homogeneous data collection is another obstacle faced by the Med Ports. A significant legal barrier is the lack of clear regulations, which can create uncertainty and hinder the implementation of green initiatives. Difficulties in integrating legacy systems with new technologies and concerns about data privacy are also significant barriers. A streamlined permitting process is identified as a legal enabler, simplifying regulatory requirements and accelerating the adoption of green technologies and practices. Additionally, the outdated environmental regulations not addressing new operations and the absence of uniformity in green port criteria present another challenge for development. Research on the green port criterion is expanding. However, Med Ports find it challenging to determine their development direction due to the abundance of green port requirements. As an enabler, a streamlined permitting process, favoring the promotion of clean/alternative energy projects can facilitate in the effort for reducing GHGs emissions. Lastly, at the environmental level, the Med Ports stated that extreme weather events (e.g. heat waves) increase port emissions and air pollution (e.g. due to intense use of A/C units) and can increase GHGs concentrations (inability of diffusion due to low ABL).

Details of the barriers and enablers identified for each sector / theme of the CS2 innovation pathways can be found in appendix 7.

3.3 Case study 3: Main River

The Main River is a major European waterway, located in the heart of Europe. It is the largest eastern tributary to the Rhine River and connects the North Sea to the Black Sea via the Main-Danube canal, bridging the European water divide. The Main River basin is a densely populated and intensively used area of about 25,000 km² which is already subject to significant challenges and competitions for its water, land and energy. The effects of climate change are expected to lead to a strong increase of summer droughts and heat waves due to significantly higher temperatures and a strong decrease of summer precipitation. At the same time, the risk of winter floods increases significantly due to heavier precipitation in this season. This will have considerable consequences for almost all actors in agriculture, forestry, water and energy management. A fundamental and forward-looking revision of available resource management measures is essential for ensuring climate change resilient development of the region. CS3's Living Lab is spatially limited. It covers the section of the Main River between Schweinfurt and Würzburg as well as the surrounding region. Nevertheless, the solutions and ideas developed in it should be transferable to other regions along the Bavarian Main and in other parts of Bavaria. (ARSINOE D2.5)

CS3 focuses on the climate change impacts on the water resource (in terms of quantity and quality) in the wider context of the water-energy-food nexus.

3.3.1 Problem statement

Climate change poses major challenges in the region and is likely to exacerbate competition for water, land and energy resources. This will have considerable consequences for agriculture, forestry, water and energy management. Governance does not address challenges in holistic ways at present and might not do so in the future unless processes are revised. As such, the region is at risk of being pushed beyond its resilience thresholds and will need a new level of responsiveness to cope with climate change. A fundamental and forward-looking revision of available resource management measures is essential for ensuring climate change resilient development of the region. A revision of methods must take place, and new methods may need to be developed. Currently, most adaptation measures are sector-focused but the challenges are interconnected.

Therefore, a common strategy is urgently needed that takes the interconnectedness of sectors and challenges into account. The co-design and co-production of science-driven technical, social and cross-sectoral innovations and governance is required to build new and climate resilient development and transformation pathways. A systemic transformation of the region requires time and broad societal support, which must be considered when formulating development paths, but must not be a reason to postpone changes. While climate adaptation is being driven forward, climate protection must not be lost sight of. Interactions between the two fields of action must be taken into account and synergies exploited.

3.3.2 Future vision

In 2050 changes in land-use, water-management and cooperation between different sectors as well as societal changes occurred.

The landscape of the region covered by the living lab is characterized by a mix of urban centers and smaller towns, healthy forests, agricultural areas and areas used for energy production. Water bodies have been returned to their natural state. Forests have been preserved and converted to be more resilient to the changing climate. Game populations in forests are well-managed. Forests serve multiple purposes. They store water and provide fresh and cool air. Forests provide timber and serve as recreational spaces. Agroforestry helps protect soils and contributes to biodiversity. Sustainable agricultural practices are the norm. Crops and cultivation methods are adapted to sites and where resource-efficient agriculture is not possible, sites are transformed and used for other purposes. There is no more intensive animal husbandry. Land take and soil sealing are limited and where necessary reversed. Settlement development prioritizes the use and transformation of existing structures over developing new areas. In urban areas blue and green infrastructure compliment grey infrastructure. These changes in land-use result in a high-quality soil, limited risk of soil erosion and improved water-absorption and retention. Energy comes from renewable sources. The energy system has been decentralized: energy is produced, stored and used locally. Energy efficiency has increased.

The region benefits from a healthy water balance; the goals of the Water Framework Directive are met, and the value of water is recognized. Cascading water-use is the norm and re-use systems are installed at different levels (household, buildings, settlements). Water quality is established according to its use, allowing an efficient use of water and energy resources. Groundwater is primarily used for public water supply. Public water supply is prioritized over other purposes e.g. when establishing water rights. Water for public water supply primarily stems from local sources. Interconnections between water suppliers and long-distance water supply contribute to security of supply.

Water is reused, treated locally, and used efficiently. The energy for water treatment comes from renewable sources, whereas rainwater is absorbed and retained by soil or specific systems for water retention. There is a separate sewerage system so that the rainwater that reaches the sewer system is not mixed with wastewater and can be stored or returned to the natural water cycle. The state of the water balance is transparent, and all water-users are aware of the challenges and possible measures for different situations. Different actors are aware of their impact on natural resources and their dependence on them and of their impact on other sectors in the region. They act accordingly: They use resources efficiently and consider the long-term impact of their actions and communicate with those affected by their actions. Sustainability and resource-efficiency are well understood and used as guiding principles. Actors who implement measures that benefit climate resilience, for example by contributing to the water balance, water quality, biodiversity or soil quality, are rewarded and supported. Resource-management is interdisciplinary. Governance is transparent, quick and decisions are based on a reliable and simple legal footing. Governance structures and regulatory frameworks are conducive to increasing climate-resilience. Permission-processes are not impacted by politics. Standards for resource-efficiency and protection are being controlled.

Consumption patterns reflect the shift to resource-efficiency. Regionally produced goods are valued more highly than others. Prices reflect the environmental costs of products: Water withdrawal fees are established. Producers and consumers consider the water and carbon footprints of products.

3.3.3 Innovation pathway

The CS3 innovation pathway focuses on the water sector, land use and soil management, as well as public awareness and education related to climate change impact in the region. For the region to become more resilient to climate change risk related to the water resource, it needs radical change in the way the water resource is managed mobilizing social and institutional innovations rather than new technologies. Several actions and management measures have already been identified but implementation is lacking. Many innovative ideas have been proposed as part of the Living Lab (in red in the innovation pathway below) to more effectively manage water within the region in the context of climate change. The years between 2030 and 2050 are needed for the innovations that were implemented in previous years to take effect. Moreover, this time can be used to revise innovations in case they did not deliver the expected results or if they had negative side effects. "Gaps" in these years do not mean that the vision could be achieved sooner. Instead, changes need time to spread and take effect.

The debate of innovation pathways within the Main River case study revealed some overarching tasks which are central to the successful implementation of the pathways.

- **Act now:** The development, implementation and evaluation of measures to increase climate resilience take time. Some measures will take a while to take effect. For these reasons, action must be taken now to achieve climate resilience by 2050.
- **Protect the climate:** Effective climate protection is a prerequisite for successful climate adaptation. Adaptation to largely unchecked climate change is almost inconceivable. At the same time, advancing climate change limits which measures can be taken successfully. Climate resilience therefore requires both: effective climate protection and adaptation to unavoidable consequences of climate change.
- **Take a systemic view of climate resilience and tackle it together:** Climate change and its consequences affect everyone. Challenges are interlinked, but adaptation strategies often focus on one area of work or life, or one specific challenge. If you want to avoid maladaptation and prevent resource conflicts, you need to look at and tackle things together.
- **Create public acceptance for the transformation to climate resilience:** Climate protection and adaptation are tasks for society as a whole. They can only succeed with broad public support. This support can be strengthened through good communication, education, opportunities for citizens to participate and a focus on change as an opportunity rather than change as a reaction to a crisis.
- **Pursue existing targets:** Climate resilience depends in part on the achievement of targets set years ago. In addition to climate protection targets, examples include the targets of the Water Framework Directive or targets for reducing land consumption. Reasons for failure to achieve targets must be addressed and the targets must be actively pursued.
- **Fund the transformation to climate resilience:** Climate protection and adaptation must be possible everywhere in the region. The financial situation of municipalities, companies or private individuals should not stand in the way of taking measures wherever possible. Where necessary, financial incentives or financing options for adaptation projects should be created. Where counterproductive financial incentives such as environmentally harmful subsidies can be

identified, they should be critically examined and, if necessary, eliminated. Awareness of the damage caused by climate change that can be avoided through targeted adaptation must be created across the board.

- **Find and train specialists for climate resilience:** People who have climate resilience in mind, understand the challenges and can successfully work towards improving climate resilience in their area of work must work in all sectors as well as in administration.
- **Contribute to climate resilience at all levels:** The work in the "Living Lab Bayerischer Main" focused on local and regional challenges and solutions. Although climate protection and adaptation must take place locally, it is important not to lose sight of the influence of framework conditions shaped by federal policy and the EU. Decisions made there must be conducive to local climate resilience. Examples are the continued pursuit of the EU Green Deal's goals or the restoration of nature.
- **Use the "big toolbox" of known measures and innovative solutions:** There are known measures that could improve climate resilience which are not widely used. At the same time, there is a number of innovative ideas for increasing climate resilience. In addition to infrastructural measures and technical solutions, nature-based approaches, behavioral changes, governance solutions as well as knowledge and awareness raising should be considered. Improving the climate resilience of a region is a large and complex task that requires the use of many different solutions. The following measures could be taken in the areas of water, land use and soil, public awareness, education and participation.

It is worth noting that several measures contribute to more than one part of the vision. For example, hedges that are planted and maintained at regular intervals have a positive effect on water retention in the area and biodiversity. Green and blue infrastructure in cities not only improves the cityscape but also protects against heavy rain and heat. For easier reading, all innovations were listed once and in relation to one goal.

Tap-water cycling route and IRRIBIGDATA are the two innovations to be tested within ARSINOE through the Open tender.

Sector /Theme	Innovations						MS2025
Water / Water balance	W 1.1.1 Personnell strategy for basic public services and water administration which considers climate resilience						staffing for climate resilience improved
	W 2.1.1 Municipal/regional "climate fonds" (like the Innovationfonds of Badenova or the Klimafond Nürnberg)						Financing of climate resilience of the water sector improved
	W 3.1.1 priority of public water supply enscribed in BayWHG		W 3.1.2 Permits for projects relating to climate resilience of public water sector can be considered granted after a fixed timespan if a decision has not been made				
	W 4.1.1 KAnG-implementation: municipal climate adaptation strategies require inclusion of public water sector		W 4.1.2 support services for climate risk assessments and strategies in enterprises responsible for critical infrastructure		W 1.2.1		Climate risks for the water sector are well-understood; Awareness of climate risks in public water supply and municipalities improved
	INNOVATION GAP: W. 5.1.1 further innovative ideas wanted	W.5.1.2 standardisation of procedures for creating and enlarging water protection areas	W. 5.1.3 easier processes for the prolonging of water rights for public water supply*	W. 5.1.4 IT-systems to improve information sharing and create common knowledge base for those involved in approval process			Back-log of unapproved water protection areas reduced
	W 6.1.1 digital "water registry" listing all extractions and water rights	W 6.1.2 "water footprint" on all products (e.g. following ISO 14044; or using tools listed in the "Water Footprint Toolbox")	W 6.1.3 news report on the state of the water balance (like a weather report)	W 6.1.4 rules for irrigation: irrigation happens primarily through rainwater and where necessary water from surface water bodies; determine "irrigation worthy" crops	W 6.1.5 prize for ugliest/driest lawn awarded to draw attention to drought and sustainable water use	W 6.1.6 creative public communication e.g. "Tap-water-friendly cycling route" along the Main (ARSINOE CIW)	State of the water balance is transparent / Consumers are informed and know the price of water from different sources
	W 7.1.1 proliferation of organic farming methods in areas with poor water quality to reduce pesticides, herbicides and nitrates		W 7.1.2 "toolbox" enables water suppliers and farmers to change their cooperation agreements to account for climate change (to potentially be implemented within ARSINOE)				Water quality improved in areas where standards are not met
	W 8.1.1 Introduce water extraction fee and perscribe its use for resource protection						Public funding for water protection improved

Figure 15: CS3 Innovation pathway for the water sector from present to 2025 - *needs of legal framework adaptation which would be innovative; innovation in red: haven't been tested / implemented elsewhere; innovation in green: implemented or supported by ARSINOE

Sector /Theme	Innovations					MS2030		MS2040	MS based on Vision 2050
Water / Water balance	W 1.2.1 training on water and climate change for ppl. in the water sector: apprenticeships cover climate // knowledge exchange on best practices between supply companies (e.g. building on "water neighborhoods", existing online platforms, "Water Resilience Coalition")					Appropriate resources for improving climate resilience of water sector		Infrastructruers are made climate resilient <u>speedily</u> : new wells, local & regional cooperation, long-distance water-suppliers, water protection areas	Public water supply is ensured: Water available at all times, good quality and appropriate cost; infrastructures are climate resilient; Emergency strategies consider needs of water sector under climate change
	INNOVATION GAP: L 1.2.1 financing solutions for creation of green and blue infrastructure (jointly developed by public and private sector) (already included in G12)								
	W 3.1.3 water infrastructure is considered to be of superior public interest and receives the privileges associated with that status	W 3.1.4 early start of construction and resilience measures allowed*				regulatory framework allows for speedy adaptation			
	INNOVATION GAP: W.4.2.1 cooperation of public water sector and regional planning associations happens routinely					Strategies for climate resilience consider water as a basic public service			
						municipal and regional planning considers needs of public enterprises in the water sector			
	INNOVATION GAP: W 5.2.1 further innovative Ideas wanted					Back-log of unapproved water protection areas reduced		Sufficient number and size of water protection areas	Water balance is intact and well protected: quantitative
	W 6.2.1 Regional monitoring system for water withdrawal for irrigation	W 6.2.2 switch to drought resistant crops	W 6.2.3 innovative strategies for irrigating greenery in public spaces: use of sensors; rainwater and reused water; volunteering for trees during drought	W 6.2.4 water-efficient irrigation technologies (drip-irrigation) combined with sensors and schedules where irrigation is necessary; IRRIBIGDATA for integrating solutions (ARSINOE CIW)	W 6.2.5 restrict water-use if necessary during drought	Water-use is considered; groundwork for more efficient use laid	W6.3.1 use of treated wastewater	Water-use is efficient and well-considered; cascade-use is widespread	
	W7.1.1		W 7.2.2 Biogasproduction using plants with fewer detrimental effects on water and soil quality (+benefits for biodiversity) (e.g. Silphie, Veitshöchheimer Hanfmix)			Waterquality meets legally mandated standards		Water quality maintained	
	W 8.2.1 "climate resilience audit" for new projects at municipal level (e.g. building on existing "climate-audits")	W 8.2.2 Fee for unnecessarily draining soils and water bodies		W 8.2.3 New and existing state funding programmes are audited for conflicts with water protection; (levels: EU, national, federal state, municipal)		Public financing for water protection further improved	W 8.3.1 funding programmes conflicting with climate resilience revised	Public financing does not incentivise actions conflicting with water protection	

Figure 16: CS3 Innovation pathway for the water sector from 2030 to 2050 - *needs of legal framework adaptation which would be innovative; innovation in red: haven't been tested / implemented elsewhere; innovation in green: implemented or supported by ARSINOE

Sector /Theme	Innovations				MS2025	Innovations			MS2030			MS2040	MS based on Vision 2050	
Landuse / Soil	L 1.1.1 Bavarian alliance for green and blue cities for information sharing, support for project planning, prize for "best blue-green-city-project"; create a "Rainwater Agency" (e.g. similar to "Berliner Regenwasseragentur")				awareness of the need for green and blue infrastructures among decision-makers widespread	L 1.2.1 financing solutions for creation of green and blue infrastructure jointly developed by public and private sector	L 1.2.2 municipalities incentivise water retention: split waste water fees, prohibition of "stone gardens", ecologic criteria as basis for awarding municipal plots of land, "kommunale Freiflächenkonzepte" consider climate adaptation	L 1.2.3 planning of building projects includes mandatory planning of water retention areas	Green and blue infrastructures are part of climate adaptation/sustainability strategies and local planning of all municipalities and cities			Green and blue infrastructures in and around settlements are very frequent	Water retention in urban areas improved ("Sponge cities") and urban development does not negatively affect water-retention	
Landuse / Soil	Innovation gap:L 2.1.1 proliferation of building materials that allow for infiltration		Innovation Gap: L 2.1.2 incentives for reuse and renovations of strcutres rather than new buildings		Land consumption is 5 ha/day	L 2.2.1 monitoring of obligation to unseal soil if sealed elsewhere		L 2.2.2 urban development considers ressource efficiency and land consumption		Land consumption is 0ha/day		Land consumption is negative		Water retention outside of settlements is improved; nature acts as a sponge
Landuse / Soil	L 3.1.1 "green trenches" next to fields used for retaining water	L 3.1.3 forest conversion using a variety of drought-resistant species	L 3.1.2 "Ökopunktekonten" incentivise water retetion measures									Nature acts as a sponge		
Landuse / Soil	L 4.1.1 soil protection included in education and training of farmers and city-planners	L 4.1.2 letting agreements incentivise soil protection (e.g. similar approach used by ACKERWERT)			Soil protection has higher priority	L 4.2.1 reduce times without plants on fields, use intercrops, plant leguminous plants; ensure there are roots in the soil in order to increase humus content in soil	L 4.2.2 create registry of drainage systems		Soils can absorb percipitation	L 4.3.1 demolition and changes to drainage systems in the interest of improving water balance		Water is retained locally by soil		
Public awareness and education	P 1.1.1 change curriculums to include mandatory teaching of climate change and its (local) effects and room for projects on climate change and sustainability	P 1.1.2 education of teachers and "role models" like sports trainers on climate change and adaptation	L 1.1.1 // L 4.1.1	W 1.1.1 // W 6.1.2 // W 6.1.3 // W 6.1.5 // W 8.1.1		W 1.2.1			Education for sustainable development established for children and teens				Public support for socio-ecological transformation arising from an understanding of climate change, its consequences and planetary boundaries. Consumption patterns reflect the shift towards	
Public awareness and education	P 2.1.1 establish citizen climate councils		P 2.1.2 Support volunteering for the environment						Options for public participation commonplace					
Water and biodiversity	P 1.1.1	L 3.1.1 // L 3.1.3 // L 3.1.4 // L 3.1.6 // L 3.1.7			L 1.2.1 // L 3.2.2		W 7.2.2		Biodiversity loss stopped // Native species prosper			Biodiversity increases // Species extinction stopped	Forests are healthy and serve multiple purposes. Water bodies are restored and the goals of the WFD are met.	

Figure 17: CS3 Innovation pathway for land use / soil management, public awareness and education, water and biodiversity -*innovation in red: haven't been tested / implemented elsewhere.

3.3.4 Barriers and Enablers

While generally a large variety of (often innovative) pilot projects are already conducted in the Main region, and funding and supporters are readily available for small scale testing projects, stakeholders repeatedly reported the difficulty of implementing new, but also existing measures on a large scale. Some stakeholders argue that the focus should therefore not be set repeatedly on testing new measures, but rather on consequently implementing the existing ideas. This results in requiring supportive measures that might not qualify as innovations themselves despite their novelty, but that are necessary for facilitating the implementation of innovations. Also, as some of the suggested “innovations” are in fact tested and well-known we use the terms “innovations” and “measures” to refer to actions which could boost climate resilience in the region. The proliferation of solutions requires a strong political commitment at all levels of government to address climate change and its consequences. Economic incentives for climate adaptation and long-term thinking in management decision are necessary. Broad societal coalition for climate resilience and education for sustainable development to empower people to make choices about climate adaptation, the use of technology and the reduction of red tape to speed up adaptation.

On the political context, due to the federal structure in Germany, responsibilities and / or funding are subject to a complex interrelation of the different levels, leading in parts to delays and inflexibility. The attitude towards climate change adaptation varies from strong political will to implement measures to populists denouncing adaptation measures as “green ideology”. In addition, strong lobby groups hold the power to both facilitate and hinder the implementation of adaptation.

From an economic perspective, many stakeholders pointed out that implementing new measures results in uncertain revenues. Compensation via national funding programmes is often complex or not sufficient. In parts, however, some innovations were shown to pay off economically or at least cause no damage (no-regret measures). In some sectors the implementation of adaptation measures is slow because decision-makers focus on the short-term rather than the long-term. Innovations are considered costly and connected to risk in the short-term possible long-term benefits are not considered. As opposed to the general trend in many sectors, no significant labour shortage was reported by the stakeholders when it comes to finding qualified personnel to fill adaptation-related positions.

Engagement and high motivation for changes is seen among people in many sectors and society at large (as opposed to also large groups with indifferent or disinterested attitudes towards climate change). Some indifferent groups may be convinced to adaptation measures if led by examples or within cooperation with trusted partners. In parts, people also refuse to pioneer, i.e., being the first to change the common/traditional workflow, due to concerns regarding their reputation (social pressure). Motivation also soars if people are personally affected by climate change impacts or if they keep high autonomy in implementing or managing adaptation measures. However, even this holds true mostly for stakeholders who are already invested in climate adaptation. For widespread dissemination, the topic of climate change adaptation should be brought to disinterested or indifferent people as well, by, e.g., addressing them at their workplace (e.g., mandatory training).

Currently, many sectors (e.g., administration, education etc.) are committed to an on-going, but time-consuming digitisation process. This bears the potential for synergies with implementing new measures, e.g., regarding monitoring or investing in new technology. In general, technologies and the workflows they are used for are attuned to each other. Updating technology or implementing new measures could therefore lead to massive altercations of existing workflows, resulting thus in high investments with uncertain outcomes. Therefore, many stakeholders argue for using existing infrastructure and technology as a low-level entry point for adaptation measures.

Both the Bavarian Climate Law and the National Climate Adaptation Law serve as guideline for climate adaptation at the municipal level. Some measures, however, are not covered by current guidelines of legal frameworks which may result in uncertainty among stakeholders regarding the implementation of their measures. Also, the option for implementing large-scale measures on, e.g., forest or agricultural lands, may depend on the kind of ownership of the land (e.g., renting vs owning resulting in short-term vs long-perspectives; or: status change of landscape elements prescribing certain types of treatment).

Often, meteorological extreme events bring the importance of climate adaptation to the attention of decision makers: For instance, in the wake of drought years, water saving policies in municipalities passed legislation more easily. In this respect, climate change impacts themselves are often perceived as enablers to adaptation.

Details of the barriers and enablers identified for each sector / theme of the CS3 innovation pathways can be found in appendix 7.

3.4 Case study 4: Ohrid and Prespa lakes

CS4 is a transboundary case study, comprising the Albanian, Greek and North Macedonia parts of the Ohrid and Prespa lakes. It aims at improving the climate resilience of environmental, economic, and social sectors related to water use, by providing an intelligent comprehensive innovation set of long-term planning solutions, allocation and use of sufficient quantity and of adequate quality water for all users, respecting their interests in order to improve human health, food production, conservation of natural environmental systems, clean energy production and sustainable growth of all sectors. Water availability will be analyzed in the wider transboundary region of the lakes Ohrid/Prespa, to propose a new water governance management framework, adapted to climate change challenges. This CS will contribute to secure a balanced use of available water resources and bridge the gap between social and economic aspects facing the climate change impacts on the transboundary surface and groundwater systems of Ohrid and Prespa lake. All socio-economic sectors are highly dependent on the water regime of the greater Ohrid/Prespa region and therefore highly sensitive to water scarcity induced by climate change. Existing studies and management plans for the region have identified need for adaptation to climate change impacts and foreseen urgent actions for improvement of quality and quantity of surface and sub-surface water, based on a sustainable and efficient use of water, supported by the appropriate water governance solutions. (ARSINOE D6.5)

3.4.1 Problem statement

“How to ensure the implementation of transboundary integrated water management strategy including the adoption of climate adaption actions within each sector currently operating in the Ohrid/Prespa lakes?”

3.4.2 Future vision

Prespa region in 2050 has a population double its present one, as negative demographic trends are reversed and attractive green jobs for young people emerge. Sustainable growth is based on economic sectors such as tourism, agriculture, fishery and zero-waste light industry, taking advantage of scientific research, modern technologies, and synergies. Economy is based on green jobs and clean E sources.

Traditional sectors are improved by modern IT technology.

Agricultural production is adapted to climate change through diversification (including revival of old crops), modern technology applications, and improved irrigation efficiency. agricultural technologies are applied to be resilient and sustainable across all sectors, through precision agriculture and other types of innovative ways which ensure no waste of materials, water/irrigation efficiency and degradation in biodiversity. Tourism is developed in a sustainable way, paying attention to the carrying capacity for visitors and even distribution in space and time, as well as taking advantage of synergies with other sectors (e.g., fisheries, agriculture

This development is based on a transboundary plan, including common labelling of products and improved infrastructure, protection and promotion of cultural and natural heritage) through transboundary events with transboundary collaboration and assistance.

There is regular and permanent water monitoring as a pre-condition for ensuring water quality and quantity, based on transboundary co-operation and data accessibility. Monitoring tools innovations are developed within this project so the planning and the development with fit the sustainable development goals.

Through scientific research and collaboration between the three countries, a good understanding of the connection between the three lakes and the pressures on them is achieved, leading to reversing the trend of decreasing water level in Greater Prespa and improved water quality in all lakes. Authorities and local citizens hold a high environmental awareness, ensured through social innovations and capacity building, and taking advantage of citizen science applications and local incubators through which they are learning about a resilient way of doing things and passing it on to the generations.

Conservation and restoration of biodiversity and water-related ecosystems is achieved, including not only lakes and wetlands, but also forests. There is a joint coordination for protected areas at transboundary/national/regional/local level, bringing different sectors on the same table. A Transboundary Crisis Management Plan related to climate change (covering extreme weather events and natural disasters such as long drought, wildfires, bird diseases) as well as an early warning system allow prediction, effective management and even prevention of such conditions.

The natural and cultural heritage in the UNESCO Ohrid region and Prespa region is highly protected, eliminating all anthropogenic impacts on the regime of surface waters, water sources and lakes. The Ohrid and Prespa heritage is protected through sustainable tourism, greater awareness of cultural heritage and the significance of the region.

3.4.3 Innovation pathway

The CS4 trans-boundary innovation pathway is based on the co-design process which took place in each of the country (Albania, Greece, North-Macedonia – see workshop outputs in Appendix 5) and is common to the 3 countries. It is the result of a close collaboration between the e national teams. All innovations identified should be implemented in the 3 countries unless specified (i.e. some innovations only apply to Greece).

The pathway covers many different sectors (Water supply / environmental monitoring; Forest and wetland protection; Fishery; Agriculture; Tourism and cultural heritage; Energy; Social awareness, education and governance;). Stakeholders have identified a mix of technological and social innovations; some are still to be developed (innovation gaps).

WATER4ALL in North Macedonia and IWRS in Albania are the innovation to be tested within ARSINOE.

Sectors	innovations			MS 2025	innovations		MS 2030
Water supply/Environmental monitoring	Real-time groundwater level measurement -> predict lake water level -> alerts (WATER4ALL- ARSINOE CIW)			Identifying causes for water drop in Big Prespa- Historical survey of water level			
	Sensors & IoT Platform with real-time water quality parameters (AQUASmartTech, GreenSense & Solutions ARSINOE CIW)			Evaluation of pollution sources: wastewater, chemicals	Integrated Water Resilience System based on sensors & incl. educational initiatives (IWRS - ARSINOE CIW)	Transboundary Water Monitoring System (based on relevant work of PPMC)	Monitoring of droughts, amount of precipitation, soil types/fertility, water flows (input/output), Common measuring processes aligned with WFD
	Platform for exchange of information & access to a common database (related to WGMW roadmap)	Citizen science applications (existing for plants in GR, also birds)		Common monitoring methodology, granting data accessibility			
Forest and Wetland Protection	Continuous control and measurement of elements to maintain the balance of common ecosystems	Transboundary agreements and Management Plan for all protected areas to limit eutrophication	Advanced Grazing Systems (NBS) in forest & lake ecosystems	Protection/restoration of forests & wetlands for stability/improvement of ecosystems	Transboundary Forest Monitoring System (focus on wildfire-related parameters)		Sustainable & efficient use of forests
Fishery					Innovative fishing methods/ equipment (e.g. specifically decreasing time demand for managing IAS like L.	Environmental Conservation approach for freshwater habitats through sustainable	Sustainable fishing practices
Agriculture	Continuous measurement of land surface and soil characteristics				New crop varieties - Rediscovery of old ones		Sustainable Agricultural Management/ Diversification of agriculture
Tourism & Cultural Heritage	Specific apps with information for tourist, incl. sustainability (especially in water management)			Awareness of visitors with appropriate signage	Multifunctional hub (with innovative education)	Common econ. activities (e.g. fishing tourism, sustain. farms for visit)	Synergies between sectors (primary & tourism)
	Sustainable farms-open for tourism (incl. sustainable water management)	Transboundary Visitors Management Plan (equal distribution space & time)		Sustainable tourism - Reduce carbon footprint activities	Immersive and eco-friendly tourism experience, incl. promotion of resp. accommodation (Eco-friendly tour - ARSINOE CIW)		All accommodation facilities are green categorized
Education-Social Cohesion-Social Awareness &	Transboundary workshops & field trips with youth (ARSINOE activities)	Transboundary multidimensional & multifunctional hub, incl. data collection (e.g. Technology&Ideas)		Public education -awareness: Multidimensional & Environmental Education	Innovative education workshops for children & adults (also professionals)	Climate-adaptive education platform (EcoLearn)	Educational activities for raising awareness
Institutional-Legal Framework-Policy					Transb. Wetland Management Committee (representing all sectors), based on the one functioning in GR 2005-2022		Participatory Governance incl. all stakeholders
Infrastructure/Renewable Energy	INNOVATION GAP			Building infrastructure to withstand the intensity of extreme weather events associated with climate change	Buildings development and orientation towards non-polluting industries		Non-polluting industry

Figure 18: CS4 - Innovation pathway from present to 2030 * in green: innovation to be tested within the framework of ARSINOE project; in red: innovation gap (not yet developed or implemented elsewhere) * in purple: innovation to be implemented only in Greece

Sectors	innovations		MS 2035	innovations			MS 2040-2045
Water supply/Environmental monitoring	Integrated Pesticide Management (incl. Programms for management of pesticide packages)		Improving water quality and reducing pollution in aquatic ecosystems	water measurement with digital system	Raindrop collection -> gardens, underground tanks (training programms)	real time monitoring and leakage detection and reduction system in water distribution networks	Improved water supply, achieved good water quality & quantity
		Technical innovation for submerged species (recording & removing)	Limiting lake vegetation/eutrophication	Transboundary Management Plan for Crises related to Climate Change	Little Alert Boxes network: real-time data on envir. parameters	Early warning system on transboundary level (clear competencies e.g.	Transboundary co-ordination of crises related to Climate Change
Forest and Wetland Protection			Management of IAS (substantially reducing populations)				Wet meadows restoration
Fishery	Training seminars for fishers (reporting IAS, stop enrichments)	Making products of IAS and other small-sized species (e.g. cat food)					
Agriculture	Innovative irrigation techniques based on agro-ecological practices, with resp. training for sustainable agriculture and innovative funding schemes/business models		Increased effectivity of irrigation (-50% water consumption)		INNOVATION GAP		Climate-smart agricultural practices reducing water pollution and runoff into lakes
Tourism & Cultural Heritage	Implementation of common label for products (already produced in BorPres)		Lakes function as one tourist destination, across 3 countries	INNOVATION GAP			Programs for waste reduction and recycling in tourism
Education-Social Cohesion-Social Awareness & Economy				Economic incentives for young generations			Better demography in region-population increasing
Institutional-Legal Framework-Policy	Online participatory platform incl. local residents (u.d. in GR PoliPrespa)		Participatory Governance incl. all citizens				
Infrastructure/Renewable Energy	Solar panels compatible with agriculture & protection of ecosystems		Improved share of renewable sources for clean energy	Financial instruments for renewable and efficient energy			Renewable energy transition is achieved
	Alternative urban planning strategies and innovative land use governance policies		Sustainable Urban Development Policies	Digital Twin of Catchment area, input: in situ observations	3D twins in the transb. Region		Digital twins

Figure 19: CS4 - Innovation pathway from 2030 to 2045 * in green: innovation to be tested within the framework of ARSINOE project; in red: innovation gap (not yet developed or implemented elsewhere)

3.4.4 Barriers and enablers

Key political barriers are related to the limited knowledge, experience, capacity and human resources to manage, carry out and harmonize reforms in climate adaptiveness and mitigation across sectors, and the delays due to required cooperation of three states (bureaucracy, different systems/methodologies) while the harmonization of national directives in water related issues, with EU Directives and the existing transboundary structures (e.g. Prespa Park Management Committee including Working Group on Water Management), will support the implementation of the innovation pathway.

In terms of economic factors, the high initial and investment costs required, in the context of limited economic resources, can be considered a hurdle. However, the reduced costs of water and energy consumption and the reduced cost of damage through prediction/prevention of hazards, is currently leading to acceptable return of investment

The reluctance to implementation of new technologies as well as new behavioral models, especially since young population (main potential users of innovative tools) is decreasing and many people still residing in the area are of older age, and the possible distrust if the population feels being monitored or results lead to restrictions, also due to perception that environmental legislations are not fairly implemented are the main social barriers. Nonetheless, raising awareness of personal, community and sectoral responsibility and a shared concern for the water scarcity in the region will favor the implementation of the pathway. Additionally, the active NGOs in three countries with networking between them (e.g. PrespaNet), having ties with local stakeholders will have a positive effect.

Low level of information about technological development, artificial intelligence, incomplete local infrastructures, and accessibility issues are considered as major technological barriers. But the availability and accessibility of technological innovations are increasing, favored by the existence of on-going projects which can favor exchange of experience between countries.

Complicated procedures for land use, legal documentation and authorization and the lack of cohesion between transboundary laws and regulations e.g. no-fishing season in the lakes are considered as major legal barriers. But regulatory and law frameworks are improving towards alignment with EU policy framework.

The main environmental barrier characterizing CS4 is the competition of interest among biodiversity / ecosystems and other water consuming sectors. On the other hand, there is an aspiration for a supportive impact on biodiversity preservation / loss mitigation, and the collected data will be useful to environmental projects and raise awareness.

Details of the barriers and enablers identified for each sector / theme of the CS4 innovation pathways can be found in appendix 7.

3.5 Case study 5: Canary Islands

The Canary Islands have a subtropical climate that allows a number of fruit trees to be grown that are not cultivated in the rest of Spain. In addition, again due to the climate and natural isolation, the islands have maintained varieties that have given rise to numerous designations of origin in the field of vines, and the banana has also received a protected geographical distinction. All these crops are very sensitive to changes in temperature, and to water shortage deriving from it. This is why in the context of climate change, in which a general increase in global temperatures is to be expected, could seriously affect these tropical crops, which are also the Islands' main export. (ARSINOE D6.5)

3.5.1 Problem statement

“How to facilitate cross-cutting governance, knowledge transfer, and the islands’ adaptation of primary sector to new climate condition thus supporting the farming ecological transformation and sustainability?”

3.5.2 Future vision

The Canary Islands are a territory that has adapted to climate change and has managed to complete an ecological transition where a greater share of food supply and food security are guaranteed. Society is educated within conscious consumption values where water, food and energy are not wasted and all the waste generated is revalued, becoming a usable product. Agricultural production is 100% ecological and the population values local, km 0 and ecological products over exports. Water is managed in an integrated and efficient way, so the quality of the water is excellent, there are no discharges into the sea or the ground, and reclaimed water is used to irrigate the fields and for street and sewage cleaning. There is no abandoned land, as they have all been recovered, promoting agro-ecology and a mosaic landscape on the islands that allows us to adapt well to temperature changes. There is a fair coexistence between small and large farmers, where everyone has access to the same opportunities, where the sector is monitored, with open, accessible and public databases, with innovative technology that helps in all stages of production, improving work and working conditions in the sector, thus favoring generational change. Tourism is still important, but it is no longer fundamental for the Canary Islands, leaving more room for the primary sector, promoting its development, all under the command of a fair, green, ethical and accessible government.

3.5.3 Innovation pathway

CS5 innovation pathway aimed at adapting the Canary Islands to a warmer climate and makes the primary sector resilient to drought and water scarcity. It focuses on the water management, the primary sector from production to consumption, and in a lesser measure the tourism sector. The innovations identified and selected by local stakeholders are a mix of technologies and new social and institutional practices (e.g. institutionalisation of traditional knowledge sharing; use of a tourism tax for environmental protection purposes).

SICMA solution will be tested within the ARSINEO framework.

sectors	innovations (can be more than one)			MS 2030	innovations (can be more than one)			MS 2040	innovations (can be more than one)		MS 2050
WATER	Nature-Based Solutions,(i.e wetlands) for treating domestic wastewater in rural and dispersed areas of the islands:			Installed small wastewater treatment natural plants	utilization of brine for resource generation, ceasing to be a waste product:	Full operation of desalination plants with Renewable Energy:		Groundwater extraction for consumption in low-lying areas (densely populated) is stopped to restore aquifers	Swarm Robotics Systems (MATRIX) for Pipeline Inspection:	use sludge generated in wastewater treatment plants as a source of energy	The islands' water infrastructure network provide sufficient water for the supply and needs of the population
					Irrigation and foliar water using ozonated water	water disinfectants system more efficient than Chlorine, generating fewer or no byproducts (i.eOzone system)		Irrigation water quality has been improved by installing treatment plants to reuse treated effluent			
PRIMARY SECTOR (Food production and consumption)	A crop mapping system which identifies the main crops by region, which facilitates the reuse of different types of waste in various industries	SICMA Canarias tool: Friendly and ready-to-use platform that integrate a wide selection of climate data layers and other derived indicators and variables, co-designed based on stakeholders' requirements	Guideline enabling the identification of byproducts obtainable from various agricultural and livestock waste	Agricultural crops are adapted to resource availability, climate and environmental restoration of abandoned land	Distributed systems where participants make monthly donations to farmers and, in return, they receive a specific production		Food security has been achieved, through increased agricultural production, access to land, reduced losses and a balance between need and exports		Tracking distributed system based on blockchain technology	comprehensive tracking system are in place for the food product supply chain, as well as for the organic fertilizers used, to measure the sustainability of crops	
					Application for farmers that suggests what to plant based on the specific area of the island, considering climate change and the expected natural precipitation		The areas with the highest potential for atmospheric moisture uptake are used for planting				
					Agriculture carbon market as a form of circular green economy		Canarian agriculture is attractive, stable and generates an income with important incentives				
AGRICULTURE	Traditional Knowledge sharing (by Public Administrations)			The synergies between farmers and researchers are excellent and fosters cooperation and collaborative learning	Greenhouse plastics for 3D printing of agricultural equipment	collection of organic city waste cities resued in farming activties	electric agricultural machinery	Waste generated in the agricultural sector is revalued and transformed into a usable product	AGTECH (smart agriculture technologies)	There is already technology that enables farmers to use mobile devices to perform actions such as irrigation, providing them with free time and improving their quality of life	
	On-Farm Experimentation (OFE) collaborative learning model:		Smart Field Notebook	Farmers and agricultural technicians undergo ongoing training, facilitating the adoption of organic farming practices							
TOURISM	Tourism organic waste for agricultural compost			Sustainable agritourism is a relevant sector that combines agricultural activities with the enjoyment of foreign visitors	Tourist tax implemented to offset the resource consumption of tourists in the islands, earmarked entirely for environmental protection in the region			The Canary Islands is recognized as a sustainable destination where all economies converge equally			

Figure 20: CS5 - Innovation pathway * in red: innovation gap (do not exist yep or not implemented elsewhere); in green: innovation funded under ARSINOE framework (CIW)

3.5.4 Barriers and enablers

Water Sector: From an economic perspective, the need for a substantial investment in infrastructure poses a barrier, especially within the context of an energy monopoly. However, the commercialization of brine and the potential to generate new sources of income through innovative technologies could drive development. Socially, population growth and the current lack of social demand for increased integration of renewable energies in the electrical matrix pose obstacles. Yet, awareness of coastal issues and society's willingness to appreciate improvements in water management present opportunities. In the legal sphere, restrictions on wastewater use and illegal discharges of brine are identified as barriers. Finally, from an environmental standpoint, the reduction of CO₂ emissions and water savings act as crucial enablers for the proposed innovations.

Primary Sector: Politically, although specific barriers are not identified, there is an opportunity to enhance existing solutions to meet citizens' practical needs in terms of crop mapping. Economically, the need for significant public investment is highlighted as a barrier to adopting online monitoring systems and blockchain technologies. However, the potential to offer products to citizens based on their monthly contributions and the online recording of agricultural activity promise economic improvements for farmers. Socially, concerns lie in the accessibility of crop mapping tools to the public and the diversity of farmer profiles. Nevertheless, these innovations are recognized to contribute to cohesion and solidarity initiatives. Legally, innovations seem not to encounter significant legal obstacles, but blockchain technology holds the potential to control regional emissions, which could be a significant enabler. Environmentally, innovations offer significant benefits such as waste management, CO₂ reduction, and the promotion of product traceability, preventing food alerts. These environmental aspects can act as key enablers for the adoption and acceptance of these innovations in the agricultural sector.

Research, Education, and Technology Sector: Politically, barriers are identified related to the need for institutional support for the development of traditional knowledge and possible pressures from large companies manufacturing fuel-based machinery. Economically, the initiative of traditional knowledge may face challenges, as it involves time and an initial investment that may be difficult for farmers, emphasizing the importance of support from public institutions. Additionally, adopting alternatives to conventional plastics in greenhouses may seem initially costly, but the existence of subsidies for those using sustainable materials could act as a facilitator. From a social perspective, highlighting traditional knowledge for young people to appreciate and the practice of Co-Learning are perceived as facilitators. Moreover, the growing awareness of microplastics and plastics in the sea creates an opportunity for society to accept alternatives to conventional materials in greenhouses. Regarding environmental factors, the need to return to traditional agricultural practices, beneficial for the Canary Islands by consuming less water, is highlighted. Furthermore, adopting degradable materials in greenhouses and transitioning to more sustainable agricultural practices would contribute to reducing CO₂ emissions.

Tourism Sector: In the political sphere, barriers are identified concerning potential odors from implementing organic waste containers in the streets and the reluctance to disturb tourists, given that tourism is the main economic driver of the Canary Islands. However, the possibility of creating community composting projects is highlighted as an enabler to manage organic waste more sustainably. Technologically, no significant barriers are mentioned, and the implementation of waste management systems in hotels is emphasized as an easily implementable measure. Regarding legal factors, it is mentioned that the tourist tax could not be applied to vacation rentals, but environmental regulations would support the implementation of sustainable waste management practices. In summary, despite political and social challenges, the implementation of community projects and environmental awareness emerge as key opportunities to move towards more sustainable practices in the management of organic waste and the use of the tourist tax in the Canary Islands.

Details of the barriers and enablers identified for each sector / theme of the CS5 innovation pathways can be found in appendix 7.

3.6 Case study 6: South-West Black Sea

Case study 6 focuses on the connection between upstream land uses and the coastal and marine ecosystems of the Black Sea, including the Danube Delta, under climate change conditions and bring out innovative approaches including Nature-Based Solutions (NBSs). CS6 follows an integrated virtual watershed - from source to sea - management approach and provides climate resilient good practices based on systemic solutions and innovations that will enhance the adaptive capacity of ecosystems and the local communities involved. NBSs will be introduced across the watershed, to enhance the protection from soil erosion, river and sea water pollution, flood protection, groundwater replenishment and coastal zone erosion.

It is composed of 43 sub-case studies in Romania (Danube Delta), Bulgaria (Ropotamoi river natural reserve), Greece (Aliakmon River), Romania (Danube Delta), and Türkiye (Southwestern Black Sea). To tackle specific challenges faced in Bulgaria, Romania and Türkiye, Innovation Pathways were developed after collaborating with national stakeholders. Each sub-case study developed a specific Innovation pathway to tackle the specific challenge(s) each area is facing. In parallel an international innovation pathway for the whole case study aiming at tackling overarching challenges the region faces common to the 3 countries was also co-developed.

3.6.1 Romania

The Danube Delta Biosphere Reserve is the largest protected river-sea macro ecosystem with a unique biodiversity heritage, hosting in its numerous lakes and marshes over 7200 plant and animal species, of which more than 350 species of birds and 130 fish species. 97% of bird species existing in the Danube Delta are protected by the Bern Convention. This wetland is extremely vulnerable to the frequent variation of nutrients load and long periods of draught, which threaten the adaptive capacity of ecosystems and the socioeconomic activities of local communities.

3.6.1.1 Problem statement

How do we ensure efficient water circulation in the Danube Delta, pollution control and local economy development while maintaining/restoring local ecosystem health?

3.6.1.2 Vision

In 2050 the Danube Delta is characterized by a good environmental status, pollution flows (excess nutrients, chemicals and solid waste inputs) and extreme events (i.e. floods) are monitored and mitigate throughout the river basin thanks to early warning system and real-time data collection and cooperation across the 8 Danube countries. The well-being of inhabitants is based on fishing, farming and tourism activities which have adapted to climate change and benefit from naturally preserved Danube Delta environment.

3.6.1.3 Innovation Pathway

To achieve a good environmental status of the Danube delta ecosystem under extreme weather conditions (i.e. increase drought and flood), the Romanian sub-case study pathway is targeting four areas of intervention, namely water quality (for monitoring and data management), aquaculture and fisheries, agriculture, citizen science. Stakeholders are mostly looking at technological innovations rather than social innovation to achieve the vision. The newly established international centre for advanced studies on River-Sea systems Danubius-RI⁴ is expected to greatly contribute in terms of development of advanced technologies and tools. It has an integrated, interdisciplinary and participatory approach to enhance the process and system understanding and to enable a sustainable management of River-Sea Systems. DANUBIUS-RI will act as a Service Provider, a 'one-stop shop' for knowledge exchange in managing river-sea systems; access to harmonized data; and a platform for interdisciplinary research, inspiration, education and training.

Proverse digital twin solution and immersive social communication tool will be tested as part of the ARSINOE framework.

⁴ https://danubius-ri.eu/accredited_service_providers

sectors/theme	innovations			MS 2030	innovations			MS 2040
Water quality - Monitoring and data management	no innovation needed per se			Distributed monitoring points across Danube Delta	Monitoring platforms for water quality			Effective collaboration with the scientific community for data-analysis
	modelling program for integrated data collection (RAPID-N for Natech Risk Analysis and Mapping)	Digital twin technology to create a dynamic, 3D model of the Danube Delta ecosystem (ProVerse - ARSINE CIW)		Functional data-collection system and diagnosis	Services of DANUBIUS Center: Functional models for river - delta and river - sea interaction	Model of pollutant dispersion integrating hydrological conditions (i.e. SWMM-EFDC	Functional systems for diagnosis	Fully developed early warning system
Aquaculture and Fisheries	Services of DANUBIUS Center: genomic-based tools for understand adaptation capacity of species	Bathymetry for fish finder (CIW)	Sustainable feed for aquaculture	Adaptive management framework	Services of DANUBIUS Center: Selectivity Controls for fishery	Services of DANUBIUS Center: Gene database for threatened species		Functional network of stakeholders and Administrative and Research Units from the Danube meadow
Agriculture		Soil moisture sensor (i.e. MOLE CIW)	new biofertilizers	Understand climate change response	Remote control of irrigation for water management (MICRO SWITCH, WaPOR Platform / AQUAMAPS, MODIS, Landsat, SMOS, AMSR, ASCAT)		Remote sensing for soil moisture (TDR SM sensors, GNSS reflectometry, Airborne remote sensing)	Creating condition for Danube Delta soils to easily adapt to climate changes
Citizen science	Community-Centric Platforms for Knowledge Sharing (i.e. ProVerse's immersive social communication tool)	Web tools - Knowledge management portals	Operational Training Service for small businesses	Local network for integrated local economy	Web technologies portals/ platforms (CitizenLab, SPOTTERON, EU.Citizen-science, etc.)			Social empowerment

Figure 21: CS6 Romania Innovation Pathway from present to 2040 *in red: innovation gap (not yet developed or identified); in violet innovation coming from Danubius-RI; in green: innovation to be implemented within the ARSINOE framework

sectors/theme	innovations			MS 2050
Water quality - Monitoring and data management	Remote sensing monitoring		Early warning system for eutrophication	The local authorities are prepared to manage the ecological state in Danube Delta
	Services of DANUBIUS Center: integrated systems for measure and analyse water quality parameters across Danube River	Mapping system for targeted pollutants	Alert system for local pollution	Aligned monitoring systems across the Danube river and common database
Aquaculture and Fisheries	no innovation needed per se			Restored fish reserve of the Danube Delta and conserved heritage
Agriculture	Services of DANUBIUS Center: Adapted technologies for carbon sequestration	Services of DANUBIUS Center: Working system for assessing plant–soil feedbacks along soil evolution		Avoid desertification
Citizen science	no innovation needed per se			(Ex. Benefit for the society) Restored biodiversity and functional ecosystems

Figure 22: CS6 Romania Innovation Pathway from 2040 to 2050 *in red: innovation gap (not yet developed or identified); in violet innovation coming from Danubius-RI; in green: innovation to be implemented within the ARSINOE framework

3.6.1.4 Barriers and enablers

The major barriers in implementing the innovation pathway for the Danube Delta are related to the differences in economic status of delta's communities and aged population that do not have proper training for using advanced technologies. These might lead to limited adaptation to new production and marketing systems.

The key enablers are linked to the protected area status of the Danube Delta. Thus, a structured action plan for biodiversity protection and sustainable development already exists and is regularly updated to improve delta's ability to adapt against the climate changes effects.

Being a protected area, strategic agendas developed for Danube Delta management integrate responsibilities for conservation of Danube Delta heritage such as fish reserve, traditional / cultural products or activities. Thus, adapted regulations based on functional monitoring systems distributed across the delta are mandatory for each specific identified challenge, regardless of the price or people acceptance.

Details of the barriers and enablers identified for each sector / theme of the CS6 innovation pathways can be found in appendix 7.

3.6.2 Bulgaria

Ropotamo Complex, on the southern Bulgarian Black Sea coast, is comprised of the downstream stretch and estuary of the Ropotamo River, seasonally flooded forests, small freshwater and brackish lagoons, sand dunes, a bay and various inlet. Because of its variety of habitats, the wetland is very biodiverse, hosting 60% of Bulgaria's reptile species, 57% of its mammals, 60% of its freshwater fish and 50% of its nesting birds. (255 different bird species have been recorded). Climate change poses major challenges in the region and is likely to exacerbate the difficulties of protecting the complex ecosystems. Its effects concern different aspects: protection of biodiversity, extreme events (drying or flooding of certain areas), infrastructure, etc.

3.6.2.1 Problem statement

How do we ensure that we are best positioned to address the challenges posed by climate change affecting the Ropotamo Reserve?

3.6.2.2 Vision

In 2050, Ropotamo Reserve will be an example of integrated management that is based on detailed and up-to-date information, ensuring a balance between the needs of the different ecosystems that make up, as well as between ecosystems, infrastructure and the human factor. At the same time, the necessary information will be collected for the reserve to guarantee its resilience to climate change and extreme events that are possible within 30 years' time. Protecting the reserve will be a mission not only for the state institutions responsible for it, but also for society as well, which will have the knowledge of why it is necessary to protect this precious place, as well as recognizing its important role in this process. The Ropotamo reserve will not be an isolated element, but part of a whole system built by men to protect the valuable elements of the world around us - integrated data on the state of the rivers flowing into the Black Sea and data from Black Sea monitoring carried out by all Black Sea countries would be an ideal scenario for a better future.

3.6.2.3 Innovation Pathway

The emphasis on fewer specific technological innovations and more on the integration of existing systems and social innovation within the Ropotamo Reserve's planning framework is reflective of a strategic focus on enhancing systemic efficiency and effectiveness. This approach can be seen as a practical strategy to optimize existing resources, encourage the sharing of data and expertise, and foster a unified approach to environmental management and climate change adaptation. This is necessitated by the identified in the 3 WGs weaknesses and opportunities for improving existing management practices, which are evidently based on the need for an integrated approach, uniform data collection and "working together better" than new technology which would solve a problem. The unique situation is partly based on the protected status of the area, which management is very much in the hands of the government and its structures, so the integrated approach would support them in finding the best possible solutions supported by strong data. Here are several reasons why the approach is valid, as discussed throughout the meetings:

Resource Optimization: Using the already existing government entities and systems avoids duplication of efforts and reduces costs associated with developing new technologies or systems from scratch but also avoids the need for more extensive changes in legislation. By enhancing and integrating existing technologies and procedures, the project can achieve more substantial outcomes in a shorter

timeframe.

Data Management: Integrating data collection and sharing across different institutions facilitates a more comprehensive understanding of climate impacts. It allows for more accurate forecasting and better decision-making, stepping on cumulative knowledge and resources of multiple stakeholders, but in a easy-to-use and ready format.

Social Innovation: Focusing on social innovation involves developing new strategies, concepts and ideas that would better meet social needs. In the context of climate change and/or protecting the reserve, this was discussed to involve innovative ways of engaging communities, improving communication and trust between stakeholders, and fostering a culture of sustainability.

Interagency: Enhancing interagency coordination can lead to more effective and timely responses to climate-related events. This would require not technological innovation but improvements in governance structures and/or policy integration, and/or collaborative strategies.

ENOVA BioSense - solutions for instant water quality assessment based on new generation of biosensors is the solution to be tested within the ARSINOE framework.

sectors	innovations	MS 2025	innovations					MS 2030
Sustainability	Innovation gap	MS1.1 A model is developed for the distribution of functions between different institutions	ENOVA-H2O: rapid test for the assessment of organic pollutants in water within seconds. / EMBIO diagnostics : a multi-use handheld chemical analyzer	River flooding modeling / Flood early warning (Google Deepmind) / Digital Twin for flood early warning	Tubebarrier as flood barrier (NOAQ Tubewall)	ThirdEye drones^ provide high resolution information on crop status. (CIW)	Fire warning systems^^ (No ready CIW innovation or link)	MS1.2 Up-to-date climate data is being collected: air temperature, rainfall, water level, physicochemical monitoring (pollution), water temperature, groundwater levels
High level of awareness	Digital twin for forecasting (No ready CIW innovation)	MS2.1 Currently available information is identified and along with information needed for more accurate forecasting 30 years ahead	No need of innovation per se					MS2.2 Established (inter-agency) system. Established working rules and/or dealing with uniform data
Integrated Approach	No need of innovation per se	MS3.1 Institutions to be involved in developing an integrated management approach are identified	No need of innovation per se					MS3.2 Allocation testing completed; identified weaknesses and needs for correction
Activated Civil Society	Potential use of VR for public engagement. The aim - to showcase the potential outcomes of environmental policies, allowing citizens to visually and interactively understand and discuss proposed changes.	MS4.1 Trust is built in institutions and better communication between citizens and institutions is developed	No need of innovation per se					MS4.2 Citizen participation as a form and a way of working - phone, online, platforms, apps is structured and applied

Figure 23: CS6 Bulgaria Innovation pathway period present to 2030 *in red: innovation gap (innovation not yet developed or not yet identified); in green: innovation funded under ARSINOE framework (CIW)

sectors	innovations	MS 2035	innovations			MS 2040	innovations			MS 2045
Sustainability	Groundwater mapping (SkyDowser)**	MS1.3 Analysis of current management practices is finalised	Risk management solutions * (InfoSequia /HydroPC)			MS1.4 System developed for utilization of the collected data; plans and measures developed and approved	N/A			MS1.5 Interim verification of the results of the work is performed and adjustments (if necessary) are made
High level of awareness	No need of innovation per se					MS2.3 Implemented and tested working system and established rules for interagency coordination in decision-making	SkyDowser* *	Vegetation resilience to Climate Change and extreme droughts/rains	InfoSequia /HydroPC	MS2.4 Collected uniform data is used to plan actions to address the negative effects of climate on environmental components <i>Fire warning systems ^^</i>
Integrated Approach	Flood - early warning (Digital twinNelen & Schuurmans, Virtual City)	MS3.3 A national strategic integrated action plan is developed	No need of innovations perse			MS3.4 Legislative framework focusing on an integrated approach to territory management				
Activated Civil Society	Flood - early warning (GoogleDeepMind	MS4.3 The system is finalised in terms of participating institutions, rules and required human resources and	Illegal logging monitoring and control (No ready	<i>ThirdEye drones^ / Fire warning</i>	Poaching - alert system (cameras) (No ready CIW	MS4.4 The system has been actively tested and updated, resulting in a working system for engaging citizen participation in an integrated				

Figure 24: CS6 Bulgaria Innovation pathway period 2030 - 2045 *in red: innovation gap (innovation not yet developed or not yet identified)

3.6.2.4 Barriers and enablers

The implementation of the Innovation Pathway in Ropotamo Reserve faces several important barriers and enablers. The summaries below highlight the key messages to be communicated to policymakers and stakeholders.

Regarding the overall sustainability aspect of the case study, the main barriers are: Political instability and lack of strategic support can slow down the adoption of new technologies and practices. This is combined with high implementation and operational costs, resistance to change, potential technological complexity, regulatory compliance issues (stemming also from the protected aspect of the area), and extreme weather events. However, EU support and supportive national legislation can provide crucial and vital foundation for innovation. Planning and actively searching for funding opportunities, along with increased understanding of climate change, advances in communication and data analysis, adoption of supportive regulations, and integration with climate adaptation strategies are the factors that can enable progress.

When it comes to innovation for higher level of awareness, policy gaps and lack of proactive public collaboration, high development costs, skepticism about new systems and resistance to data sharing, complexity of digital twins, challenging compliance with data protection laws when dealing with data sharing, and climate change impacts on existing (and future) model accuracy can impede progress, are the main barriers. Support from climate policies, increased public interest in forecasting and sharing solutions, adopting ready solutions adapted to local contexts, changes in legislation, and adaptation strategies can enhance awareness on the other side will favor raising awareness.

An integrated approach to wetland management is highly needed but inter-agency lack of structured cooperation, lack of political will, resistance to change (public, societal, business), technical complexity, and regulatory compliance issues can hamper collaborative efforts are key barriers to be overcome. National government support, public and stakeholder engagement, including public support for integrated measures, advanced technologies to support challenging integration (including AI), supportive regulations, and adaptation strategies based on integrated approaches to provide solutions can support successful integration.

Activating civil society engagement would be hampered by slow policy adoption of new initiatives, public skepticism, technological complexity in regard to adopting available new ideas, and lack of legal framework can impede new initiatives. Raising awareness on the importance of civil society, identifying funding for innovative projects, increased public interest, and advances in technologies can increase engagement and implementation.

By addressing these barriers and leveraging the enablers, the Ropotamo Reserve can successfully implement its Innovation Pathway and achieve its sustainability goals.

Details of the barriers and enablers identified for each sector / theme of the CS6 innovation pathways can be found in appendix 7.

3.6.3 Turkey

The Black Sea is a unique marine ecosystem that may face serious climate-induced problems exacerbated by anthropogenic influences. Concentrating on the south-western coast of the Black Sea including its connection to the Sea of Marmara through İstanbul, the focus of the case study is marine water quality, which is an important indicator for a healthy Black Sea. Therefore, for the south-western Black Sea, the idea is to improve resilience through innovations that will increase adaptive capacity and resilience of the case study area to climate change and other anthropogenic drivers.

The Black Sea coasts including southwestern coast have “bad water quality” with high turbidity, high nutrient levels, coupled to frequent occurrence of harmful algae blooms, and hypoxia. (BSC 2019) Climate change induced risks addressed in this case study are warming and eutrophication that risk water quality.

3.6.3.1 Problem statement

How do we ensure that Southwest Black Sea is resilient to climate change-induced impacts and to allow sustainable blue economy to flourish while maintaining/restoring a healthy ecosystem state?

3.6.3.2 Vision

The southwestern Black Sea is a synonym for Blue Economy. It is well known for its holistic and integrated planning and management of various sectors functioning in harmony with the natural environment and is highly resilient. Energy demand is met by green sources with a large storage capacity and the region is carbon neutral. Urban centers are placed in interior parts not to impact the coastline. However, there are engineering structures that protect coasts and ecosystems from anthropogenic and climate change impacts. The only mode of mass transportation is railway. Marine transport is also improved and does not disturb marine life. The industrial fish fleet is halved. Small-scale fisheries are dominant. Gender equality is achieved in the sector and fishermen and fisherwomen actively take part in conserving fish stocks and biodiversity, which is not a concern anymore. As a result of strong efforts, marine biodiversity in the region is back including sturgeon and bluefish. Technology is intensively used for monitoring and conservation activities on land and in the sea. There is an underwater observatory, which is also used for tourism. “Ecotourism” as a term is replaced with “responsible tourism” and is the main sector. It is supported by outdoor sports activities and cultural and historic heritage, and these take place in all seasons. The region is one of the pesca-gastronomy centers. Using marine and coastal products, new and authentic tastes are offered. The region is governed by an international assembly of Black Sea countries. Local governments are also strong, so they are efficient in pollution prevention and natural resources management. Citizens are well-informed on sustainability through advanced education and ocean literacy activities integrated into official curricula and are empowered. They participate in the governance of the region as well as contribute to monitoring and conservation.

3.6.3.3 Innovation Pathway

The above vision has been jointly developed with stakeholders involved in Istanbul Living Lab from the H2020 BRIDGE-Black Sea project to mutualise forces and avoid “stakeholder fatigue” as the 2 projects seek similar goal, agenda, timeline and participant within the scope of the second round of Living Lab workshop. It enables the two projects to mutualise forces and reduce duplication of work. However, the ARSINOE and the BRIDGE-BS projects had different approaches to pathways. While the BRIDGE-BS opted for a wider approach to future trajectories (“sustainability transformation” approach) for the sustainable development of the blue economy in the region, the ARSINOE project is looking more specifically at the role of innovations with the co-design of innovation pathway. In the context of CS6, the emphasis has been made on the monitoring and data collection aspects, identified as a major short coming for climate change adaptation and resilience. The BRIDGE-BS transformative pathways and ARSINOE innovation pathway are complementary approaches to achieve the above vision.

The Turkish CS6 innovation pathway is focusing on technological innovations able to mitigate present and future human induced impacts on marine biodiversity (i.e. from fishery and aquaculture activities and land-based pollutions) and ensure the blue economy can thrive in harmony with a healthy marine environment. Many technologies are yet to be fully developed; high expectations are put on the possibilities offered by AI related innovations to radically transform data collection and management capacity for marine biodiversity observation and preservation.

A smart monitoring sensor system will be tested within the ARSINOE framework.

sectors	innovations			MS 2025			MS 2030
Monitoring	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures	Integrated seawater pH, pCO2 and O2 monitoring system (ARSINOE CIW)	Identification/monitoring of marine waste source(s) using remote sensing and other data processing technologies*	Coordination is established between existing monitoring projects and infrastructures in the PS area. Technology gaps are identified and a roadmap specific to the PS area is developed.	Seamless monitoring data integration to Digital Twins		Underwater in situ observatory technology demonstrator deployed and validated.
Waste Management	nitrate sensor for wastewater monitoring			Sensor technologies tested and validated for wastewater source monitoring	Cost minimizing materials and applications	Innovative, carbon neutral building materials	Green buildings with zero waste and full circularity demonstrated in experimental neighborhoods
Cultural/Historical Heritage	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures including archaeological remains and shipwrecks.			Site selection and mapping needs are drafted as a Black Sea Cultural Heritage Implementation Plan	No need of innovation per se		All heritage elements such as biodiversity hotspots, shipwrecks and underwater archaeological settlements in the marine and coastal habitats are identified and mapped.
Fish Farms	No need of innovation per se			Unsustainable fish farming practices are defined and a roadmap for their replacement is in place.	No need of innovation per se		Significant few policies are in place for all sectors in the blue economy
Catch Fisheries	No need of innovation per se			new policy development for small scale fishery development	No need of innovation per se		80 percent of capture fisheries is ecosystem based managed.
Biodiversity/Conservation	Autonomous marine robot, autonomous submarin	AI-powered identification of marine and land stocks	new identification techniques such as eDNA to monitor marine biodiversity	Digital Twins including biodiversity layers are produced.	No need of innovation per se		Marine Spatial Planning Directive is in place.
Planning			new identification techniques such as eDNA to monitor marine biodiversity	Nationwide PhD program on marine planning in place to fill in expert gap.	AI-fed by monitoring data used for planning to better identify needs		Marine Spatial Planning Directive is in place.
Net Zero Carbon	Wave power technologies, offshore wind power	Net zero technologies for shipping		Policy is in place for net carbon zero targets for all sectors.	No need of innovation per se		Carbon net zero technologies start to be widely adopted by all sectors.

Figure 25: CS6 Türkiye innovation pathway from present to 2030 *in red: innovation not yet fully developed or does not yet exist (innovation gap); in green: innovation implemented within ARSINOE framework

sectors	innovations		MS 2035	innovations		MS 2045
Monitoring	Electrochemical, fast responding seawater nitrate and phosphate sensor	AI-supported, intelligent and responsive underwater sensing and monitoring platforms smartly reacting to extreme climate events and ecosystem shifts	30 percent of the PS are declared as marine protected area with observatories and conservation monitoring technologies	Underwater E-DNA analyzer capable of rapidly assessing biodiversity shifts - powered by AI and big data analytics	Fully operational Digital Twin including all levels of ecosystem functioning so habitats are monitored in real time	Southwest Black Sea Land-sea protected area established where sustainable blue economy is demonstrated with all sectors and benefits monitored with in situ technologies
Waste Management	Autonomous underwater vehicles (AUVs) capable of detecting and tracking pollutants		Infrastructure installed for swarms of underwater vehicles to detect pollution	marine waste monitoring*		Wastewater is eliminated at source: Possible max number of green buildings are established and only fully treated wastewater is introduced to the sea.
Cultural/Historical Heritage	No need of innovation per se		Ecotourism is well invested in with a multitude of options available in different coastlines of the Black Sea.	No need of innovation per se		Southwest Black Sea becomes world class attraction center for ecotourism and heritage-based underwater tourism providing visitors with unique, high-tech boosted holiday experiences.
Fish Farms	Early warning system against epidemic in fish farms	Environment-friendly fish-feed	Sustainable fish farm with minimal impact and equipped with high tech monitoring systems is demonstrated to sector people.			All fish farms have minimal/reversible impact on ecosystem, with participation of all genders and stakeholder groups, systems revised and updated with regular stakeholder input.
Catch Fisheries	AI-powered identification of marine and land stocks	remote sensing monitoring of illegal fishery / innovative technologies to monitor over-fishing	Industrial fish fleet is halved, the remaining fleet is technologically updated and made carbon neutral and low-impact.			Fish stocks are back to their 1950s level.
Biodiversity/Conservation	AI-fed regional planning					Southwest Black Sea protected area established, with biodiversity restored and conserved for future generations
Planning	Three dimensional digital twins for MSP developed at a high TRL level.		For land and for sea 1/100000 implementation plans are renewed.		Cost minimizing materials and applications	Land-sea plans are jointly implemented, managed as an integrated whole.
Net Zero Carbon	marine waste monitoring*	Autonomous underwater vehicles capable of detecting carbon compounds in situ	Plans and investments for the carbon-neutral sectors are in place.	algae-based bioenergy		The land-sea integrated Southwest Black Sea pilot area is a world class example for being carbon neutral as a whole.

Figure 26: CS6 Türkiye innovation pathway from 2030 to 2045 *in red: innovation not yet fully developed or does not yet exist (innovation gap)

3.6.3.4 Barriers and enablers

The main barrier and enabler is the political will in Türkiye, where the central authority holds all the power. *Ceteris paribus* changing governments will change vision, perception, and priorities related to legislation and execution so even supportive economic and social conditions may not enable the implementation of the pathway and vice versa. For instance, a future government may prioritize biodiversity/nature conservation and promote innovations such as an autonomous marine robot. Referring to environmental Kuznet's curve, economic growth is another important enabler, i.e. reaching a certain income level increases spending on environmental protection. On the other hand, inflation or stagnation renders investments costly and in case of limited financial resources, other types of investments than environmental might be preferred. One other barrier is the private sector's reluctance to R&D investments. Considering the marginal effect of coastal and marine protection on profitability, returns on investment would probably be low and the private sector would abstain more from the sector. Lack of data is another barrier to AI technologies, which require large data sets. Thus, the development of such technologies may be longer until enough data is generated to train models. Increased public awareness and strong NGOs are important as the demands and needs of the public are assumed as the determinants of governments and political will. Additionally, new regulations and codes are required to generate demand for some of the technologies and innovations, e.g. cost-minimizing materials and applications. Finally, political stability in the Black Sea region is essential.

Details of the barriers and enablers identified for each sector / theme of the CS6 innovation pathways can be found in appendix 7.

3.6.4 CS6 Regional level

3.6.4.1 Problem statement

"Within a source-to-sea approach, how can data collection and monitoring across the Black Sea region support the good environmental/ecological status (as referred in the MSFD) of fresh water and marine ecosystems in a climate change context?"

3.6.4.2 Vision

In 2050, monitoring and data collection in the Black Sea region is a collaborative effort through the interregional Black Sea Observatory, facilitating the collection of data with common principles and parameters. This includes a common classification system continually updated to reflect the status, with citizens trained and encouraged to participate in the process. The use of AI and machine learning techniques helps identify errors and detect missing data, while low-cost monitoring stations and DIY technology are established and connected directly to the common database. Monitoring utilizes cross-cutting technologies, including remote sensing/satellite data, UAVs, and AI/deep learning techniques, and data are available under the FAIR principle, incorporating social data to better serve society's needs. Collaboration between the private and public sectors and the communities is strengthened, empowering local governments to make informed decisions based on data analysis.

3.6.4.3 Innovation Pathway

ARSINOE's Case Study 6 Black Sea focuses on connecting upstream land uses and coastal and marine ecosystems of the Black Sea. Its aim is to bring out innovative approaches including Nature Based Solutions (NBSs). It intends to follow an integrated watershed management approach from source to open sea and provide climate-resilient good practices. Within the project's scope, CS6 worked with stakeholders at a local and international level to decide the vision for the Black Sea and to identify the innovation pathways needed to fulfil the developed vision. To go from "Vision" to "Reality" the Innovation Pathways developed focus, not only on improved Monitoring and Data Collection and utilisation of AI & Machine Learning technologies, but also on Community Inclusion and International Cooperation, all important parameters to achieve the developed vision through an inclusive societal framework with close interregional and international cooperation.

As it can be easily observed, there are still gaps presented in the innovation pathways, that can be justified due to the uniqueness of the Black Sea region itself, as it consists of a fascinating tapestry of cultures, histories, and economic dynamics. Seven main reasons can be identified that make international cooperation challenging:

1. Cultural Diversity, posing challenges in terms of communication and understanding between nations,
2. Historical Context, the historical context of the region has shaped unique socio-economic structures and mind-sets within each country affecting approaches to innovation and collaboration
3. Geopolitical Complexities, such as territorial tensions, energy resources, and political alliances, all factors that can impede international cooperation
4. Economic Disparities that create unequal partnerships and hinder the sharing of knowledge and expertise
5. Infrastructure Challenges, directly connected to the factors named above
6. Environmental concerns faced differently, as each country has different priorities and resource allocation towards environmental protection
7. Institutional Frameworks, as the legal systems and the regulatory environments differ in each country, hindering the harmonisation of standards and regulations

Considering the above, strong International Cooperation between the Black Sea countries is the only way to reach climate resiliency, especially considering the region's fragility towards Climate Change.

sectors/theme	INNOVATIONS			MS 2025	INNOVATIONS		MS 2030
A.Monitoring/Data Collection	Joined task force to identify critical data sources and guidelines/rules for sensitivity analysis and accuracy	Series of roundtables to determine/develop protocols for data selection and protocol development		[MS.A-25.1] Critical data sources are identified. Characteristics and which sensors should be used (to collect data, in what way and how often) are identified.	Electronic Monitoring Systems (EMS), E-logbooks, Real-Time Data Collection,	WUNDERGROUND	[MS.A-30.1] Common Database is created (e.g. Remote waste identification)
				[MS.A-25.2] Guidelines/rules for sensitivity analysis & accuracy are created for everyone to follow (so they do not need to post-process the data). pre-post protocols for low-cost sensors are established.	(Continuation of Task Force and Roundtable discussion on data collection and interpretation)		[MS.A-30.2] Currently available information are identified
					Establishment of an Interdisciplinary Scientific Group working on climate forecasting for the Black Sea region		[MS.A-30.3] The information needed for more accurate forecasting (30 years ahead) is identified.
					Exploitation of social media for environmental monitoring/measurements		[MS.A-30.4] Distributed monitoring points
					WG of experts to assess and observe the functionality of the collection systems		[MS.A-30.5] Functional data-collection system and diagnosis
B.AI/Machine Learning	Joined task force to evaluate the existing models and their compatibility & performance to AI/Machine			[MS.B-25.1] Existing models and their compatibility & performance to AI/machine learning are evaluated	Establishment of an International/Interregional Working Group (WG) of Experts and Society to draft clear guidelines about data used for AI		[MS.B-30.1] Clear guidelines about handling, using, processing, collecting data used for AI are established
					Development of innovative VET programmes specifically targeted at machine learning education		[MS.B-30.2] Training and educating people for AI/machine learning (creating the

Figure 27: CS6 Regional level - Innovation pathway from present to 2030 for “monitoring / data collection” and “Machine Learning trajectories

sectors/theme	INNOVATIONS		MS 2035	INNOVATIONS				MS 2040	INNOVATIONS	MS 2045
A.Monitoring/Data Collection	Exploitation of social media for environmental monitoring	Training, educating citizens on the importance of climate data & funding the installation of DIY stations	[MS.A-35.1] Up-to-date climate data (air temperature, rainfall, water level, physicochemical monitoring (pollution), water temperature, groundwater levels) are collected by including DIY stations (if they follow some basic/common principles) and socio-economic data	Multihazard Early Warning Systems (MHEWS)				[MS.A-40.1] System developed for utilization of the collected data; plans and measures developed and approved	Standardised sensors - both in terms of measurement and in terms of deployment -	[MS.A-45.1] A "sustainable" upgradable(time-meaning) monitoring stations is established.
				Drone+LiDAR for emergency response	Application Framework Drone System	Monitoring platform for water quality (pollution, eutrophication)	WaterView - IR2 - real-time and diffuse collection of precipitation data (CIW)	[MS.A-40.2] Fully developed early warning system		
B.AI/Machine Learning	Innovation GAP		[MS.B-35.1] Piloting AI models (to be better prepared for a unified database)	no need of innovation per se				[MS.B-40.1] A unified database is established and AI/machine learning is commonly used in projects within the Black Sea area	Innovation GAP	[MS.B-45.1] Integration and optimisation of AI system

Figure 28: CS6 Regional level - Innovation pathway from 2030 to 2045 for “monitoring / data collection” and “Machine Learning trajectories * in red: innovation gaps

sectors/theme	INNOVATIONS			MS 2025	INNOVATIONS		MS 2030
C.Community Inclusion	My Water Level: App to set automatic, location-based warnings for self-chosen low and high water levels.	All4Elevation: turn smartphones into "smart sensors" to conduct elevation measurements for flood prevention	Crowdsourcing of Flood Multimedia for Hydrological Models in the Black Sea	[MS.C-25.1] Structuring citizen participation as a form and a way of working	New kind of games (including toys) to facilitate game and teach science or research methodology	Crowdsourcing of Flood Multimedia for Hydrological Models in the Black Sea	[MS.C-30.1] Research Products are more accessible to the citizens (user friendly and easy to understand) - simplification for the general public
						Innovative STEAM education (including games, challenges etc)	[MS.C-30.2] Producing popular versions of science project findings, data interpretation to engage younger generations and their lecturers/trainers in schools
							[MS.C-30.5] Young generation and citizens are educated for participating in data
					Danube Living Labs Pilot application Potelu Living Lab Romania		[MS.C-30.3] Building trust and better communication between citizens and institutions.
					Open Database for good practices (evaluated by experts -public&private sector)		[MS.C-30.4] Good practices are explored

Figure 29: CS6 Regional level - Innovation pathway from present to 2030 for "community inclusion" trajectories * in red: innovation gaps

sectors/theme	INNOVATIONS	MS 2035	INNOVATIONS				MS 2040	INNOVATIONS	MS 2045
C.Community Inclusion	No innovations needed per se	[MS.C-35.1] Soft measures to stimulate civic participation are in place: communication, campaigns, online presence, open days, gamification	(previous innovations will also support the achievement of this next MS)		Education system restructure for citizen engagement and participation		[MS.C-40.1] A working system for engaging citizen participation in an integrated governance approach is in place		
	No innovations needed per se	[MS.C-35.2] Communication between research project results is enabled by integrating NLP AI models							

Figure 30: CS6 Regional level - Innovation pathway from 2030 to 2045 for “community inclusion” trajectories * in red: innovation gaps

sectors/theme	INNOVATIONS			MS 2025	INNOVATIONS		MS 2030
D. International Cooperation	No innovations needed per se			[MS.D-25.1] Coordination among different scientific and public institutions is achieved			[MS.D-30.1] Updated legislative framework focusing on an integrated approach to territory management & new government structures to support the Black Sea Observatory is developed
							[MS.D-30.2] Financial aid programmes to young scientists/researchers are in place
					(previous innovations will also support the achievement of this next MS)	Methodology on how to create a unified adaptation strategy and response on common strategies	[MS.D-30.3] Governmental support at an international level and intergovernmental efforts for coordination and communication of data collection and monitoring
							[MS.D-30.4] Common channel for data validation and transferring to higher offices (Regulatory Authorities & EU offices) is established, clearly stating who is the validator and who is the transferer

Figure 31: CS6 Regional level - Innovation pathway from present to 2030 for “internal cooperation” trajectories * in red: innovation gaps

sectors/theme	INNOVATIONS	MS 2035	INNOVATIONS				MS 2040	INNOVATIONS	MS 2045
D.International Cooperation	Develop a transparent and well-defined catalogue of validators and transferrers of data - with a common channel	[MS.D-35.1] A system (inter-agency) for dealing with uniform data is established					[MS.D-40.1] New plans with updated procedures based on the results obtained (iteration loops) and tailored data to support decisions		[MS.D-45.1] An Organisation that will manage the developed financial aid for regional research and will ensure research projects' continuation is established
	No innovations needed per se	[MS.D-35.2] Capacity building and training of teams in individual institutions are in place							[MS.D-45.2] Using data to plan actions to address the negative effects of climate on environmental components
	Interregional Intercalibration Exercises between scientific groups	[MS.D-35.3] Working rules established							
	Establishment of an online coordination tool for listing regional research project coordination	[MS.D-35.4] Detailed and documented financial schedule for regional research and research projects continuation							

Figure 32: CS6 Regional level - Innovation pathway from 2030 to 2045 for “internal cooperation” trajectories * in red: innovation gaps

3.6.4.4 Barriers and enablers

The political landscape in the Black Sea region can be characterised by diverse political statuses and strategies followed by the countries within the region. These inconsistencies in the adoption and implementation of sustainability agendas, are further hampered by the lack of political will. Additionally, political dependencies on economically and strategically stronger states impede independent decision making, posing great challenges for the implementation of cohesive policies for monitoring, AI, community inclusion, and international cooperation. Despite these barriers, there are several political enablers that can support innovation. For instance, existing international organisations and alliances can be utilised to foster closer cooperation between the Black Sea countries allowing them to jointly work together, while already established governmental initiatives and national strategies about environmental protection, disaster preparedness and water management are critical enablers, as they align political objectives with technological and educational advancements.

Economic disparities among Black Sea countries create significant barriers to innovation. Differences in economic status and inflation rates hinder investment in new technologies and infrastructures, such as monitoring systems and AI tools. High initial costs and economic instability further challenge the development and maintenance of innovative solutions, particularly in sectors requiring substantial research and investment. Economic enablers include the potential for long-term economic benefits and the availability of funding programs. Profits generated from various economic activities in the Black Sea region can support technological advancements. Additionally, growing funding opportunities for AI and educational programs, coupled with potential cost savings from increased efficiency and predictive capabilities of new technologies, provide strong economic incentives for innovation.

The Black Sea region's multi-cultural landscape poses social barriers due to varying educational levels, societal needs, and understandings of sustainability. Public scepticism about AI technologies and concerns over job replacement also present challenges. Moreover, privacy concerns and differing levels of acceptance of new technologies across socio-economic groups hinder the widespread adoption of innovative solutions. Social enablers are driven by the younger generations' familiarity with and enthusiasm for new technologies. The rise of social media and global communication has influenced younger people to be more environmentally conscious and supportive of sustainability initiatives, acting as a critical demographic agent for political and social changes. Educational reforms integrating new technologies and increasing parental focus on interactive learning tools further enhance societal acceptance and engagement.

Technological disparities between countries in the Black Sea region create significant barriers. The need for continuous updates and integration of new technologies with existing systems requires substantial technical expertise and resources. Additionally, challenges in data accuracy and the need for sensor calibration and real-time data collection complicate the implementation of technological solutions. Technological advancements and widespread internet connectivity are major enablers. Fast internet and broadband connections facilitate research and communication, while existing technologies support monitoring efforts. The rapid advancement of AI and machine learning tools enhances model accuracy and capabilities, emphasizing the need for a regional task force. The availability of smartphones and other digital platforms also supports interactive learning and community engagement.

Legal barriers are closely intertwined with political and technological challenges. Different regulations and data protection frameworks across countries complicate the implementation of new technologies. Especially for accrediting new Vocational Education and Training (VET) programmes regulatory challenges remain, as any educational programme needs to be compliant with national and international standards further hinder progress. Supportive legal frameworks, such as the EU Framework for AI and international agreements like Agenda 2030, provide a foundation for developing new laws and policies. These frameworks facilitate discussions on creating joint task forces and pave

the way for harmonized regulations that support innovation in monitoring, AI, community inclusion, and international cooperation.

Environmental barriers are less prominent but still present challenges, particularly in the potential impact of new technologies on sensitive ecosystems. Furthermore, the need for careful planning of new technological infrastructures and new products is crucial to avoid environmental drawbacks. The increasing frequency of extreme weather events and the demand for renewable energy highlight the urgent need to adopt new technologies. AI and machine learning technologies can significantly aid environmental monitoring and management, emphasizing the need for immediate action. The growing climate crisis also motivates local communities and young professionals to engage in sustainability and resilience efforts.

Details of the barriers and enablers identified for each sector / theme of the CS6 innovation pathways can be found in appendix 7.

3.7 Case study 7: Southern Denmark

Southern Denmark is a region dominated by low-lying coastal areas, coastal cities and vulnerable natural resources where often extreme sea-level rise, storms and runoff events occur. The CS7 partners agreed to focus on the following specific geographical area in Esbjerg: an area along the coast of Esbjerg and part of the inner city was in 2018 pointed out by the EU Flood Directive as in severe risk of flooding from storm surge. According to law this obliged the municipality of Esbjerg to develop a risk management plan. To ensure a holistic management of water in the area, Esbjerg Municipality themselves identified an area in the central part of the city, which is in high risk from flooding from surface water as well as high groundwater levels, as per the Danish Law of Planning.

3.7.1 Problem statement

How to ensure efficient and sustainable flood risk management ensuring citizens safety as well as investment safety for both existing and future investments in city, enterprises, and other values.

3.7.2 Future vision

Wherever people or assets are exposed to water-related challenges and “water from all sides”, solutions are implemented in close dialogues with citizens, and the public and private sectors. This includes blue-green solutions and land connections for the dual benefit of citizens’ welfare and biodiversity. These solutions unite different urban spaces and strengthen the historic links between the city of Esbjerg, its port, and the marine environment. Associated key and “wicked” problems are handled in robust, sustainable, and multifunctional manners, embracing new technical and other innovations. Citizens, businesses, and public institutions are well-informed and contribute in a coordinated way to solving the challenges of climate change and sustainable development founded in a just, economic model.

3.7.3 Innovation pathway

The CS7 innovation pathway has been co-designed to support the Esbjerg municipal risk management master plan against present and future climate extreme events namely flooding and storm surge. The region is particularly in need of new economic models, risk management tools to raise awareness on climate risk and engage the public and the private sector.

Flood-MapEx, Citizenlab, Saferplaces are the solutions to be tested within the ARSINOE framework.

sectors / themes	innovations			MS 2025
Citizen/civil society	INNO #1 Web portal/platform for citizen engagement and communication with the municipality (ARSINOE CIW)	INNO #2 App for direct citizen communication and engagement	INNO #3 Concepts for involving citizens in transformational adaptation and emergency preparedness	MS2025.1 Citizens are informed about flood protection and urban transformation
Public Authority (Esbjerg Municipality, national government etc.)	INNO #4 A multifunctional storm surge barrier			for phase 1 of the storm surge barrier is starting. Financing of phase 1 has been clarified.
Private sector (industry, enterprises and investors)	Inno #1	INNO #5 Pathways or factors to motivate private investments in shared (e.g. public-private) protection solutions	INNO #3	MS2025.3 The private sector is informed about flood protection and urban transformation.
				MS2025.4 The private sector takes an active role in preparing the ("master") plan for the storm surge barrier (Phase 2).
Utility sector (water, wastewater, electricity, district heating)	INNO #6 Identification of potential cascading risks (ARSINOE output)	INNO #7 Climate change risks assessment tool for the (electric) utility sector [assessments comprise more scenarios and factors].		MS2025.5 Improved knowledge of current climate risks to the utility sector(s)
Knowledge institutions				

Figure 33: CS7 Innovation pathway from 2024-2025 *in red innovation gap (not yet developed or need further development)

sectors / themes	innovations		MS 2030
Citizen/civil society	INNO #8 (a) New economic model encourages and motivates citizen/civil society to contribute economically.		MS2023.1 Common understanding of the need for and benefits of water and storm surge management is established, including the role ("identity") of citizens and civil society
	INNO #8 (b) New economic models clarifies economic measures needed of the public sector; motivates implementation.		MS2030.2 Masterplan or programme for "climate resilient urban transformation" in Esbjerg including phase 2 of the storm surge barrier has been finalized
Public Authority (Esbjerg Municipality, national government etc.)			MS2030.3 Phase 1 of the storm surge barrier (Højvandsmuren) at a level of 4,8 m is established
			MS2030.4 Detailed project planning for phase 2 of the storm surge barrier is starting, including financing
Private sector (industry, enterprises and investors)	INNO #9 Tourist service: "Water communication for tourists in German/English". AI-based or a real person.		MS2030.5 Investors (private sector and local stakeholders) contribute actively to heightening and implementing the master plan
	INNO #8 (c) New economic/ finance models motivates the private sector to contribute economically to common solutions.		MS2030.2 Masterplan or programme for "climate resilient urban transformation" in Esbjerg including phase 2 of the storm surge barrier has been finalized
			MS2030.4 Detailed project planning for phase 2 of the storm surge barrier phase 1 is starting.
Utility sector (water, wastewater, electricity, district heating)	INNO #9 Improved management of risk to the (electric) utility sector		MS2030.6 The electricity grid is unaffected by climate ri
	INNO #10 Novel pumping system (new technologies) for solving back water problems		MS2030.7 Back water problems has been solved/reduced
Knowledge institutions	INNO #11 Improved models for projecting/assessing storm surges and their impacts (ARSINOE)	INNO #12 Improved decision-making tools based on novel AI/ML technologies (ARSINOE2)	MS2030.8 Knowledge institutions are actively involved in plans for flood protection and urban transformation; shares experiences from other countries, cities, to facilitate science-informed decisions.

Figure 34: CS7 Innovation pathway from present to 2030 *in red innovation gap (not yet developed or need further development)

sectors / themes	innovations		MS 2050
Citizen/civil society	INNO #13 (a) Education in "climate catastrophes" (prevention, preparedness) for adults (e.g. EducationEsbjerg)	INNO #13 (b) Education in "climate catastrophes" (prevention, preparedness) in public schools	MS2050.1 Citizens are active players in and support climate adaptation and are well informed about crisis preparedness, including their potential roles
Public Authority (Esbjerg Municipality, national government etc.)			MS2050.2 Phase 2 of the storm surge barrier is established at a level of 6 m
	INNO #14 New multi-functional harbour facilities and systems		
Private sector (industry, enterprises and investors)	INNO #15 Visitor Centre for experience / knowledge about climate, offshore, energy, catastrophes and more.		MS2050.3 Quayside 2.0 established
	INNO #16 New means for protecting buildings against residual climate risks, e.g. west of phase 1 of the storm surge barrier		
	INNO #18 New off-grid solutions		
Utility sector (water, wastewater, electricity, district heating)	no innovation needed per se		MS2050.4 Well defined areas of responsibility and financing for management of groundwater, surface water and seawater. Utility sector has emergency preparedness systems in place for managing crisis situations. Surface water is handled on terrain and coordinated between municipality, utility and citizens.
Knowledge institutions			

Figure 35: CS7 Innovation pathway from 2030 to 2050 *in red innovation gap (not yet developed or need further development)

3.7.4 Barriers and enablers

The themed barriers and enablers for each innovation are shown in the below tables. Overall, the key barriers and enablers are most often related to the political, economic, social, and technological themes. This is due to the innovations' focus on a broad stakeholder engagement of civil society, the private sector, and the role of the public sector. This leads to challenges of what is feasible from a social perspective, as many interests need to be included, while at the same time, not all solutions are feasible

from an economic and/or technological perspective. To address these barriers, communication of project processes and inclusion and engagement of all stakeholders is essential.

Details of the barriers and enablers identified for each sector / theme of the CS7 innovation pathways can be found in appendix 7.

3.8 Case study 8: Torbay & Devon County

Torbay, located in the English Channel in Devon, South West England has suffered from flooding over many years from a number of different sources, including surface water run-off, highway flooding, sewer flooding, main river and ordinary watercourse flooding during intense rainfall events.

The Torbay Living Lab was framed as being at the intersection of water, infrastructure, health, transport and biodiversity, with flooding being a connector among these themes and topics. Challenges set by existing climate impacts of flooding within Torbay link out to social and infrastructural issues, which a range of stakeholders are keen to turn into opportunities. Some infrastructure plans have been suggested by the Council but there has been community push-back as none of the plans sit well with the local community. Common ground and collaboration are sought to support the efficacy and effectiveness of any interventions. Nature-based solutions and blue-green infrastructure are being explored by various stakeholders, as well as conventional grey (concrete) ones. (ARSINOE D6.5)

3.8.1 Problem statement

“How can Torbay identify the extent of and reduce the wide-ranging impacts and consequences of future flooding of all types within a context of structured, reactive responses rather than organic, proactive prevention and adaptation; limited collaborative planning, communication and community empowerment; limited inclusion of data and people in solutions in real-time; limited current capacity in systems; and limited mechanisms to join up plans, agencies, sectors and systems across the longer-term?”

3.8.2 Future vision

Climate change impacts are understood and planned for and Torbay is focused on rewilding, greening and water-sensitive urban planning, design and infrastructure (including buildings, roads, hotels etc.) to achieve multiple goals, whilst maintaining Torquay, Paignton, and Brixham’s separate identities. Connection to nature and interconnectedness amongst stakeholders is key, as is shared finance for interventions and access to health services.

Communities are educated and engaged, with decisions being made collaboratively and through co-creation, focused on early-warning, preparedness and protection, particularly of the vulnerable.

Torbay is a Centre of Innovation, not just technological but also financial, economic (e.g. circular economy), social and cultural. Everyone is empowered to play a part and water is loved!”

3.8.3 Innovation pathway

The Torbay innovation pathway is targeting a mix of technological and social innovation to adapt to increase flooding events. Most innovations identified are expected to be implemented within the

decade, which reflect the urgency of the situation as the region is already experiencing extreme flooding events. However, many of the innovation needed are yet to be developed or have not been tested before, thus the region will certainly be a testbed for innovative solutions.

ARGOS and Torbay Community Development Trust are the solutions to be tested within the ARSINOE framework.

Sectors	innovations				MS 2025
Cross-sector Health Community Biodiv Infra Water/flooding	Social prescribing (beginning to happen in region)	2* Climate Literacy Outreach Programme	1* Water is Life Project	5* Nature-based problem solving initiative	2025-1 -People's connection with water & nature has led to improved physical & mental health
	4* Community/School SuDS/NBS			19* Blue Greeb Infrastructure Mapping & Strategy (emerging)	2025-2 -Rewilding/greening/water sensitive urban planning is policy & being implemented
				16* Miyawaki forest (unique approach to reforestation)	2025-3 -Nature-based solutions are used within flood alleviation & the planning process (2024)
			6* Flood-risk roof tax		2025-4 -A policy for green walls/roofs on new developments is co-developed & implemented
	18* Smart' data & AI-based flood warning system (ARGOS, SaferPlaces)	Innovative permeable pavements (new materials or methods)	7* Smart water butts as flood early warning system (SDS/Our Rainwater)		2025-5 -Property flood resilience measures for residential & commercial properties in flood vulnerable areas of Torbay are provided & being used effectively (2023)
	8* Sustainable business model for innovations/implementation	15* Public good/levy for communities	12* Emergency responder resource priority allocation model (ARSINOE)	10* Dashboard (ARSINOE)	2025-6 -Timely access and distribution of resources is achieved – there is knowledge of who is investing in/working on what through monitoring & eval (2024)
	17* Flood Action Group – Devon Resilience flood forum Tools / capacity to keep flood groups alive / legacy	9* Community Water Officer	10* Joy app. Torbay together, Devon Connect link app to website	14* Organisational social networking space	2025-7 -A place (perhaps online) for local good quality, easy to use practical info for use during a time of flood is established (2024)
	1* 13* Climate 'Fear to Hope' Workshops		3* Culture & Creativity Networks 11* Citizen science & observation		2025-8 -Local communities understand and accept risks of and from storm events

Figure 36: CS8 - Cross-sector innovation pathway present to 2025 * in red: innovation gap; in green: innovation funded by ARSINOE framework

Sectors	innovations					MS 2030	innovations	MS 2035	innovations	MS 2040
Cross-sector Health Community Biodiv Infra Water/flood ing							Torbay and it's environment via community initiatives i.e. policy patch school and local green space projects		1* /3*	been daylighted & restored as a water feature for the town
	16*					2030-1 Retrofitting of rain gardens & BGI is standard practice & all sites are allocated for implementation by 2035				
	1#New soil permeability enhancement/de-compaction methods									
	1* / 2* /17* / '18* / 10*	RainShare - community sharing of harvested rainwater Rainwater in toilets Retrofit houses with sustainable water use Way to reuse & sell water back	20* Property flood resilience measures Temporary flood barriers or other devices for high-risk roads and locations Automatic flood barrier for harbour area that would stop overtopping	Flood sensors for roads 2# Property level flood warning sensors	Add on in Google maps to show flooding and depth in case of danger to life from deep water	2030-4 - Support during floods is significantly enhanced Local flood warnings are in place & effective Water usage has decreased from 2023				
						2030-2 Forecasting of & responses to flood events results in reduced after-event clear-up costs (2028)	1* 2*	Better use of waste water /recycling		
	No innovation needed per se					2030-3 - Sustainable housing/development is embeded in a Green Economy with minimum green criteria embedded in local policy				
	Community insurance – Flood RE	15#Public good/levy for communities				2030-5 - Financial help is available for communities impacted by flooding Financial instruments for climate change & flood damage have been implemented				

Figure 37: CS8 - Cross-sector innovation pathway 2025 to 2040 * in red: innovation gap

Sectors	innovations			MS 2025	innovations			MS 2030
Water/flooding	Green currency			2025-9 -Existing enforcement of water policies is Strengthened				
Infrastructure					19*			2030-6 - Public transport & planning to local beaches and coastal footpaths is improved
Biodiversity					3# Pop up shop/ green café/ workshop	3# Drought resistant alternative plants workshop	Beat the Street (existing scheme) but green space equivalent	2030-7 - A policy on climate resilient plants has been co-developed & implemented
Community	4# CC curriculum support package	5# Connection Building Programme	6# Filling the Void initiative	2025-10 -Climate change education/training for educators is compulsory & built into LEA/DfE policy	4#			2030-8 - Compulsory climate change education is happening in all schools
					1*			2030-9 communities have co-created solutions together

Figure 38: CS8 - innovation pathway for water / infrastructure / biodiversity / community * in red: innovation gap

3.8.4 Barriers and enablers

Politically, the primary barriers include the challenges of obtaining regulatory approvals and navigating policy changes, while supportive government initiatives and funding programs can significantly enable progress. **Economically**, the pathway faces constraints due to limited funding and potential economic downturns but can benefit from local economic boosts through tourism and job creation, as well as long-term cost savings from sustainable practices. **Socially**, public skepticism and resistance to new ideas, as well as engagement challenges across diverse community groups, pose significant barriers. However, strong community networks, educational outreach, and active involvement in project co-design can enhance acceptance and participation. **Technologically**, access to advanced tools and the expertise to use them is limited, but leveraging local innovation hubs and providing training programs can mitigate this issue. **Legally**, complex regulatory compliance and liability concerns are barriers, while supportive legal frameworks and partnerships with local legal experts can facilitate smoother implementation. **Environmentally**, the projects must contend with climate variability, existing environmental degradation, and their associated risk. Torbay's increasing environmental awareness offers a strong foundation for success. By aligning with local biodiversity projects and promoting the environmental benefits of the pathways identified, these initiatives can contribute to ecosystem resilience.

Overall, to support these pathways and foster innovation, focusing on promoting sustainable, community-led efforts, increasing access to funding, enhancing community education and fostering collaborative partnerships must be the primary goals.

Details of the barriers and enablers identified for each sector / theme of the CS8 innovation pathways can be found in appendix 7.

3.9 Case study 9: Sardinia

The Sardinian Case Study addresses the following goals: (1) ensuring food security in the face of climate change; (2) ensuring sustainable food production based on local chains; (3) stimulating sustainable food processing; (4) promoting sustainable food consumption and facilitating the shift to healthy sustainable diets. Since staple food production is projected to be seriously threatened by climate change in the area and considering the strategic importance of durum wheat and its end-use products to preserve food security and avoid social conflicts, particular emphasis in this Case Study on durum wheat crop and its related focus areas (water, energy, food, ecosystems) has been given (ARSINOE D6.5). From an agricultural viewpoint, this global approach is based on two strategic pillars: (i) genetic improvement in order to select and release new genotypes to enhance and stabilize yields in a climate change context; (ii) sustainable crop management techniques based on conservative agriculture and precision agriculture in order to preserve and/or restore natural soil fertility and optimize the use of agronomic inputs such as chemical and fertilizers

3.9.1 Problem statement

“How to enhance and stabilize sustainable and resilient food production under conditions of climate change and limited production inputs, such as land, water, energy, and others (fertilizers and pesticides)?”

3.9.2 Future vision

Sardinia 2050 will be a successful reality for agricultural production. There will be a re-appropriation of agricultural lands by farmers. New crop management techniques will be adopted, and new varieties will be selected to tackle increasing temperature and more erratic precipitations due to climate change in Mediterranean conditions. Agricultural technology and machinery as well as more efficient use of water resources and renewable energy will be implemented. New control technologies for extracting ground waters and reducing salinization will be used and interconnected reservoirs to cope with drought periods will be enhanced. Durum wheat and cereals will be more profitable and farmers producing more sustainably will be rewarded. Integrated agriculture and precision farming will be commonly applied, and soil ecosystem services will be valued. Reliable seasonal forecasts will be implemented to optimize timing and crop management interventions. Sustainable agronomic inputs, including the use of organic fertilizers from circular economy, will be widespread. Training for agricultural workers will be provided, dialogue between all actors of the food supply chain will be enhanced, and there will be greater awareness in consumer choices in favor of sustainable, locally produced foods. Food waste will be minimized through increased information and awareness among producers and consumers. Information to cope with climate change will be free and available for all. Climate-resilient policies will be implemented to lead to the sustainable and resilient agricultural development of Sardinia, meeting the challenges of the main SDGs.

3.9.3 Innovation pathway

CS9 focuses on the agriculture sector including the local food chain and the related water and energy sector. Many of the milestones identified by stakeholders do not necessary need innovations to be achieved but rather policy measures (to be further explored within Task 6.4 and reported in deliverable 6.8).

Four innovations are being tested in the case study: Innovative biostimulants for plants (CONCIMI BIOLOGICI); smart agriculture technologies (Lobelia-AgroClimate), Integrating Rain harvesting and solar pumping (SOLAR PUMPING); participatory certification system (COCCOI IGP).

sectors	innovations				MS 2030
Sustainable agriculture	Lobelia.AgroClimate for South Sardinia: digital technologies to support agriculture,	CONCIMI BIOLOGICI: : Innovative Biostimulants for Crops in the Mediterranean Island as an innovative circular economy tools -	new machines and tools such as reliable Decision Support System (DSS) based on crop simulation models (CSM); advanced statistical methods (e.g. multivariate methods); Artificial Intelligence (AI) algorithms and remote sensing technologies that optimize the use of agronomic inputs (e. g. water, fertilizers)"	Spreading conservative agriculture at in-farm level (e.g. minimum tillage; sod seeding)	MS1. Stabilizing/improving food production by changing/optimizing the use of inputs to provide more sustainable food
			driven-assisted tractors, precision drills and spreading machines (e.g. spreading fertilizers and chemicals)		MS8. Improving farm competitiveness
	Block chain, panels, participatory certification systems, traceability and supply chain/product certification				MS2. Enhancing access and information on food production sustainability process towards the consumer (e.g. Carbon footprint) as well as transparency of the food supply chain (e.g. origin and processing).
					MS5. Information, dissemination and training
					MS10. No frauds (e.g. forbidden agronomic practices; misleading information on the origin of production; unjustified incentives)
Local food chains	COCCOI IGP: provide block chain and panels technology and participatory certification systems				MS8. Improving farm competitiveness
	no innovation needed per se				MS5. Information, dissemination and training
Water and energy	SOLAR PUMPING: Integrating Rain Harvesting and Solar Pumping for Aid Irrigation as new sensors and water storage systems with use of Sustainable Energy				MS7. Water efficiency of the agricultural supply chain

Figure 39: CS9 - Innovation pathway present to 2030 * in red: innovation gap; in green: innovation funded by ARSINOE framework

sectors	innovations		MS 2040	innovations			MS 2050
Sustainable agriculture	Optimizing control tools (e.g. food production system)	Early Warning Systems (EWS) to prevent extreme events and environmental disasters -	MS12. Ensuring the hydrogeological safety of the territory	New machines and tools that reduce GHG emissions			MS9. Achieving a Carbon Neutral Agriculture
	Soil ecosystem services monitoring protocols			no innovation needed per se			MS11. Developing food production systems from sustainable agriculture
	no innovation needed per se		MS 13. Enhancing employment in agriculture				
	Selecting and releasing new crop varieties adapted to climate change conditions		MS1. Stabilizing and/or Improving food production by changing and/or optimizing the use of inputs to enhance sustainable food production				
Local food chains	COCCOI IGP: support local food production chains involving farmers and end-users -		MS2. Improving access to information on sustainable food production processes to the consumer (e.g. Carbon footprint); providing information about all the agri-food chain steps (e.g. origin of food production; site(s) of food processing); implement innovation and/or tool prototypes	COCCOI IGP: provide traceability through product certification (e.g. UE commercial branding)			MS3. Reducing food waste
				no innovation needed per se			MS4. Increasing local food production and reducing dependence from imported food
Water and energy				Energy communities	in-farm hydrogen micro-generators with energy storage system	new control technologies for extracting ground waters and reducing salinization)	MS6. Increasing energy efficiency of the agricultural agri-food supply chains

Figure 40: CS9 - Innovation pathway from 2040 to 2050 * in red: innovation gap; in green: innovations funded by ARSINOE framework

3.9.4 Barriers and enablers

The main political barriers to implement innovations aiming at adapting agriculture and food security in climate change conditions deal with the gap between the urgency of measures tackling climate change and the poor readiness of regulations both at central (i.e. UE, Governments) and local (i.e. Regions) level. This is due to: changing Governments; conservative lobbying; technical times to: (i) legislate, (ii) implementing general directives into national and regional laws, (iii) implementing regulation etc. However, the pressure of public opinion on decision-makers is creating a positive trend for governmental policies framed into the European Green Deal, IMO emission regulation and From Farm to Fork Strategy.

As regards the economic aspects, the main barriers are to be found in limited spending capacity, credit access and high innovation costs on the part of agri-food producers (i.e. farmers and food processors), especially the small ones (e.g. land smallholders). From the consumer's point of view, the equivalent

can be found in limited purchasing power. Other general points are a certain resistance as well as an inertial attitude towards innovations both on the producer and the consumer side. From this viewpoint, a special focus on low interest rates for capital investments and for the implementation of innovative solutions can be powerful tools to break down these economic barriers.

Concerning social issues, cultural resistance to change, particularly in the low-education class, can play a primary role in hindering the spreading of innovations. Focus on education and enhanced access to social communications can help to overcome social resistance to innovation.

While technology is the main factor in spreading and implementing innovations, low average know-how level, resistance and/or limited access to innovations can jeopardize its possible beneficial effect. However, the accent on data availability, disruptive technologies and processes and low-cost technology innovation will help to outweigh the technological barriers to innovation.

In terms of legal aspects, a permissive regulation for food waste production and restricted access to funding for spreading the innovation are still strong legal barriers to spreading and implementing innovation. Legal interventions aimed at facilitating the implementation of innovation in agriculture should focus on i) incentives and supporting regulation for sustainable practices (e.g. conservative and/or precision agriculture; amendments and fertilizers from circular economy); ii) soil protection regulation. In terms of agri-food chains: regulations encouraging and supporting agreements between the chain actors and, more in general, supporting regulations for fighting climate change (e.g. duties on polluting industrial and agricultural productions).

The environmental, multifaceted impact on agricultural production is to be found in: high-performing new machinery (e.g. seed drills and threshers) affecting soil structure, increased soil and air pollution due to food waste, use of smelly products from waste processing (e.g. composts from circular economy), decreasing groundwater level and soil salinization due to excessive irrigation. Effective enablers can be found in long-term soil fertility conservation and restoration, low-input agronomic practices (e.g. minimum tillage and sod seeding), low GHG emissions due to reduced dependence on long distance imports and, more in general, enhanced information about production sustainability.

Details of the barriers and enablers identified for each sector / theme of the CS9 innovation pathways can be found in appendix 7.

3.10 Synthesis

Based on the ARSINOE case studies, the key climate change risks faced by the European regions are higher temperatures and changes in water regimes leading to drought, water scarcity, and flooding which are expected to have drastic impacts on agriculture, human well-being, and infrastructures. The impacts of climate change on biodiversity are also of great concern. The strategy to adapt to climate change hazards is context specific, nonetheless most regions are targeting innovative interventions to sustainably manage water, engage local communities and tackle environmental impacts and biodiversity loss.

3.10.1 Key fields in needs of innovation

As shown in figure 32 below, to tackle climate change risk, such as increase heat and drought, innovations are primarily needed to better manage water and soil and support the agriculture sector to adapt to new farming conditions. Driving the farming sector (Canary Islands; Danube Delta; Sardinia) and cities (the city of Athens) towards sustainability will also require innovations in the energy sector to increase the adoption of renewable energies and reduce the overall sectoral energy consumption, thereby mitigating climate change. For the case studies tackling water scarcity (Danube Delta; Main River; Prespa and Orchid lakes), investing in innovation for a better water and soil management was identified as a priority. As changes in the water regime are expected to negatively impact local biodiversity, innovative practices to manage natural ecosystems are essential. Finally, social innovative practices to facilitate community engagement and raise awareness in climate change impacts, adaptation and resilience practices are needed. The case studies facing water flooding including storm surge as the main climate hazard to tackle (Ropotamo complex in Bulgaria; Southern Denmark; Torbay and Devon County) also identified water management and community engagement as crucial area for innovation. Additional innovations are critically important for risk management and impacts on infrastructures (better assess, predict, prevent and protect against the risk).

The need for innovations in the fishery and tourism sectors is context dependent (whether the sector is of importance in the region), and is often identified to render fishery or tourism practices more sustainable rather than answering the need for adaptation to climate risks.

The need for innovative practices regarding governance and planning identified in Turkey and the Black Sea region is broad. In case of the Prespa and Orchid lakes and the Mediterranean ports this need is particularly essential due to their transboundary nature. These case studies involve different national administrations, which add an extra layer of coordination required to develop a common response to shared resources or mutual interest.

Case studies	Climate Change risks	Fields of intervention										
		Water	Community engagement / Education	Environment / Biodiversity	Soil management / Agriculture	Energy	Risk management	Fishery	Tourism	Governance / Planning	Port / Infrastructures	Urban greening
CS1	Urban Heat	x	x			x	x					x
CS5	Drought / increase heat	x			x				x			
CS9	Drought / increase heat	x			x	x						
CS6R	drought / water scarcity	x			x			x				
CS3	Water scarcity	x	x	x	x							
CS4	Water scarcity	x	x	x	x	x		x	x	x		
CS6B	Water flooding	x	x	x			x					
CS7	Water flooding	x	x				x					
CS8	Water flooding	x	x	x							x	
CS6T	Marine ecosystems changes			x				x	x	x		
CS6I	Biodiversity loss		x	x						x		
CS2	Extreme weather events			x		x	x			x	x	

Figure 41: Targeted areas of intervention depending on climate change risks

3.10.2 Key barriers and enablers to support innovations for climate change adaptation

Barriers and enablers for the implementation of the innovation pathways in each case study were identified using the PESTLE framework. Despite the diversity of context, climate risks to be tackled, and innovations targeted, generic barriers and enablers for climate adaptation innovations can be derived from the ARSINOE case study regions.

Political and legal barriers and enablers

In many European regions climate policies are still not adapted to the urgency of the crisis. Climate adaptation is often not the focus of policy, reflecting a lack of political will and commitment in certain sectors. Inconsistencies between adoption and implementation of climate change policies highlight the difficulties faced by administrations in harmonizing changing policies across different levels of governance (from supra national to local). This is also a key barrier. Political instability and short-term political views hamper the implementation of climate adaptation innovations. Closely linked to political barriers are legal barriers, such as delays in adapting the legal framework to new conditions driven by extreme climate change. The regulatory framework is perceived in many case studies as a barrier to innovation. As many innovations fall in the domain of data collection and management, such as artificial intelligence (AI) related technologies, concerns about data privacy and reluctance to share data can prevent the rapid implementation of AI-related technologies. Fortunately, enablers do exist that can facilitate climate adaptive innovation, countering the previously mentioned barriers, starting from EU policies and funding that favour the European innovation ecosystem (EU Climate and Environment related policies; growing funding opportunities; New EU AI framework). Cooperation mechanisms across academia, industry, and society are also seen as a strong enabler. Finally, pressure from civil society to unlock policy barriers is seen as a major factor.

Economic barriers and enablers

While growing funding opportunities have been identified as policy and an economic enabler, there is still a general perception that funding is lacking for implementing technological innovations. This has been identified as a critical economic barrier for the innovation pathways implementation, along with a certain reluctance from the private sector to invest in innovation due to high economic uncertainty, particularly in the field of environmental monitoring, which is not necessarily profitable. Upfront high cost is also seen as a barrier to innovation, from the research and development stage to implementation. Nonetheless, incentives to adopt green practices and reduction of damage costs in the long term should accelerate the adoption and implementation of climate adaptive innovations.

Social barriers and enablers

The cultural resistance to change by adopting new practices or technology has been identified in many of the ARSINOE European regions. This resistance is linked to scepticism regarding new technologies (i.e. AI) or fear of jobs replacement (e.g. due to automatization of tasks), posing a social barrier to the adoption of innovation. Moreover, this resistance to change is reinforced by a lack of awareness. Therefore, education, awareness campaigns on social media about climate change impacts and solutions, as well as environmental activism, community networks and project co-design with local stakeholders is some of the key social enablers.

Technological barriers and enablers

Lack of knowledge and skills, along with difficulties in accessing knowledge, have been identified as some of the main barriers to the spread of technological innovation. Additionally, issues related to data availability, access and standardisation pose challenges, as technological innovations are often data consumption intensives.

Local innovation hubs and low-tech innovations are seen as promising enablers.

Environmental barriers and enablers

Lack of environmental data to support technological innovation such as AI or Digital Twins is a barrier for the implementation of those innovations.

Interestingly, climate change impacts themselves are seen as enablers by creating an urgent need for climate adaptation. Additionally, previously mentioned environmental awareness and enhanced information on sustainable production can trigger change, boosting the adoption of climate adaptation innovations.

3.11 Recommendations

Strengthen climate policy frameworks

Immediate actions are crucial to achieve climate resilience by 2050, as developing, implementing, and evaluating climate resilience measures require time, with some taking longer to show effects. Climate resilience efforts at local and regional levels should be supported by conducive national and EU policies, such as the EU Green Deal, and a better integration of climate policies across all governance levels, from local to EU or vice versa. This cohesive approach will significantly strengthen climate policies and legislative frameworks, thereby supporting the adoption and implementation of innovative solutions in the field of climate adaptation.

Systemic approach

Addressing climate change impacts require dealing with interconnected challenges thus climate resilience and adaptation strategies should follow a holistic approach, addressing those interconnected challenges across different sectors to avoid maladaptation and resource conflicts. Co-developing integrated environmental climate adaptation strategies with all community stakeholders will enhance the resilience of the interconnected systems against climate change risks and effects.

Utilize a wide range of measures

New technologies offer great opportunities to improve the efficiency and effectiveness of existing and future systems. Nonetheless, effective adaptation strategies should employ both known and innovative measures, including infrastructural, technical, nature-based approaches, behavioral changes, governance solutions, and awareness raising.

Skilled workforce

The swift digital transformation of the workplace necessitates the implementation of upskilling and reskilling programs. These programs are essential to ensure that innovative technologies are rapidly adopted and to mitigate resistance to change. Simultaneously, developing training programs for specialists in climate resilience across all sectors and within administrative roles will accelerate the implementation of climate adaptation measures. Individuals equipped with knowledge of climate resilience, who comprehend the associated challenges, will be better positioned to effectively enhance climate resilience within their respective fields.

Foster collaboration

Encourage collaboration among public institutions, stakeholders, and communities to ensure successful synergies and multi-level contributions

Wide public engagement

Achieving climate resilience needs widespread public support, fostered through effective communication, education, citizen participation, and framing change as an opportunity. Public awareness of present and future climate change effects must be further increased; citizens should be engaged through innovative education, community involvement, and non-profit public initiatives.

Financial support and incentives

Identifying and securing funding opportunities to overcome financial barriers for implementing adaptation strategies such as innovation pathways is of utmost importance. Easy access to financial opportunities to all regions, municipalities, companies, and individuals is a prerequisite to the success of climate protection and adaptation measures while counterproductive financial incentives should be eliminated.

Financial opportunities and constraints are being further explored within WP7 where specific instruments will be identified in each CS to support the implementation of the innovation pathways.

4.0 Innovation for Climate Change Adaptation and Resilience

Effectively addressing climate change necessitates a blend of technological and social innovations. Technological innovations focus on developing new tools, processes, and systems designed to mitigate and adapt to climate change, while social innovations entail modifications in behavior, policies, and societal norms to support a sustainable future. It is essential to distinguish between these two types of innovation, as they must be approached differently within a research and innovation agenda.

To effectively develop and implement technological innovations, substantial investment in research and development is crucial. This includes not only significant funding but also the adaptation of infrastructure and the creation of regulatory frameworks that facilitate innovation while ensuring safety, efficiency, and environmental compatibility. Additionally, technologies must be economically viable, and the workforce must be trained and equipped with the skills necessary for developing and deploying new technologies.

Social innovations, defined as creative and purposeful changes in social practices, will also play a critical role in overcoming challenges related to adaptation of climate change. These innovations are vital for fostering the emergence or adoption of new behaviors and practices and for promoting a more sustainable and resilient society.

Overall, ARSINOE innovation pathways are dominated by technological innovations with two exceptions (CS3 – Main River; CS8 –Torbay and Devon County) where local stakeholders prioritized changes in societal behaviors, norms, and policies over innovative technologies to adapt to climate risk related to water scarcity and flooding.

4.1 Innovations to adapt to climate change risk

This chapter summarizes the main innovations (technological and social) identified within the ARSINOE innovation pathways for each of the key field of intervention (3.10.1.).

4.1.1 Technological innovations

The full list of technological innovations identified within the ARSINOE innovations pathways can be found in appendix 6.

Water management

This is by far the field with the highest number of existing innovations (50) identified within the ARSINOE pathways. It reflects the severity of impacts climate change is having on the water resource globally, affecting its distribution, quality and availability across regions. These impacts have profound implications for ecosystems, agriculture, human health, and overall society, thus the urgency to change the ways communities are using and managing the resource. The technologies to be replicated and adopted to adapt to increasing heat, drought and water scarcity range from innovations to cool cities and provide access to potable water, flood infrastructure protection and early warning systems, to digital monitoring with solutions for collecting real time data and now casting, the use of smart phones as smart sensors. New models for water resources as well as new technologies for water treatment and depollution, and for reducing the overall consumption of water are also part of the portfolio of innovations stakeholders have co-designed.

Community engagement and education

In this field, technological innovations are not considered to play a crucial role (overall only 4 innovative technologies were integrated in the ARSINOE IP) but rather serve to provide tools to facilitate citizen engagement and awareness such as online web portal and smartphone applications for direct communication between citizens and policy makers. However, one very promising technology for community engagement and education was identified, namely the use of virtual reality. This technology can raise awareness on future changes by visually confronting people with new realities based on climate change scenarios.

Biodiversity and environment

To address present and future impacts of climate change on the biodiversity, innovative technologies are set to play a pivotal role, i.e. in monitoring ecosystems and fighting illegal practices (e.g. poaching alert system using camera; Autonomous underwater Vehicle), and allowing continuous and real-time data collection and analysis (Digital Twin Environment).

Soil management and agriculture

Within the ARSINOE innovation pathways, innovative technologies are primarily mobilized to drive the field of soil management and agriculture towards sustainability. They are mainly related to smart agriculture, enabling continuous monitoring of soil and water parameters. This allows farmers to adjust their practices to the optimum needs of plants and crops, reducing the use of water, pesticides and fertilizer thus leading to more sustainable farming practices.

Energy

The energy sector was not the primary focus of ARSINOE Living Labs and adaptation strategies, only four case studies defined it as a priority field of action. Targeted innovations are needed to reduce energy consumption and further develop renewable energy sources (e.g. solar, hydrogen).

Climate change risk management

Climate change risk management is another field where technological innovations are set to play an important role. Digital tools are being developed for smarter data collaboration, enabling the modelling, development, simulation and assessment of risk management strategies and the creation of early warning systems. Those decision-support tools will allow policymakers to better design and anticipate responses to climate risks and hazard.

Fishery

Only two case studies (CS4 and CS6 – South-Western Black Sea) targeted the field of fishery specifically, here again the end goal lean towards the sustainability of the sector in general, using technologies based on remote sensing to monitor and control illegal activities or record real-time catches. Innovations in the blue biotechnology sector are targeted to provide alternative food sources for the aquaculture sector.

Tourism

In the field of tourism, technological innovations will help raising awareness of tourists on sustainable practices using, for instance, smartphone application.

Ports and infrastructures

This field includes only technologies applied to the port and shipping activities (CS2 – Mediterranean ports), other infrastructure technologies linked to coastal protection have been classified in the field of water management, related to flood hazard.

The CS2 innovation pathway combined technologies to adapt the ports logistic and infrastructures to extreme weather events such as storm surge and heavy rain. Digital solutions will be implemented to monitor GHG emission of ports activities, detect and mitigate sources of air pollution on one side, provide shipping energy and cost saving optimization on the other side.

Urban Greening

The field of urban greening is only relevant to Athens case study, the technologies targeted by the CS aim to cool the city by creating vertical gardens, enhancing green rooftops, and monitoring urban biodiversity.

4.1.2 Social and institutional innovations

The full list of social innovations identified within the ARSINOE innovations pathways can be found in appendix 6.

Water management

The field of water management features the highest number of social innovations to be mobilized in strategies to adapt to climate change. These innovations are identified in the innovation pathways of CS3 (Main River in Germany), CS4 (Prespa and Ohrid lakes – Transboundary case study in the Balkans) and CS8 (Torbay and Devon County in the UK). They are primarily related to the management of water ecosystems in a transboundary context, requiring new forms of collaboration and partnerships. Social innovations are also expected to foster a new relationship between local communities and water ecosystems, such as rivers (i.e. water is life project Innovation that activates community observation to capture data that can feed into real time tracking of impacts – CS8), raising awareness on water risks and climate change (i.e. The world's ugliest lawn : prize for ugliest/driest lawn awarded to draw attention to drought and sustainable water use – CS3). Citizen science was also identified as a promising solution for flood monitoring (i.e. Innovation that activates community observation to capture data that can feed into real time tracking of impacts – CS8). Finally, innovative economic incentives are targeted to better manage the water resources (i.e. Public good/ levy as a mechanism to create a sustainable financial model for communities – CS8).

Community engagement and education

Social innovations are essentially related to innovative forms of stakeholder engagement, such as sustainability Living Labs (i.e. the ARSINOE Living Labs) and other type of knowledge-sharing and community-building events. Another innovative initiative targeted for replication to promote community engagement and education for climate change adaptation is the “Filling the Void initiative” (CS8). This collaborative initiative with other coastal towns facing similar challenges includes Leadership Learning Set to explore approaches and build confidence in addressing the ‘unknown’ and providing sufficient information to fill the void, which might otherwise be filled by speculative voices (particularly on social media).

Biodiversity and environment

In the field of biodiversity and environment, citizen science initiatives have again been identified as valuable solutions within the portfolio of social innovations to be mobilized. These include support for environmental volunteering and initiatives to strengthen international cooperation and partnerships in research and academia for harmonized protocols and environmental data collection (i.e. Joined task

force and series of roundtables). Finally, a gamification approach to environmental management has also been identified by stakeholders as an innovative solution (i.e. Replicate the “Beat the Street” initiative which turns towns into giant games - To be adapted to green space equivalent – CS8).

Soil management and agriculture

Social innovations identified by local stakeholders during the innovation pathways co-design process in the field of soil management and agriculture will support both adaptation and mitigation strategies to climate change. The overarching long-term goal in this field is to drive the food production system towards sustainability by drastically reducing its environmental footprint (fuelling the biodiversity crisis), which will be further aggravated by climate change impacts. Evidently it also directly contributes to climate change, as the European agricultural system contributes to more than 10% of the EU’s total greenhouse gas⁵. Social innovations can support mitigation, adaptation and resilience to climate change. For instance, the implementation of an agriculture carbon market can serve as an incentive for the adoption of circular economy practices (e.g. in CS5 – Canary Islands), the development of local food production chain from farmer to end-users (i.e. branding of sustainable products and participatory certification systems, loyalty programs between farmers and consumers). To adapt farming practices, sharing and spreading knowledge is essential, using concepts like farm experimentation as a collaborative learning model.

Energy

Three social innovations related to the energy sector have been identified to address the economic impacts of climate change, such as rise of energy costs and potential supply disruptions. The city of Athens (CS1) is planning to establish an Energy Poverty Office at the municipal level, develop alternative urban planning strategies and innovative land use governance policies, while Sardinia (CS9) is seeking to establish energy communities.

Climate change risk management

Alliances to support knowledge exchange between cities or regions sharing similar climate change (i.e. Extreme Heat Resilience Alliance; the Bavarian alliance for green and blue cities) is a good example of social innovation to be replicated in the field of climate change risk management.

Fishery

Only one social innovation has been identified, in the region of Prespa and Ohrid lakes (CS4) as a relevant in the field of fishery: implement trainings to fishermen for up-skilling and reskilling.

Tourism

The social innovations targeted by local stakeholders (in CS4 and CS5) primarily aim to transition towards sustainable practices (eco-friendly tours, product labelling), foster synergies across sectors (between tourism and agriculture, i.e. sustainable farms open to tourists or the use of organic waste from the tourism sector as compost for farming) or across countries (i.e. transboundary visitors management plans).

⁵ https://climate.ec.europa.eu/news-your-voice/news/looking-how-mitigate-emissions-agriculture-2023-11-13_en

Governance and planning

In the field of governance and planning, the concept of “15-minutes city” is included to the portfolio of innovations co-developed within the Athens case study for making the city resilient to climate change by 2050.

Ports and infrastructures

The social innovations to be implemented in the ports case study (CS2) aim at measuring and reporting port’s sustainability performance, providing a vulnerability index to shows which locations might be most vulnerable in the future

Urban Greening

In the context of the Athens case study, greening the city aims to cool the urban environment to adapt to higher temperatures in general and heat waves in particular. The city is looking at implementing concepts, such as green corridors and pocket parks, and involving citizens in the conservation of the city’s biodiversity by applying the “Tiny Forest” initiative in Athens (the forests are planted, maintained and monitored with the help of local volunteers, businesses and schools).

4.2 Innovation Gaps

Local stakeholders and CS leaders have identified portfolios of technological, social and institutional innovations across various fields and sectors. Among the targeted innovations, not all are yet fully developed, available on the market, or previously tested; some are still at the conceptual stage formalized in terms of needs and ideas. Within the CS innovation pathways, those innovations have been labelled as “innovation gap” and should be the focus of future research and innovation agenda to secure the necessary funds (for full technological development and market diffusion), and policy support to raise awareness and trigger behaviour change (to allow full adoption of innovative social and institutional practices). It is worth noting that innovations have been categorized as “innovation gap” when the case study lead teams weren’t aware of any similar innovation implemented or tested elsewhere or couldn’t locate any innovation providers. Despite thorough research through literature review, online searches, and ARSINOE open tenders for innovations (WP5) and the Climate Innovation Window platform, some of the innovations below might have already been developed or tested elsewhere. Nonetheless, those technologies or innovative practices would be characterized by a low level of diffusion, preventing them from being widely disseminated and replicated across Europe. Therefore, they would still benefit from policy support actions within research and innovation agenda at European or national levels.

4.2.1 Water management sector

Most of ARSINOE Living Labs have pinpointed innovation gaps and needs to adapt to the impacts of climate change within the field of water resource management. The need to change the way the water resource is perceived, managed and shared is particularly pressing in CS3 where a radical new approach is needed based on institutional changes in the way the water resource allocation and sharing among sectors. In CS8, the need for innovative social practices is primarily related to community engagement for raising awareness and sharing knowledge on flood risk to have local communities better prepared in the event of such hazard. [Table 3](#) summarizes innovations needed for communities to adapt to climate change water related risks, which are not yet fully developed. Further technological development is

particularly needed in the field of flood management and flood risk preventions. Improved tools for water pollution monitoring and prevention are also required. Finally, new technologies could also support authorities in water resource allocations.

Table 3: Innovation gaps in the field of “water management”

Social and institutional innovations needed in the field of water management, yet to be fully developed	Technological Innovations needed in the field of water management, yet to be fully developed
Permits for projects relating to climate resilience of public water sector can be considered granted after a fixed timespan if a decision has not been made	Digital "water registry" listing all extractions and water rights
Easier processes for the prolonging of water rights for public water supply	Way to reuse & sell water back
Standardisation of procedures for creating and enlarging water protection areas	IT-systems to improve information sharing and create common knowledge base for those involved in approval process of water rights
News report on the state of the water balance (like a weather report)	Technical innovation for submerged species (recording & removing)
Rules for irrigation: irrigation happens primarily through rainwater and where necessary water from surface water bodies; determine "irrigation worthy" crops	Mapping system for targeted pollutants
"Toolbox" enables water suppliers and farmers to change their cooperation agreements to account for climate change	Alert system for local pollution
KAnG-implementation: municipal climate adaptation strategies require inclusion of public water sector	Remote sensing monitoring
Water infrastructure is considered to be of superior public interest and receives the privileges associated with that status	Early warning system for eutrophication
Cooperation of public water sector and regional planning associations happens routinely	Functional systems for diagnosis
Regional monitoring system for water withdrawal for irrigation	Monitoring platforms for water quality
Priority of public water supply encribed in BayWHG	Crowdsourcing of Flood Multimedia for Hydrological Models in the Black Sea
Fee for unnecessarily draining soils and water bodies	Operational flood forecasting system including levee performance <i>To be further developed</i>
New and existing state funding programmes are audited for conflicts with water protection; (levels: EU, national, federal state, municipal)	Nowcasting the Weather using Machine Learning (<i>Google deepMind Flood early warning - Research stag</i>)

Create registry of drainage systems	Automatic flood barrier for harbour area that would stop overtopping
Funding programmes conflicting with climate resilience revised	BGI* Mapping & Strategy (emerging)
Transboundary Management Plan for Crises related to Climate Change	Novel pumping system (new technologies) for solving back water problems
Climate 'Fear to Hope' Workshops - Workshops and events to engage communities who are fearful about the climate crisis	Improved decision-making tools based on novel AI/ML technologies
Organisational social networking space - to connect organisations (and communities) to facilitate shared working around flood risk, impact & action	Add on in Google maps to show flooding and depth in case of danger to life from deep water
Public good/ levy as a mechanism - to create a sustainable financial model for communities	Property flood resilience measures
Sustainable Business model - when funding runs out, there is a new fund ready e.g. Needs to be financially sustainable. Payment for public good	Temporary flood barriers or other devices for high-risk roads and locations
Community Water Officer - Person to communicate flooding to Torbay. Could be a train the trainer so there are flood wardens in the town	Property level flood warning using property sensors that would also be used to give alarms to other residents
	Flood sensors for roads
	Innovative permeable pavements
	New control technologies for extracting ground waters and reducing salinization

4.2.2 Community engagement / education

In the field of community engagement and education, many stakeholders highlighted the need to develop new educational contents, training and curriculums, and more broadly alternative approaches to educate on climate change and risk adaptation (e.g. gamification approaches; role model; web-tools).

Table 4: Innovation gaps in the field of "community engagement / education"

Social and institutional innovations needed in the field of community engagement / education, yet to be fully developed	Technological Innovations needed in the field of community engagement / education, yet to be fully developed
Methodology on how to create a unified adaptation strategy and response on common strategies	Web tools - Knowledge management portals
Change curriculums to include mandatory teaching of climate change and its (local) effects and room for projects on climate change and sustainability	
Education of teachers and "role models" like sports trainers on climate change and adaptation	

Operational Training Service for small businesses	
Open Database for good practices (evaluated by experts – public & private sector)	
New kind of games (including toys) to facilitate game and teach science or research methodology	
Innovative STEAM education (including games, challenges etc)	

4.2.3 Environment / biodiversity

In the field of environmental management, the need for innovative social practices can be classified in two folds (Table 5): 1) boost scientific cooperation and design common protocols to integrate the latest technological advancements in environmental research in the form of cross-regional Working Groups (i.e. in the field of modelling, AI and machine learning), 2) disseminate knowledge to civil society on the latest scientific developments in the field of environment and biodiversity preservation.

Regarding technological innovations, significant progress has been made in the field of environmental monitoring techniques, such as advance autonomous monitoring vehicle, Digital Twin, or eDNA sampling, but their applications are still limited to specific fields and need to be further expended (i.e. for monitoring rapid ecosystem shift or pollution events)

Table 5: Innovation gaps in the field of "environment / biodiversity"

Social and institutional innovations needed in the field of environment and biodiversity, yet to be fully developed	Technological Innovations needed in the field of environment and biodiversity, yet to be fully developed
Establishment of an Interdisciplinary Scientific Group working on climate forecasting for the Black Sea region - Joined task force to evaluate the existing models and their compatibility & performance to AI/Machine Learning	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures including archaeological remains and shipwrecks.
Establishment of an International/Interregional Working Group (WG) of Experts and Society to draft clear guidelines about data used for AI	new identification techniques such as eDNA to monitor marine biodiversity
WG of experts to assess and observe the functionality of the collection systems	Seamless monitoring data integration to Digital Twins
Exploitation of social media for environmental monitoring/measurements	Electrochemical, fast responding seawater nitrate and phosphate sensor
Training, educating citizens on the importance of climate data & funding the installation of DIY stations	AI-powered identification of marine and land stocks
Development of innovative VET programmes specifically targeted at machine learning education	Autonomous underwater vehicles capable of detecting carbon compounds in situ
Pop up shop/ green café/ workshop: Workshop/ event for garden centers, council, gardeners to highlight drought resistant alternative plants	AI-supported, intelligent and responsive underwater sensing and monitoring platforms smartly reacting to extreme climate events and ecosystem shifts
	Underwater E-DNA analyzer capable of rapidly assessing biodiversity shifts - powered by AI and big data analytics

	Fully operational Digital Twin including all levels of ecosystem functioning so habitats are monitored in real time
	Autonomous underwater vehicles (AUVs) capable of detecting and tracking pollutants
	Standardized sensors for monitoring- both in terms of measurement and in terms of deployment
	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures. Technology exists for underwater noise only: https://www.subacoustech.com/)
	Identification/monitoring of marine waste source(s) using remote sensing and other data processing technologies There are some technologies under development but neither meets the scope here: https://www.giz.de/de/downloads/giz-2023-en-advances-in-remote-sensing-of-plastic-waste.pdf https://www.undp.org/vietnam/blog/remote-sensing-smart-city-solution-municipal-waste-management

4.2.4 Soil management / agriculture

New farming practices have been proposed in the different ARSINOE Living Labs that are yet to be tested and /or fully adopted by farmers. Research in the field of agronomy and biotechnologies to develop heat resistant crops or next generation bio-fertilizer must be prioritized for the farming sector to adapt to new climate condition and extreme events. Many innovations have already been developed in the field of smart agriculture (see sub-chap 4.1.1), nonetheless the need to further develop those climate data related technologies (Table 6) and ensure a wide adoption within the agriculture sector remain.

Table 6: Innovation gaps in the field of “soil management / agriculture”

Social and institutional innovations needed in the field of Soil management / agriculture yet to be fully developed	Technological Innovations needed in the field of Soil management / agriculture, yet to be fully developed
Reduce times without plants on fields, use intercrops, plant leguminous plants; ensure there are roots in the soil in order to increase humus content in soil	Switch to drought resistant crops
	New crop varieties - Rediscovery of old ones
	Innovative irrigation techniques based on agro-ecological practices, with resp. training for sustainable agriculture and innovative funding schemes/business models
	GAP in terms of solution to support climate-smart agriculture practices
	Electric agricultural machinery
	New biofertilizers
	Ground treatment method for fields to improve soil

	permeability (due to compaction and crop type)
	Spreading digital technologies to support agriculture, by exploiting the real-time availability of data from remote sensing, in-situ data and weather forecasts, will have the potential to facilitate informed decision making by providing timely information on crop health and soil conditions,
	New machines and tools such as reliable Decision Support System (DSS) based on crop simulation models (CSM); advanced statistical methods (e.g, multivariate methods); Artificial Intelligence (AI) algorithms and remote sensing technologies that optimize the use of agronomic inputs (e. g. water, fertilizers)"
	Enhancing block chain, panels, participatory certification systems, traceability and supply chain/product certification
	Soil ecosystem services monitoring protocols

4.2.5 Energy

As the adaptation of the energy sector to climate change wasn't a key focus of most of the ARSINOE Living Labs, only few innovation gaps were identified (e.g. need for new off-grid solutions and improved management of risk to the (electric) utility sector -Table 7). It is worth noting that in Sardinia, local stakeholders highlighted the need to develop specific financial instruments for renewable and efficient energy sources.

Table 7: Innovation gaps in the field of "energy"

Social and institutional innovations needed, in the field of energy, yet to be fully developed	Technological Innovations needed in the field of energy, yet to be fully developed
Financial instruments for renewable and efficient energy	New off-grid solutions
	Improved management of risk to the (electric) utility sector

4.2.6 Climate change risk management

New approaches are needed to manage climate change risks; in some Living Labs (i.e. in CS3 Main River, and CS7- South Denmark) innovative ideas and needs have emerged that should be further explored and developed particularly in the field of finance (i.e. new economic models to share societal cost of climate risk adaptation measures) and education (i.e. raise societal awareness on climate change risks for more effective risk prevention policies and community preparedness), as shown in Table 8. In terms of technological innovations, further research is needed to develop innovative solutions to protect human infrastructures against extreme events.

Table 8: Innovation gaps in the field of "climate change risks management"

Social and institutional innovations needed in the field of CC risks management yet to be fully developed	Technological Innovations needed in the field of CC risks management, yet to be fully developed
support services for climate risk assessments and strategies in enterprises responsible for critical infrastructure	Improved assessment of climate change risks on the (electric) utility sector [assessments comprise more scenarios and factors].
financing solutions for creation of green and blue infrastructure (jointly developed by public and private sector) (already included in G12)	New multi-functional harbour facilities and systems
early start of construction and resilience measures allowed	New means for protecting buildings against residual climate risks, e.g. west of phase 1 of the storm surge barrier
Identification of pathways or factors to motivate private investments in shared (e.g. public-private) protection solutions	
New economic model encourages and motivates citizen/civil society to contribute economically to flood management	
New economic models clarifying economic measures needed of the public sector; motivates implementation.	
New economic/ finance models motivate the private sector to contribute economically to common solutions.	
Education in "climate catastrophes" (prevention, preparedness) for adults (e.g. EducationEsbjerg)	
Education in "climate catastrophes" (prevention, preparedness) in public schools	
Vistor Centre for experience / knowledge about climate, offshore, energy, catastrophes and more.	
CC curriculum support package to deliver climate change to schools hand in hand with national curriculum key stage subjects and implement through inset days	

4.2.7 Fishery

As previously mentioned, innovations related to the fishery sector aim mainly at driving the sector towards sustainability. The fishing sector is continuously in need of innovations to improve fishing techniques, reduce impacts on the marine ecosystems and ease fishermen daily operations. Facilitating the accessibility and adoption of technological innovations and sustainable practices is another challenge to be addressed.

Table 9: Innovation gaps in the field of "fishery"

Social and institutional innovations needed in the field of fishery, yet to be fully developed	Technological Innovations needed in the field of fishery, yet to be fully developed
Fishers-guardians for early warning system on transboundary level	Making products of IAS and other small-sized species (e.g. cat food)
	Early warning system against epidemic in fish farms
	Innovative fishing methods/ equipment (e.g. specifically decreasing time demand for managing IAS like <i>L. gibbosus</i>)
	Environmental Conservation approach for freshwater habitats through sustainable practices

4.2.8 Tourism

Like the fishery sector, tourism targeted innovations and gaps primarily aim to make the sector sustainable in its daily operation. In that sense a research and innovation agenda should focus on 1) developing solutions to systematically collect and make accessible data on resource usage in the tourism sector; 2) developing and promote innovative practices to minimized resources consumption and waste production. Additionally, generating tourist-sustainable-behaviour is another area that would benefit from further research and development.

Table 10: Innovation gaps in the field of "tourism"

Social and institutional innovations needed in the field of tourism yet to be fully developed	Technological Innovations needed in the field of tourism, yet to be fully developed
Transboundary multidimensional & multifunctional hub, incl. data collection (e.g. Technology & Ideas)	Gap in terms of waste reduction and recycling solutions
Multifunctional hub (with innovative education)	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures including archaeological remains and shipwrecks.
Tourist tax implemented to offset the resource consumption of tourists in the islands, earmarked entirely for environmental protection in the region	
Tourist service: "Water communication for tourists in German/English". AI-based or a real person.	

4.2.9 Governance and planning

The promising development of digital tools for data collection and analysis, based on artificial intelligence technologies, offers new prospects in terms of decision support system to be used in the

field of governance and planning. Those tools are still at the early stage of development, further research and development is needed to move from proof-of-concept to policy –related applications.

Table 11: Innovation gaps in the field of "governance and planning"

Social and institutional innovations needed in the field of governance and planning, yet to be fully developed	Technological Innovations needed in the field of governance and planning, yet to be fully developed
	AI-fed by monitoring data used for planning to better identify needs
	Three dimensional digital twins for MSP developed at a high TRL level.
	AI-fed regional planning
	3D twins in the transb. Region

4.2.10 Urban greening

In the field of urban greening, urban development and the continuous spread of concrete surfaces remain an aggravating factor of climate change risks (from flooding and drought to urban heat). Urban planning needs a paradigm shift to systematically consider the impact of urban development on the water cycle and soil ecosystems. Furthermore, transitioning the construction sector towards carbon and resource-use neutral will greatly support climate adaptation strategies, starting with the mainstreaming of green building technologies.

Table 12: Innovation gaps in the field of "Urban greening"

Social and institutional innovations needed in the field of urban greening, yet to be fully developed	Technological Innovations needed in the field of urban greening, yet to be fully developed
Urban development considers resource efficiency and land consumption	Buildings development and orientation towards non-polluting industries
Planning of building projects includes mandatory planning of water retention areas monitoring of obligation to unseal soil if sealed elsewhere	Green building: Innovative, carbon neutral building materials

5.0 Conclusion and Next steps

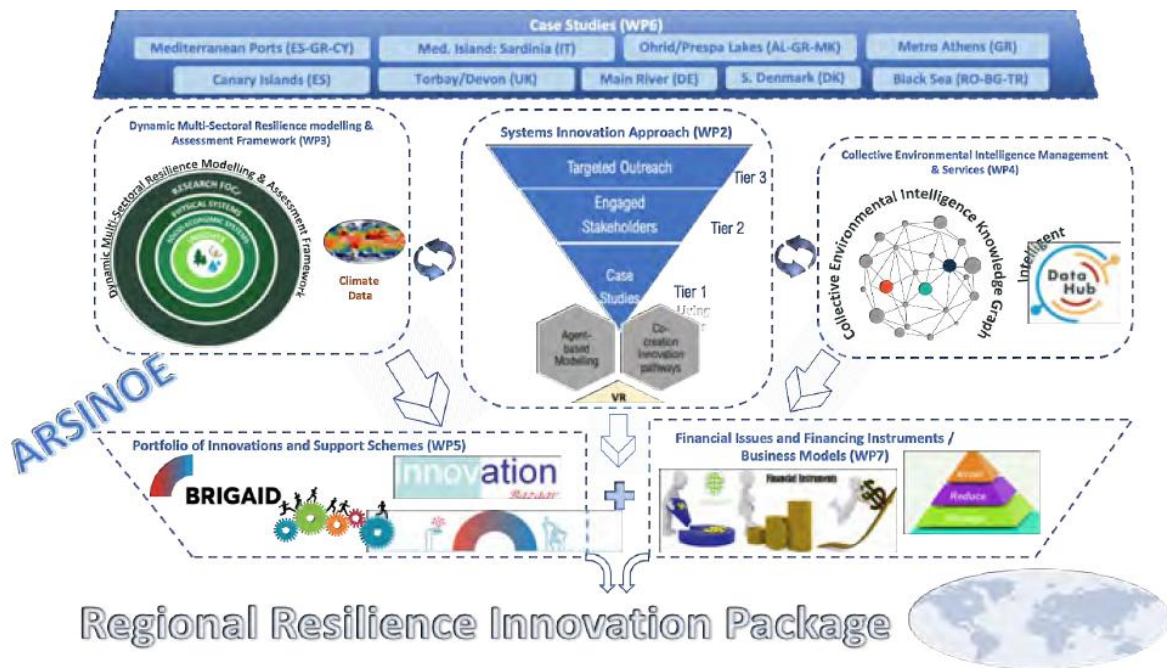
Within the ARSINOE Living Labs, local stakeholders collaboratively designed innovation pathways for climate adaptation, employing a system innovation approach. These pathways consist of a portfolio of innovations structured as a roadmap to achieve the future visions formulated during the second Living Labs workshop. Addressing climate change requires a combination of technological and social innovations. Technological innovations involve the development of new tools, processes, and systems for both mitigation and adaptation, whereas social innovations concentrate on modifying behaviours, policies, and societal norms to promote sustainability. The effective implementation of technological innovations necessitates investment in research and development, supportive infrastructure, regulatory frameworks, economic viability, and a skilled workforce. Social innovations are essential for driving societal shifts toward sustainability, facilitated by public awareness, education, collaboration, and partnerships.

The ARSINOE innovation pathways for climate adaptation focus on key areas of intervention, including water management, community engagement and education, environment and biodiversity, soil management and agriculture, energy, climate change risk management, fishery, tourism, governance and planning, and urban greening. Utilizing the PESTLE framework, case study leaders have identified the key enablers and barriers within their regions to effectively implementing the portfolio of innovations co-created with local stakeholders. Significant barriers to implementing climate adaptation-related innovations include knowledge gaps, data issues and deficiencies, cultural resistance to change, low awareness of climate change and its impacts, insufficient funding, private sector reluctance to invest in climate technologies, high upfront costs, inadequate climate policies, policy inconsistencies, political instability, legal delays, and data privacy concerns. However, a favourable environment for adopting these climate innovations is gradually emerging, supported by EU policies and funding, the establishment of cooperation mechanisms between research and industry, economic incentives for adopting green practices, increased pressure from civil society on policymakers, long-term savings from reduced damage costs, the development of education and awareness campaigns, growing environmental activism and community networks, and the proliferation of local innovation hubs for climate adaptation.

Climate resilience is a multifaceted challenge that requires immediate action, the adoption of a systemic approach, integrated policies from the European to local level, multi-level policy support, public engagement, cross-sector collaboration, financial investment, and a broad array of both traditional and innovative measures combined with skilled professionals. A more detailed examination of the innovations, both technological and social, to be implemented in the ARSINOE European regions to adapt to climate change reveals that key priorities for action in future research and innovation agendas include water management (with over 100 specific innovations targeted), community engagement (23 specific innovations targeted), environment and biodiversity (43 specific innovations targeted), soil management and agriculture (51 specific innovations targeted), and climate change risk management (40 specific innovations targeted).

The innovation pathways developed within Task 2.4 directly feed into Task 6.4 “Innovation packages development and validation in each case study”. The first phase of implementing these pathways has begun within the ARSINOE framework by financing the initial set of 23 selected innovations through the Open Tenders for Innovations (WP5 – CIW) across all ARSINOE case studies. Then, the pathways will be combined with potential financial instruments (WP7) and other supporting measures co-identified with

stakeholders, providing policymakers with all the necessary means for an effective implementation process.



Reference

- De Vicente Lopez J. and Matti C. (2016), Chapter 3: visioning and backcasting the future, in Visual toolbox for systems innovation. A resource book for practitioners to map, analyse and facilitate sustainability transitions. Transitions Hub Series. Climate-KIC, Brussels 2016. ISBN 978-2-9601874-1-0 Meadow,
- Brugge, R.v.d., Rotmans, J. Towards transition management of European water resources. *Water Resour Manage* 21, 249–267 (2007). <https://doi.org/10.1007/s11269-006-9052-0>
- Christodoulou, A., & Cullinane, K. (2019). Identifying the Main Opportunities and Challenges from the Implementation of a Port Energy Management System: A SWOT/PESTLE Analysis. *Sustainability*, 11(21), 6046. <https://doi.org/10.3390/su11216046>
- Foran, T., J. Ward, E. J. Kemp-Benedict, and A. Smajgl (2013) Developing detailed foresight narratives: a participatory technique from the Mekong region. *Ecology and Society* 18(4): 6.
- La Jeunesse I., Moujan C., Akinsete E., Guittard A, Spiropoulou A. (2023). Implementation of System Innovation Approach in all case studies. Intermediate report. ARSINOE Deliverable 6.5, 105 p.
- Loorbach, Derk A. and Jan Rotmans. “Managing transitions for sustainable development.” (2007).
- Loorbach, D. (2007). *Transition Management. New Mode of Governance for Sustainable Development. PhD-Thesis*. 1–328.
- Moujan, C., La Jeunesse, I., Akinsete, E. & Guittard, A. (2022) Description of stakeholder mapping for case studies. ARSINOE Deliverable 2.1, 64 p.
- Mulgan, G., and Leadbeater, C. (2013). *Systems Innovation*. London: Nesta.
- Roorda, C., Wittmayer J., Henneman P., van Steenbergen F., Frantzeskaki N., Loorbach D., (2014), “Transition management in the urban context: guidance manual.” DRIFT, Erasmus University Rotterdam,
- Roorda, C. & Akinsete, E. (2013). MUSIC Aberdeen, “Mini Guide to Transition Management” Rotterdam: Dutch Research Institute For Transitions
- Vanderbilt T.,(2015), Why futurism has a cultural blindspot. We predicted cell phones, but not women in the workplace. *Nautilus Issue* 028, <http://nautilus.us/issue/28/2050/why-futurism-has-a-cultural-blind-spot>, (Accessed: 8/2019)
- Volkery, A., Ribeiro, T., Henrichs, T., & Hoogeveen, Y. (2008). Your Vision or My Model? Lessons from Participatory Land Use Scenario Development on a European Scale. *Systemic Practice and Action Research*, 21, 459-477

APPENDICES

APPENDIX 1: Workshops Guidelines

WORKSHOP 1: CO-CREATE A SYSTEM MAP

What are Living Labs?

Living Labs are a participatory research tool often used in planning, product design and innovation which brings together a collective of key stakeholders **to explore a focal issue**.

LLs act as **open innovation spaces which foster co-creation** with users and the end result is expected to better address stakeholder needs.

Working groups

The working groups constitute a preparatory activity to support the living lab including stakeholders from a specific sector (e.g. agriculture), a specific group (e.g. policy makers), a specific location (e.g. national multi-sectorial stakeholders for the international Living labs), or by focusing the discussion on a specific topic, taking place prior to the living lab workshop. They are flexible and can take various forms: replicate the SIA living lab activities (system mapping, envisioning, co-creation of pathways), be the space for implantation of complementary activities, take the form of informal discussion. Notes should be taken indicating the attendees (Organisations and Roles), the activities undertaken, along with a summary of the main points discussed and any actions to be taken.

For the trans-boundary case studies, the working group will work at national level, implementing a national workshop taking place in the local language prior to each international Living lab workshop, enabling the involvement of a wider group of stakeholders. In this case, working groups are expected to implement the Living Lab activities at national level while the international Living Lab will present and discuss about the results of the national working groups, putting the discussion in an international context. The working group activities preparatory to the international living lab will be reviewed with the WP2 team prior to each workshop.

BEFORE THE FIRST WORKSHOP

Once your stakeholder mapping has been completed, the shortlists drawn up, and potential Living Lab participants have been identified, then you are ready to invite participants to join in and engage in the process. The following actions do not have to be carried out in any particular order, but it is important to consider them prior to holding your first workshop.

Initiating Contact with the Stakeholders

In many cases, the case study (CS) teams will have an existing relationship with the organisations/individuals they have chosen to invite to join in their LL. In this case it would make sense to initiate contact with an informal phone call or email explaining the request in order to determine their interest. In cases where the CS team does not have an existing relationship with the intended participant, this initial contact could be supported by a formal letter introducing the project and the request (see Appendix 1). In the event that you reach out to a potential LL member and they decline

the invitation for whatever reason, you can revisit the Shortlist on your Miro board to find a replacement.

Organise the facilitation team

Another important step is the internal organisation of responsibilities within the CS team. Eg. Who is the main point of contact for the LL members, who will facilitate the workshop? Who will take notes for reporting and preparing activities in-between the workshops?

Decide on workshop details

Format: What format will you adopt for your workshop; in-person or online (in-person is the preferred method as it provides a better space for team-building and informal interactions; eg. Over a coffee break or lunch)?

Language: For transboundary case study, review the pros and cons of holding your workshop in an international language (English) or in local language with translators depending on the stakeholders you want to invite. Language shouldn't be the reason to exclude a certain group of stakeholders, if it cannot be avoided think of an alternative way to engage those stakeholders unable to attend due to language barriers (e.g face-to-face interview).

Date and Venue: Fix a date for the workshop. This may have to be done in collaboration with the intended LL members. Furthermore, your chosen date might be influenced by your choice of venue or vice-versa. A date will have to be chosen by approximately 6 weeks to the intended date of the LL workshop, so formal invitations can be sent out in good time.

Agenda: Depending on how long your workshop will be, if it will include lunch or not etc, set out the detailed agenda. A guide agenda is provided in the '*During the workshop*' section of this guide.

Communication: Decide before the WS how you want/can communicate on the LL activities within the case study and the project, assign someone to take some pictures or short videos to be posted on ARSINOE social media for instance or any other communication channel you would like to consider.

Key Themes

Select 3-5 key themes at the core of the LL focus, which will be conversation starter to begin the discussion for the mental mapping exercise. Eg. for a LL focused on Water-Energy-Food-Ecosystems Nexus, some key themes could be Water, Energy, Food, Ecosystems and Pollution. A good way to do this is to ask yourselves questions such as what you expect to achieve from the process? What are the key resources to manage? What are the key drivers of your CS (economic, social, environmental)?

Living Lab facilitators are encouraged to prepare themselves for the mental mapping exercise, by reading related literature (see reference list), be well organised as a team (how to lead and pace the discussion, how to take the notes...), bearing in mind the expected outputs.

Workshop Invitations and Informed Consent Forms

Depending on what is appropriate in the specific context, invitations to the workshop may be sent out by email or officially delivered in hard copy. Along with the workshop invitations, participants should be sent a copy of the informed consent forms and associated participant information sheet, to be completed and returned ahead of the workshop. It is useful to have some copies of the form available at on the day of the workshop in case they are needed. Templates for the invite as well as the informed consent form can be found in Appendices 2 and 3 respectively.

WP2 Pre-workshop meeting

About a week before your workshop, there will be an opportunity for a final sit-down with the WP2 team, to go over any last minute questions you might have and see that all is in place for your workshop.

Optional Activities

Inventory of assets: It's important that you have a clear view of where you're starting from. What resources do you have that could contribute to your living lab's success? What are the existing strengths, advantages, or opportunities? This varies greatly from case to case and may include previous research and data, funding from ARSINOE and other sources, individual knowledge, material resources and skills, social bonds, and many other things depending on context. To that end, it's useful to produce an inventory of such resources, in the form of concrete, actionable outcomes that can be used in the context of each living lab focus and goals. For example, if a previous study has been conducted, what are the findings that relate to the current phase? What are the available datasets and how can they be used? If there have been working groups that have already identified issues and challenges, bring them to the labs in a synthetic form. Think of ways to present this information to workshop participants that are accessible, concise, and relevant for the lab's focus, such as maps, graphs, charts, and timelines. This will help build a shared common ground, avoid generic landing and foster confidence on the process.

Preliminary Mapping: Some teams may wish to try out the mental mapping exercise themselves prior to the workshop. Afterwards, the teams' map can be compared with the one produced during the workshop to drive insights and become aware of hidden biases and blind spots.

Preparatory stakeholder event: In some cases, it may be useful to host a pre-Workshop 1 event with your stakeholders. The event can take whichever form you wish; eg. a coffee morning, working lunch, networking discussion etc. The purpose of this event is to ease the stakeholders into the process, while providing an opportunity to potentially collect information on existing strategies related to the thematic focus of the LL.

This event is not part of the core SIA workshops, but is an additional activity that may be undertaken at the CS team's discretion. It can be connected with the inventory of assets.

DURING THE WORKSHOP

Workshop 1 – Mapping, Scoping and Objective Setting

The methodology is flexible and allows the use of complementary tools and methods during the workshop as long as CS produce the required output during the workshop. Here, during the first round of workshop, we expect the Living Lab to produce a mental mapping of their system.

Below is a draft agenda that may be used as a guide for developing your own workshop agenda. Those are the elements that should be part of your workshop. While each CS has its own objectives and history in engaging with stakeholders, additional sessions, and activities can be added.

30 min	Welcome and Introductions of participants
10 min	1. Agenda and Objective of the Workshop
10 min	2. Introduction to ARSINOE

20 min	3. Introduction to the Case Study
10 min	4. Living Lab concept and objectives
10 min	5. Break
60-90 min	6. Mental mapping
30 min	7. Conclusion: setting the LL objectives

As participants arrive, a sign-in sheet may be used to keep record of attendees (this information, as personal data, is not to be shared with the rest of the ARSINOE project members unless the participants have agreed as such within the Informed Consent Form). Completed informed consent forms which have not already been submitted will also be collected at this point.

At the beginning of the workshop, the facilitator introduces themselves and invites each person present to introduce themselves too.

Workshop Objectives

- Introduce the Project
- Introduce the Case Study
- Introduce the LL methodology (including an overview of the 3 workshops and their goals)
- **Develop a Mental Map of the CS System**
- Identify gaps in stakeholder representation
- Reach consensus on LL objectives

(See slides from training workshop and the appendix 4 regarding the frequently asked questions)

The main output of the workshop will be a graphical representation (mental map) of the different dynamics within the CS system (**Figure 42**).

Activities

1. Present the agenda of Workshop 1 and Main Objectives
2. Introduce the ARSINOE project: Aims, Objectives, Partners (We will share a default set of slides which you can customize)
3. Introduce the Case Study, presenting the general background and context of the Case Study. Here, the WP3 conceptual model could be used as a tool to explain and illustrate the main issues identified thus far.
4. Introduce the concept of the Living Lab, and the objectives of your specific LL (the challenge your LL hopes to address).; highlight the benefits for your stakeholders to be engaged
5. **Participatory activity: Mental Mapping:**
Requirements: 1 facilitator, 1 note taker, Flipchart, Markers

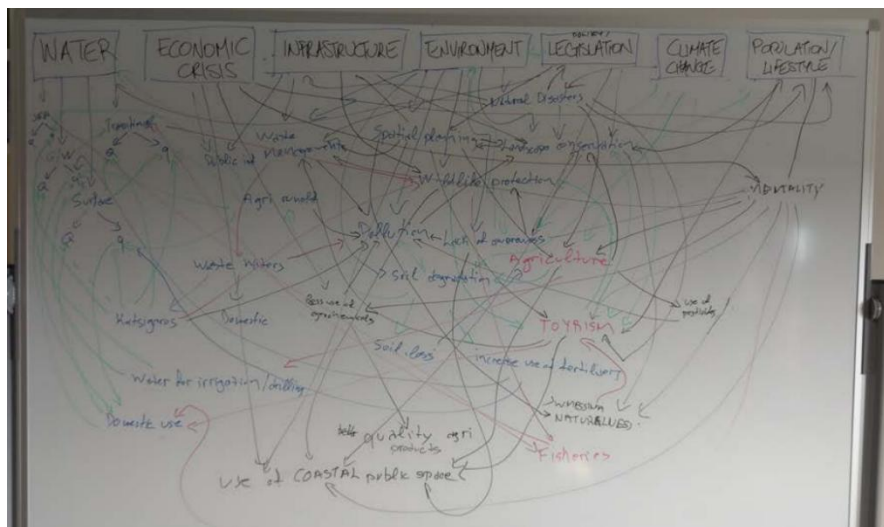
This is a participatory exercise based on system thinking approach where you will map the local system from the stakeholders' perspective; starting from pre-selected key themes at the core of the Case Study which will drive the discussion.

Step 1: Explain the purpose and process of the activity

Step 3: Invite the participants to start proposing issues related to the theme (E.g. Water... drought, pollution, irrigation... etc). Participants should explain in a few words the context in which they propose the issue

Step 5: Repeat steps 3 and 4 until the group runs out of issues or time. The note-taker should keep notes of main points and key quotes from participants.^{6*} Sessions may be recorded (audio) in order to facilitate analysis and post-workshop review, BUT only with the express consent of all participants (so ask at the beginning of the workshop).

- What are the main issues associated with x?
- Why?
- Who is involved?
- What is the impact?
- What are the financial implications?



6. Discuss the first draft of the map highlighting main points, isolate the main challenge and revisit/agree on the main objectives of the LL as a conclusion of the workshop. Assess if there are gaps in the representation of stakeholders.
7. Discuss potential timing of the next workshop.

112

Manage conflicts

Before the workshop if you're aware of open conflict between specific persons, avoid having them in the same room; using alternative mode of engagement e.g. one to one meeting ahead of the workshops can be helpful. Explain that the aim of the LL is to find solution to go ahead from those known disagreements by inviting those stakeholders to explain their points and exchange on possible solutions.

During the workshop:

- Drive the discussion towards positive thinking
- Remind the participants that we are not here to assign blame
- Acknowledge the issue and move to the next subject
- Focus the discussion on the solution, not the problem ("what can we do to change?", "What would you rather see?")

Minutes and reporting

Throughout the workshop, the note-taker, will take notes on the progress of the workshop, the explanations of stakeholders regarding the main issues raised, the potential disagreements on the state description, the main gaps, the context of the workshop. A template to support this reporting activity will be provided by WP2.

AFTER THE WORKSHOP

WP2 Post-workshop meeting

Following workshop 1, on the basis of the reporting document and the mental map, the CS team will have a debrief meeting with the WP2 team in order to review the workshop, the main outputs and discuss next-steps.

Refine Mental Maps

CS leaders will refine the maps on MIRO and circulate to the LL participants for any further input. The maps will either validate the agreed upon LL challenge or highlight a new area of focus.

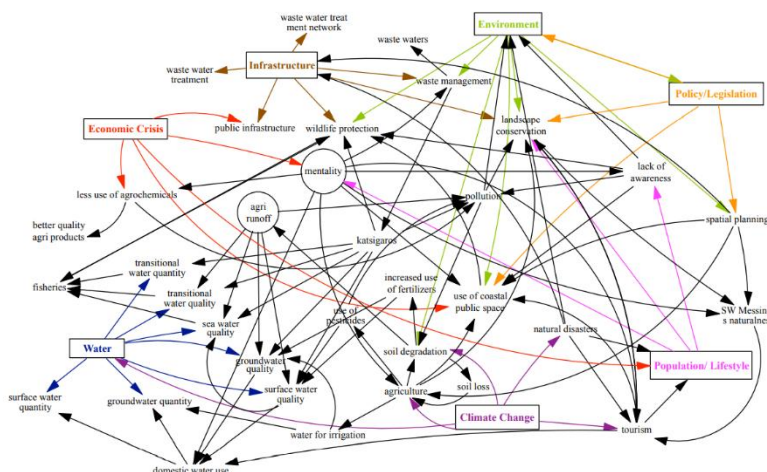


Figure 43: Example of a refined mind map post workshop (H2020 COASTAL project)

In-between workshops

It's a good idea to design shared spaces, activities and tools, such as events, blogs, newsletters, collaborative maps, social gatherings... to help keep momentum within the group, keep them engaged. Some of those can also be used by stakeholders' themselves to communicate within their own circles, brainstorm with partners, etc. They can also be useful to keep the wider spectrum of stakeholders (those that didn't make it to the shortlist) informed and connected to the process.

WORKSHOP 2: ENVISIONING A SUSTAINABLE FUTURE

The main purpose of this second workshop is to:

- Validate the refined version of the mental map
- Reach consensus on the Living Lab problem statement,
- Develop future visions aligned with relevant SDGs that respond to local challenges

The main outcomes are the future narratives that will serve as basis for developing the innovation pathways in workshop 3. They will also help framing

BETWEEN WORKSHOPS 1 AND 2

You have a messy mental map produced during the workshop, of which you have produced a more refined version. You also have a set of ideas/keywords/draft problem statements that you have shaped into a general paragraph that summarizes the group's key concerns. You may have circulated those materials among your stakeholders for initial feedback. You have identified the relevant SDGs. You will now begin filling in potential gaps, aligning the different elements around the workshop activities, and collecting relevant materials that will support this second phase of the System Innovation Approach process.

Review the map

Go back to the map and revise it once again for clarity, hierarchy, and focus: do the main topics (the ones that drove the most attention/concern/lines during the workshop) stand out much as they should? Highlight variables that are well-connected and sectors that appear dominant. Try connecting SDGs targets to specific areas of the map, that will help you with the structure and make the transition to SDGs smooth.

Now compare the map you've produced with the original outcome from the workshop: is everything represented in a truthful manner? Have you not oversimplified? Are there still redundancies, repeated words, etc, that could be rearranged...?

Fill stakeholder gaps

Some people you had identified as influential and interested couldn't make it to the first workshop. To keep the relevance of the outcomes and avoid major blind spots, it is important that their perspective is gathered and included in the map. This can be done through dedicated one-to-one interviews during which you'll gather their perception of the situation, then show them the map to see how they react

and what they see missing. Such interviews are often also a good way to trigger interest in the process and build commitment to participate in future steps.

Expand the pool of participants (if need be!)

During the second workshop participants will split into sub-groups; this means that you will need at least 12 participants (3 groups of 4 people) to produce meaningful outcomes. A larger number usually means richer and more diverse input. You may rise the total number of participants to 25. Bear in mind that there might be several last-minute cancellations! It's a good idea to call them a few days before to confirm their presence and to have some last-minute solutions to compensate for late drop-offs – those could be, among others, encouraging other participants to bring additional team members, keeping a reserve/waitlist, communicating about the project, and encouraging people to express their interest in participating.

During the first workshop's discussion, you may have discovered emerging topics that you were not aware of, or that you didn't consider very important, appearing on the map, often in central places. The problem's focus has shifted from your initial perception, revealing hidden blockers and sub-systems. You may now go back to the matrix and update it to include relevant people connected to such issues, such as academic experts, colleagues working on connected areas, community workers, business representatives, and policymakers in areas that weren't initially at the centre of focus.

You may also have identified important issues that were not discussed enough during the first workshop, perhaps due to a lack of awareness among participants. You may balance out this gap by inviting more participants that work on those specific topics or areas.

Some participants may already be working together in other settings where additional people are involved, might wish to invite colleagues, or have suggestions of people that could bring interesting input to the group. All of those could be valuable participants in this second phase, at your discretion. (Keep in mind power balance – you don't want to outnumber important voices!).

Finally you can question the presence of a stakeholder who didn't show much interest in the process as we are seeking active participants.

Fill knowledge gaps

Do some important topics fall beyond your area of expertise? Are there issues that were identified as crucial (for example, legal frameworks, regulations, public incentives and subventions, problems in knowledge transfer...) that would require further exploration? The period between workshops gives you the opportunity to expand the group knowledge in those areas through events, gatherings, discussions, blog posts, articles... Depending on your time and resources, you may want to set up a newsletter; or invite motivated stakeholders to give a presentation; share news and information with the group. All such initiatives also help build a sense of community and ownership of the process. It is also a good way to involve new stakeholders.

You may also identify relevant teams/ institutions that are already working on such issues and gather knowledge from them, either through one-to-one interviews or by extracting relevant data to support discussions during the workshop.

BONUS ACTIVITIES

** Organize field trips and site visits*

Field trips are a very efficient way to raise awareness of local problems. Even though each stakeholder is an expert in their own area, they're probably less aware of problems in other areas of the system. Conducting field trips helps to level up knowledge among the group and gives local actors the opportunity to share their expertise. By connecting specific problems with actual sites, geographies, and communities, they facilitate the envisioning process.

PREPARING FOR WORKSHOP 2

Drafting the Problem Statement

In preparation for workshop 2, you should review the LL Challenge agreed upon within the first workshop. Refine this challenge into a specific **Problem Statement** to be tackled by the LL, and addressed by the Vision. The Problem statement is often in the form of a questions, and makes more explicit the specific areas the LL will like to focus on based on the analysis of the mental map. The Problem Statement will help to highlight areas that the innovation should address further down the line.

Eg. **LL Challenge:** Addressing the WEFE Nexus balance => **LL Problem Statement:** How do we ensure efficient water management and local food security while reducing pollution and maintaining local ecosystem health?

You will discuss with the WP2 team during you pre-workshop meeting in order to finalize your Problem Statement. It might be useful to prepare a printout or an image of each map (not just the final one) to present during the workshop. This will help you explain to workshop participants how you moved from map 1 to map 2.

Outlining your Guiding Principles

A list of 'Guiding Principles' (words or short phrases) will serve as inspirational building blocks with which to develop the Future Narratives within the second workshop. These Guiding Principles will be extracted from relevant SDG targets.

In the 1st workshop report, you have included a list of relevant SDGs and targets connected to the main topics discussed during workshop 1. SDG targets are important because they will provide a consistent framing for envisioning and backcasting, the "golden thread" that will keep discussions aligned with ARSINOE's general goals. Selecting appropriate SDG targets will also help you prioritize specific topic areas where impact can be maximized. Bear in mind that choosing too many SDG targets could make bringing focus to the envisioning exercise more difficult. Instead, think about priorities and goals and select the four or five that best align with the resources, concerns, and agenda of the group as they appear on the map.

Prior to you pre-workshop meeting with WP2, extract key words and phrases from your chosen SDG targets which represent the goals and values (as many as you deem fit) upon which the LL can construct its Future Narrative. This is your list of guiding principles.

Eg.

SDG Target 2.4: Ensure **sustainable food production systems** and implement **resilient agricultural practices** that increase productivity and production, that help **maintain ecosystems**, that **strengthen capacity for adaptation** to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

SDG Target 6.4: **Increase water-use efficiency** across all sectors and ensure **sustainable withdrawals** and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

Extracted Guiding Principles:

- **sustainable food production systems**
- **resilient agricultural practices**
- **maintain ecosystems**
- **strengthen capacity for adaptation**
- **Increase water-use efficiency**
- **sustainable withdrawals**

BONUS ACTIVITIES

**** Make an inventory of assets***

This task is similar to what you did for workshop 1, only more focused. It should gather useful information and resources to support discussions, especially in relation to the “knowledge gaps” mentioned above. Reflect on the discussions of workshop 1: are there gaps in data? Map all the existing monitoring spots you are aware of (this can be easily done in a collaborative manner, using OpenStreet map or other collaborative mapping tools – you can even invite stakeholders to contribute) and print out copies or a poster-format image to be used during the workshop.

Examples:

- Is there insufficient awareness of the volumes of loss in food production due to climate change? Get some graphs and visualizations and paste them on the wall.
- Are land use regulations very strict? Hand out a map of the area where different land uses are represented to participants so that they can rely upon it during the envisioning phase.

Think of ways to present information to workshop participants that are accessible, concise, and relevant to your lab’s focus, such as maps, graphs, charts, and timelines.

**** Make a historic timeline***

Showing how much specific conditions have changed in your area over a specific time span may help assessing the amount of transformations that can be expected within your workshop’s time frame.

Decide on workshop details

Format:

The success of the second SIA workshop is based on a strong collaborative process thus, an in-person format is highly recommended.

Prepare the required materials (print-outs, post-its, markers, flip charts, visual aids etc) as well as furniture.

If your workshop takes place online, try to make the session as interactive as possible, using online interactive tools (e.g. use the MIRO board as if it was a wall in your room) and make a plan to accommodate parallel brainstorming sessions.

If the workshop is held online, consider having a 5-10 minutes session at the start of your workshop to get your participants familiar with the online tool you will use.

Distribute roles: To develop the future narrative, participants will work in sub-groups (3 to 5, depending on the number of participants), ideally you will need a facilitator for each sub-group.

If you don't have any other choice than having your workshop online, having a facilitator per break-out room is a necessity, he will be the one taking notes and writing down the narrative!

It is advised to have one team member join each subgroup during the brainstorming session. Team members may move from group to group.

Workshop Invitations and Informed Consent Forms

Along with the workshop invitations, new participants should be sent a copy of the informed consent forms and associated participant information sheet, to be completed and returned ahead of the workshop. It is useful to have some copies of the form available on the day of the workshop in case they are needed. Templates for the invite as well as the informed consent form can be found in Appendices 2 and 3 respectively. *Participants that attended the first workshop need not sign again.*

BONUS ACTIVITIES

*** Try-out/mock the Future narrative exercise internally**

To make sure that all parameters (map, guiding principles, problem statement) align, it is recommended that you try the exercise internally before you propose it to your stakeholders.

DURING THE WORKSHOP

Workshop 2 – Problem Statement and Envisioning

Just like for the first workshop, the methodology is flexible and allows the use of complementary tools and methods during the workshop (as agreed upon with the WP2 team), as long as CSs produce the required output.

The main purpose of this second workshop is to:

- Validate the refined version of the mental map
- Reach consensus on the Living Lab problem statement,
- Develop future visions aligned with relevant SDGs that respond to local challenges

Below is an indicative agenda with the key activities which must take place within your workshop.

15 min	1. Welcome and Introductions of participants (especially new ones). Reminder of Living Lab concept, objectives, and process; brief summary of activities carried out between first and second workshops
5 min	2. Agenda and Objective of the Workshop
20 min	3. Present and validate the refined mental map
10 min	4. Consensus on problem statement
15 min	5. Envisioning Part 1: Validating guiding principles
15 min	6. Break
45 min	7. Envisioning Part 2: Future Narrative
15 min	8. Feedback to the group
10 min	9. Break
45 min	10. Merging and discussion of future narratives
20 min	11. Conclusion and next steps

As participants arrive, a sign-in sheet may be used to keep a record of attendees. Completed informed consent forms which have not already been submitted will also be collected at this point.

At the beginning of the workshop, the facilitator introduces themselves and invites each person present to introduce themselves too.

Activities

Round of presentations (only if new participants have joined the group).

Reminder of the LL concept and overview of the process.

Situate the current workshop within the larger LL structure. Reviewing past workshops' outcomes at the beginning of each session, explaining what steps were taken in between and how they connect to the previous group's decisions and insights, and communicating about the process (what is expected from each session, the work that has been done in between...) is important to keep everybody on track and build commitment and ownership of the process. It is also a good way to integrate new participants.

Agenda and Objective of the Workshop: Describe in more detail the work to be done during the current session.

Present and validate the refined version of the Mental Map. Show the refined mental map explaining highlighted variables (the ones with the most connections) and sectors that appear dominant. Ask for feedback, acknowledge suggestions, and, if the group agrees, add them to the map. Validate the outcome as an accurate representation of the system's current state. To make the session more interactive, you can ask the participant to stand up, look at the map on the wall and use sticky notes to make comments on the map

Present the initial problem statement. Ask for feedback, and discuss, until you reach a consensus.

Envisioning Part 1: Validate guiding principles

Requirements: 1 facilitator, 1 note taker, large sheets of paper, Markers

Plenary session.

Step 1: Explain what SDGs are, in a nutshell

Step 2: Present the selected targets (with the relevant guiding principles highlighted)

Step 3: Present the final list of guiding principles

Step 4: Reach consensus on the listed guiding principles. Include additional principles as suggested by the LL members.

During the break, prepare the room for the second part of the envisioning exercise. Prepare the group spaces.

Envisioning Part 2: Future narrative

In groups of appx 4, invite the participants to imagine their vision for their LL area in 2050. The goal is to explore alternative futures that go beyond 'business as usual and to think out of the box, overcome blockers, and project inspiring, 'blue sky' scenarios.

Step 1: building on the guiding principles, invite participants to imagine what the area will look like in 2050. Ask participants to discuss their vision, building a rich picture of the imagined future.

Use prompt questions to help build a richer picture:

What does [...] look like? (keep the focus on visualization)

What is [...] doing? (could refer to actors, sectors, etc.)

What would you like to see instead? (let's not dwell on barriers!)

Step 4: Put down this vision on paper (illustrations and images, bullet points, annotations, short paragraphs, draw a picture/storyboard) and choose a representative to present the to the group.

Step 5: As each group presents their future visions, the facilitator guides the discussion reiterating and confirming key features. The note taker writes these down, one per post-it sticking them on the board. During the break, cluster all key features thematically.

Some tips to guide the process:

- Keep the discussion's focus on positive visions, rather than blockers.
- Think back on the last 30 years and what has changed (major innovations and break throughs) to imaging what could be possible in the next 30 years. (the Vision Timeline, if developed, could help here)

During the break, cluster all key features thematically and prepare the room for the last exercise (plenary)

Feedback and merging of future visions.

Plenary session.

As a group, discuss the main themes identified. Begin developing short phrases that represent the emerging vision, and if possible, flesh out an entire paragraph. Critically assesses the visionary image:

- 'Is this a future we want to attain?
- Would it address the identified challenges?
- Does this vision leave no one behind?

Conclusion and next steps

- Present the next workshop's goals and activities: Co-design of adaptation pathways including backcasting, potential actions, key actors, blockers, innovation gaps, etc.
- Ask SHs to list potential innovations and/or innovators that support the transition to the envisioned future and send to the CS team. These may be local. Remember innovations can be technological, social or financial/institutional.
- Introduce the ARSINOE Open Call for Tenders

AFTER THE WORKSHOP

WP2 Post-workshop meeting

Following the workshop, the CS team will have a debrief meeting with WP2 in order to review the workshop and the main outputs, discuss the next steps.

Upload reporting materials

A reporting template will be provided to CS team leaders. Keep attendance sheets and consent forms, in a secure location. as well as images from the process.

In-between workshops

- Tell the story of your future vision in a narrative format combining all the elements agreed at the end of the workshop. This will provide a direction of where we want to go and the goal to be reach by the innovation pathway(s).
- Connect future narratives with innovations you are already aware of, proposed by participants, from the Climate Innovation Window... as well as with WP4 climate resilient solutions (if any).
- Conduct a preliminary identification of innovation gaps (to feed the Open Call)

Keep your stakeholder engaged

Just like you did for the first workshop, it's a good idea to design shared spaces, activities and tools, such as events, blogs, newsletters, collaborative maps, and social gatherings... to help keep momentum within the group, keep them engaged.. They can also be useful to keep the wider spectrum of stakeholders informed and connected to the process and gather potential additional input.

BONUS ACTIVITIES

*** Examples of activities to keep your stakeholder engaged**

- if there are data monitoring gaps in your area, you may want to invite LL members to collaboratively map where the gaps are.
- If different actors are working on connected issues in other circles, you may want to set up a shared agenda of events where people can announce activities related to the LL focus.
- If you are looking for local innovators to respond to the Open Call, you may organize an 'innovation lunch' or other social event to specifically target potential applicants.

Update the stakeholder matrix (if needed)

- Review and update the Interest/Influence matrix according to the current LL challenge and focus; add/remove/rearrange stakeholders accordingly.

Compensate stakeholder gaps

- If you notice that important voices are missing, arrange one-to-one meetings to gather input.
- Expand the list of potential workshop 3 participants if necessary.

WORKSHOP 3: BACKCASTING AND INNOVATION PATHWAYS

The main purpose of this third workshop is to:

- Identify key milestones towards reaching the future narrative /addressing the challenge
- Identify Living Lab innovations for elaboration
- Develop outline Innovation Pathways

The main output of this workshop are the outline innovation pathways, which will be elaborated into draft innovation pathways to be shared with LL members after the workshop.

Innovation Pathways refer to a trajectory of change that lead from the present state of the system to the desired future state where chronological milestones are underpinned by concrete actions and associated innovations.

The Story So Far: Summary of Living Lab Activities to Date

By now, you will have completed your first two SIA workshops and are ready to prepare for your third workshop. Here is a quick recap on the workshops and what you have achieved.

Workshop 1: Mapping – Scoping – Objectives setting

Main Objectives/Activities:

- Introduce the Project
- Introduce the Case Study
- Introduce the LL methodology
- Develop a Mental Map of the Case Study System
- Identify gaps in stakeholder representation
- Reach consensus on LL objectives

Main Outputs: Mental Map of the Case Study; Living Lab Challenge

Workshop 2: Problem statement and envisioning

Main Objectives/Activities:

- Validate the mental map
- Validate the LL challenge and problem statement
- Develop Future Visions

Main Output: Future Vision

Following your first two workshops, your Living Lab (LL) has not only successfully mapped your case study and identified the main LL challenges, but it has also defined a problem statement and created a Future Narrative – a vision of your case study area in the year 2050 and perhaps even begun to identify

some potential innovations that can help to achieve this vision. You are now ready for your third workshop which will focus on identifying key milestones necessary for the achievement of the Future Narrative, and producing outline innovation pathways towards your vision.

Between Workshops 2 and 3

Validation of Future Narrative

After workshop two, CS teams work to refine their Future Narrative in the case that only an outline was produced during the workshop. The finalised Future Narrative is shared with LL members for input and feedback ahead of the third workshop.

Addressing Stakeholder Gaps

Once again, the list of LL participants is reviewed to assess if there are knowledge gaps that need to be bridged by inviting new stakeholders to participate in the third LL workshop. It may be useful for CS teams to consider inviting potential innovators to join the LL.

BEFORE THE WORKSHOP

Decide on workshop details

Format: What format will you adopt for your workshop; in-person or online (in-person is the preferred method as it provides a better space for team-building and informal interactions; eg. Over a coffee break or lunch)?

Language: For transboundary case study, review the pros and cons of holding your workshop in an international language (English) or in local language with translators depending on the stakeholders you want to invite. Language shouldn't be the reason to exclude a certain group of stakeholders, if it cannot be avoided think of an alternative way to engage those stakeholders unable to attend due to language barriers (e.g face-to-face interview).

Date and Venue: Fix a date for the workshop. This may have to be done in collaboration with the intended LL members. Furthermore, your chosen date might be influenced by your choice of venue or vice-versa. A date will have to be chosen by approximately 6 weeks to the intended date of the LL workshop, so formal invitations can be sent out in good time.

Agenda: Depending on how long your workshop will be, if it will include lunch or not etc, set out the detailed agenda. A guide agenda is provided in the 'During the workshop' section of this guide.

Communication: Decide before the WS how you want/can communicate on the LL activities within the case study and the project, assign someone to take some pictures or short videos to be posted on ARSINOE social media for instance or any other communication channel you would like to consider.

Workshop Invitations and Informed Consent Forms

Along with the workshop invitations, new participants should be sent a copy of the informed consent forms and associated participant information sheet, to be completed and returned ahead of the workshop. It is useful to have some copies of the form available on the day of the workshop in case they are needed. Templates for the invite as well as the informed consent form can be found in Appendices 2 and 3 respectively. *Participants that attended previous workshops need not sign again.*

Innovation Identification

Over the course of the first two workshops, potential innovations may have been raised during discussions; these would have been recorded within the reporting template. In addition, LL members will be invited to submit potential innovations that they have knowledge of. CS teams will also collect any innovations that have been submitted via the Climate Innovation Window with the support of WP2 and WP5.

A template to collect information on existing innovation relevant to your LL can be found [here](#) (**ARSINOE Teams Folder: General-> Files -> WP2 -> Living Labs -> 3rd Workshop Guidelines and Templates**).

- 1) CS leaders should visit the Climate Innovation Window (a meeting can be arranged with WP2 and/or WP5 to initiate this process together), and browse innovation according to 'Hazard' type, in order to identify any that may be relevant to their LL challenge, and include list these innovation on the online template located in teams.
- 2) CS leaders should circulate an offline version of this xls. template to their LL members so they can provide information on any innovations they may be aware of. CS leaders are responsible for collating this information and transferring it onto the online template located on teams.

The complete list of existing innovations must be collated at least 2 weeks before your workshop, and before the pre-workshop meeting.

WP2 Pre-workshop meeting

About a week before your workshop, there will be an opportunity for a final sit-down with the WP2 team, to go over any last minute questions you might have and see that all is in place for your workshop.

Optional Activities

BONUS ACTIVITIES

Make an Inventory of Assets

This task is similar to what you did for workshops 1 and 2, only more focused. It should gather useful information and resources to support discussions, especially in relation to pre-existing conditions that need to be overcome to reach the future vision. Reflect on the discussions of workshop 2: are there gaps in data? Legal constraints? Lack of capacity?

Examples:

- Is there insufficient awareness of the volumes of loss in food production due to climate change? Get some graphs and visualizations and paste them on the wall.
- Are land use regulations very strict? Hand out a map of the area where different land uses are represented to participants so that they can rely upon it during the envisioning phase.

Think of ways to present this information to workshop participants that are accessible, concise, and relevant to your lab's focus, such as maps, graphs, charts, and timelines.

Internal Mock session for CS Team

Prior to your workshop, it may be useful to run a practice session with members of the CS team. Role playing the LL workshop can help you refine your implementation in a practical setting.

Interim meetings/workshops with LL members and other Stakeholders

Prior to the third workshop, you may choose to hold interim activities to engage the stakeholders, e.g. workshop to brainstorm potential innovations.

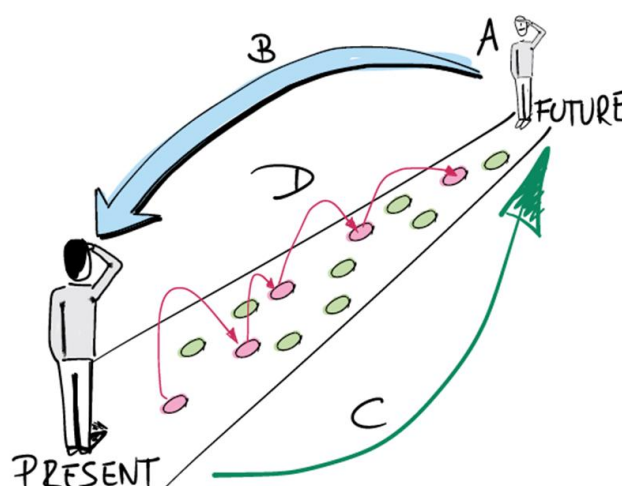
DURING THE WORKSHOP

Implementing Workshop 3– Backcasting and Innovation Pathways

The objectives of this third workshop are to:

- Identify key milestones towards reaching the future narrative /addressing the challenge
- Identify LL innovations for elaboration
- Develop outline **Innovation Pathways**

The third workshop consists of two key activities namely **Backcasting** and **Co-development of Innovation Pathways**.



Backcasting and Co-development of Innovation Pathways – Travelling from the future to the present and back again (Source: De Vicente López & Matti, 2016)

The main outputs of this workshop are the **outline innovation pathways**, which will be elaborated into draft innovation pathways to be shared with LL members after the workshop.

As with the previous two workshops, the methodology is flexible and allows the use of complementary tools and methods during the workshop (as agreed upon with the WP2 team), as long as CSs produce the required output.

Activities

Below is an indicative agenda with the key activities which must take place within your workshop.

10 min	1. Agenda of Workshop 3 and Main Objectives
10 min	2. Presentation of the problem statement and the Future Narrative (Validation)
60 min	3. Backcasting: the road from THEN to NOW
10 min	Break
60 min	4. Co-development of Innovation Pathways: Presentation and mapping of candidate innovations
	Break
10 min	5. Conclusion: Next steps – Elaboration of innovation

	pathways
--	----------

1. As participants arrive, a sign-in sheet may be used to keep a record of attendees. Completed informed consent forms which have not already been submitted will also be collected at this point.
2. At the beginning of the workshop, the facilitator introduces themselves and invites each person present to introduce themselves too.
3. Present the agenda of Workshop 3 and Main **Objectives**:
 - Identify key milestones towards reaching the future narrative /addressing the challenge
 - Identify LL innovations for elaboration
 - Develop outline Innovation Pathways
4. Present and validate the problem statement and the Future Narrative
5. **Backcasting**: This is a method to collectively create pathways to an envisioned future, taking the future as starting point and going step-by-step back in time. The choice to start from the envisioned future is essential to enable the formulation of future-oriented strategies that go beyond “business as usual” solutions and are not constrained by vested interests and stakes
 - **Step 1**: Ask the LL members to place themselves within their Future Narrative. Imagine the ‘Vision’ has actually come to pass and they are living in it. Individually, write down what **sectors and/or themes** are active or prevalent within this new norm.

For Example:

The Vision is “In 2050, Cityville is a beacon of urban wellbeing that is 100% powered by renewable energy sources. Alternative approaches to food production are the well-established and urban farming is promoted. The city operates state – of the art smart water infrastructure with adequate monitoring and efficient wastewater treatment.”

Sectors: Energy, Agriculture, Food, Water Utilities

the image of the future vision in mind, and using the canvas below (figure 2) as a tool, start moving backwards towards the present time and identify what changes should have happened to reach the desired future.

Spend 10 minutes individually to brainstorm as many changes as you can imagine. They could be: new knowledge, financial arrangements, new technologies, new political or economic frameworks, significant changes in actor configuration, cultural and formal conventions, changes in routines, rules, culture, infrastructure, etc.

Write down these changes (one per sticky-note, and identify what sector or theme these changes take place within – where possible, use a different coloured sticky-note for each sector/theme).

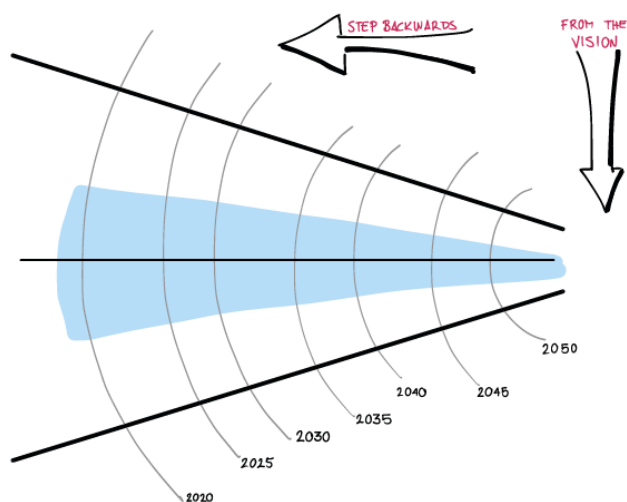
For Example:

Sector: Energy

Milestones: 100% renewable production, decentralized energy generation infrastructure in place

Sector: Agriculture

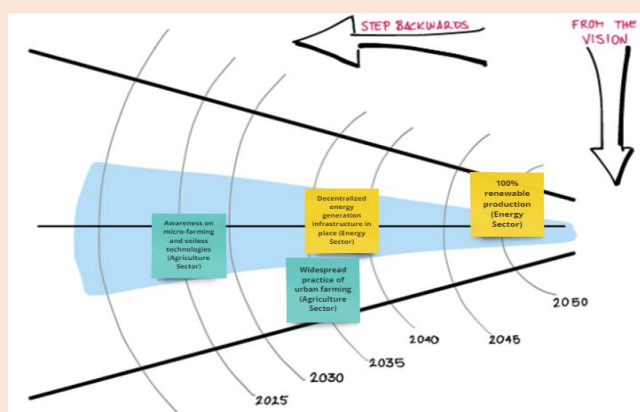
Widespread practice of urban farming, awareness on micro-farming and soiless technologies



Futures Radar (Source: De Vicente López & Matti, 2016)

Step 3: Collectively discuss the changes and plot them along the timeline using the future radar

For Example:



- **Step 4:** Identify key actors (groups of stakeholders) for each of the changes/actions

6. Co-development of Innovation Pathways: Now it is time to match innovations to the identified changes and actions. Looking at the future you can see the chain of changes that have been identified. The underlying idea for this step is to identify those innovations that can support these changes coming about.
 - **Step 1:** Present the list of identified innovations
 - **Step 2:** Collectively go through the list and identify which innovations are relevant to the changes and actions on the timeline. Write each selected innovation on a sticky-note and place it alongside the corresponding milestone. **(Note that one innovation may be relevant for more than one milestone; in this case produce additional sticky-notes with the same innovation and place on relevant milestones)**
 - **Step 3:** Highlight the remaining gaps. i.e. the milestones which are left without supporting innovations
7. Round up of the day's activities, next step will be online exchange to support the development/validation of the elaboration of the outline Innovation pathways (importantly highlighting the gaps).

Minutes and reporting

Throughout the workshop, the note-taker, will take notes on the progress of the workshop, the explanations of stakeholders regarding the main issues raised. A template to support this reporting activity is provided by WP2. Pictures should be taken of the Futures Radar Canvas during several stages of development.

AFTER THE WORKSHOP

WP2 Post-workshop meeting

Following workshop 3, on the basis of the reporting document and the outline innovation pathways, the CS team will have a debrief meeting with the WP2 team in order to review the workshop, the main outputs, initiate the pathway elaboration process and discuss next-steps.

Elaboration of Innovation Pathways

Building on the outline innovation pathways developed during the workshop, the WP2 team will work with the CS team to elaborate on the each of the innovations taking the following steps:

- Identify main barriers and challenges that could obstruct and/or hinder the innovation
- Identify enabling conditions that would support the innovation – in terms of a) Existence of Resources: Human, Financial, Political, and Technological; b) Decline/Decrease of undesirable activities and behaviors
- Validate with LL members either online or with an additional WS

Next Steps

Workshop three is the final workshop in the series of mandatory SIA workshops to be implemented under WP2. Of course, this does not mean the end of the SIA process.

Within the framework of ARSINOE, the implementation of the SIA continues via WP6 (T6.2 and T6.4), and with the selection of a relevant innovation under WP5 to be funded by the project through the open calls.

Outside of the ARSINOE project, if the stakeholders find value in the process, it is worth keeping the momentum going through further informal meetings (online or in person) where stakeholders can take steps towards implementing their innovation pathways (e.g. matchmaking with relevant partners, exploring other avenues of funding, establishing a cooperative etc.).
 Needless to say, the Living Labs live on!

APPENDIX 2: Pre-identification of innovations (outputs of WS3)

Challenge to address	
What innovations have you already discussed and identified to address your key challenge? (Please include one row per innovation identified i.e., you can have more than one innovation per challenge)	
Provide a short description of how this innovation will help to address the key challenge	
Please add information/links to specific innovations you have already identified, if available	
Is this innovation available in the Climate Innovation Window? If the your answer is yes, please include the link where to find it	
Observations	

APPENDIX 3: PESTLE framework

Identifying barriers and enablers with the PESTLE analysis

1. The PESTLE analysis

PESTLE is a framework initially developed to analyze the external factors that can influence an organization by looking at the Political, Economic, Social, Technological, Legal, and Environmental factors. In ARSINOE, it will be used to support case studies in mapping factors characterizing their systems in order to derive the barriers and enablers for implementing the innovation pathways in general and more specifically the innovations.

Table 1 below presents the framework including indicative type of factors you could consider for each of the themes including examples.

Table 13: The PESTLE framework

PESTLE	Type of factors to think about	Examples
POLITICAL factors	- International, EU, national and local governments, parties and frameworks - How countries implement EU Directives into national laws - Changing governments / Political stability - Populism - Reasonability and predictability of decisions 'Dogmas' of strong multinational companies - ect.	<i>Water Framework Directive</i> <i>European Green Deal</i> <i>Farm to Fork strategy</i> <i>Paris Agreement</i> <i>Corruption</i> <i>Effective implementation of regulation</i> <i>Lobbying</i> <i>CO2 emission trading</i> <i>IMO emissions regulation</i>
ECONOMIC factors	- Inflation - Economic growth or recession - Interest rates - Skill level of workforce in the present market - Commodity prices - National minimum wage - Historical patterns which apply or not - New paradigms, e.g. sharing over ownership models, servitization - Etc.	<i>Consumer spending behavior for local product; environmental friendly products</i> <i>Innovation potential for capital goods, digital solutions</i> <i>Readiness to implement innovative circular strategies</i>
SOCIAL factors	- Cultural factors - Average educational level - Consumer preferences - Societal trends, e.g. in fashion - Demographical structure - Disrupted workforce by new technologies and paradigms, affecting entire communities and markets - Attitude towards sustainability	<i>Increasing feasibility for closed circular solutions</i> <i>Increasing knowledgebase of customers and demand for environmentally friendly product</i> <i>'Millennials' more attentive to 'sustainability', local product, environmental pollution, resource depletion</i> <i>Raised risk awareness in regards to</i>

	▪ New 'ruling' generations(e.g. millennials) ▪ Etc.	<i>natural disaster (climate change awareness)</i> <i>Resistance to change</i> <i>Cultural factors</i>
TECHNOLOGICAL factors	▪ Disruptive technologies ▪ Disruptive processes ▪ Access to tech wisdom (e.g. best practices) ▪ Access to communication ▪ Networking of everything ▪ Open data ▪ Open standards ▪ Decoupling from non-renewable energy ▪ Etc.	<i>Average educational level</i> <i>Data availability</i> <i>5G technology as foundation for citizen science initiatives</i> <i>Internet of Things (IoT)</i> <i>Low cost technology availability</i> <i>Access to innovation</i>
LEGAL factors	▪ Interrelation with political factors ▪ Regulations ▪ Taxation ▪ Incentives, e.g. subsidies ▪ Monitorization ▪ Sanctioning ▪ Etc.	<i>Energy efficiency requirements for consumer goods or buildings</i> <i>Farmers incentives favoring certain practices</i> <i>Water use Regulation</i> <i>Restriction of usages during heat waves</i> <i>Funding for entrepreneurship</i> <i>Supporting regulation for fighting climate change</i>
ENVIRONMENTAL factors	▪ Effects vary from sector to sector ▪ Direct and indirect impact on sustainability of all activities ▪ Sourcing of raw materials and renewables is / can be affected ▪ Paradigms could change, e.g. living indoors most of the time (therefore influencing all businesses) ▪ Negative psychological aspects are / can be induced (e.g. foggy or cloudy most of the time), with high influences on communities	<i>Decrease of biodiversity</i> <i>Long term low groundwater level</i> <i>Water pollution</i> <i>Air pollution – Smog</i> <i>Marine Litter</i> <i>Flood risk</i>

	▪ Etc.	
--	--------	--

2. Application to the Innovation Pathways

Apply the PESTLE framework for each of the innovation you've have identified in your Innovation Pathway using the tables below (one table per theme / sector your IP is focusing on) by answering the question: 'what type of political / economic / technologic / legal / environmental factors could support (equal as enabler) or hamper (equal as barrier) the implementation of a specific innovation?'

You won't necessary have barriers and enablers in all categories while the same barrier or enablers can apply to multiple innovations.

The PESTLE is here to support the analysis and go beyond the obvious

Barriers and enablers should be context specific to your Case Study and not generic.

CSx - Identification of barriers and enablers for innovation related to theme / sector 1*(add the name or your theme/sector here)

Factors	Barriers / Enablers	Innovation 1	Innovation 2	Innovation 3	Innovation 4	Innovation 5
Political factors	Barriers					
	Enablers					
Economic factors	Barriers					
	Enablers					
Social Factors	Barriers					
	Enablers					
Technological factors	Barriers					
	Enablers					
Legal Factors	Barriers					
	Enablers					
Environmental factors	Barriers					
	Enablers					

- Identification of barriers and enablers for innovation related to theme / sector 2*(add the name or your theme/sector here)

Factors	Barriers / Enablers	Innovation 1	Innovation 2	Innovation 3	Innovation 4	Innovation 5
Political factors	Barriers					
	Enablers					
Economic factors	Barriers					
	Enablers					
Social Factors	Barriers					
	Enablers					
Technological factors	Barriers					
	Enablers					
Legal Factors	Barriers					
	Enablers					
Environmental	Barriers					

factors	Enablers					
---------	----------	--	--	--	--	--

*Summary of the key barriers / enablers (think about it as the key message to pass on to policy makers / stakeholders in charge of the implementation of the IP.
Summary at sector /field level or general summary.*

APPENDIX 4: CS3 innovations

Details of innovation identified and expected impacts

Water track:

‘Public water supply must take priority over other uses’: Climate change will cause conflicts of use between the public water supply and other user groups due to longer and more extreme dry periods. For this reason, public water supply must actually be given priority over other uses and management aspects in accordance with the existing regulation in the WHG, thus ensuring the vital provision of services of general interest for the population, which is necessary in terms of hygiene. In addition, the priority of public water supply must be enshrined in the Bavarian Water Resources Act.

‘Skilled labor strategy for the water industry’: Water supply and wastewater companies can only become climate-resilient if there are enough well-qualified staff. Almost a third of those employed by Bavarian water suppliers were over 55 years old in 2022 and are expected to retire in the next few years. At the same time, many companies are struggling to fill vacancies and find trainees. A skilled labor strategy for the water industry could promote job profiles, facilitate lateral entry and strengthen cooperation between water supply companies, schools, universities and employment agencies.

‘More staff and training opportunities for the water management administration’: A climate-resilient water supply is fundamentally dependent on the availability of abundant and high-quality water resources. The protection of the water balance as a state task is driven by employees in the water management administration. More jobs must be created here in the near future and employees must receive further training on climate resilience issues. Where necessary, a paradigm shift must take place: Away from a focus on drainage towards water management that aims to keep water in the area and protect it. This will strengthen resource protection and speed up administrative processes.

‘Introduction of a water abstraction charge for water conservation’: A water abstraction charge should be used to encourage efficient and sustainable water use. It should be levied on all water users. Equal rates and no exemptions can ensure simple and unbureaucratic enforcement. The revenue is invested in the protection of water resources.

‘Education, training and networking on climate change and climate risks’: Climate change, its consequences and strategies for greater climate resilience have not been a topic in the education and everyday working lives of most people in Bavaria. At the same time, a development towards more resilience in the face of climate change can only be achieved if qualified specialists and managers recognize and address climate risks. Bavaria needs an education initiative for more resilience to climate change. Children and young people must be taught the basics of climate change at school and, where possible, projects can demonstrate their own options for action. Training curricula must be adapted so that climate impacts and options for action are included, for example in environmental engineering professions or at agricultural colleges. Further training opportunities should be created for people in

employment. Better networking and the sharing of practical experience can further empower and motivate local actors.

‘Adaptation of the legal framework to enable rapid climate adaptation of infrastructure’: Climate adaptation in water management includes the renewal and construction of water infrastructure. In order for these projects to succeed quickly, planning and approval processes need to be accelerated. The construction, maintenance and operation of water and wastewater infrastructure should be given the status of “überragendes öffentliches Interesse” (overriding public interest) as they are central to the provision of basic public services. This status must be enshrined in law. Fictitious approval - i.e. acting as if an application has been approved if the competent authority does not process the application within the specified period - is a long-established instrument of German administrative law. For projects that serve to secure the supply of drinking water and wastewater disposal for the population, fictitious approval could be given to take advantage of the considerable acceleration effect. Construction projects that serve the security of public supply and/or climate adaptation and are eligible for funding should be allowed to start construction and measures early across the board.

‘Consideration of water and wastewater management in regional planning and municipal climate adaptation concepts’: The interests of the water supply must be taken into account in regional planning, e.g. water suppliers should be included in the definition of priority and reserved areas for water supply. This could be achieved through regular exchanges between those responsible for planning and supply companies. The interests of water and wastewater utilities should be taken into account in municipal adaptation concepts, e.g. by involving water suppliers and wastewater utilities in the formulation of concepts and the planning of municipal measures.

‘Support services for operators of critical infrastructure for a better understanding of climate risks and for the development of adaptation measures’: Developing good strategies to increase climate resilience requires a good understanding of relevant climate change impacts for one's own utility operations and options for action. Consulting services, especially for small and medium-sized utilities, and the development of dedicated climate services and other tools for improved action planning are desirable. The expansion of advisory services by the Free State of Bavaria, e.g. at the water management offices or the Bavarian State Office for the Environment, could be particularly helpful for utilities with few employees.

‘Water resources for the public supply’: The public water supply is fundamentally dependent on an abundant and high-quality water supply. As part of climate adaptation, resources for the water supply must be secured through protected areas and water rights, and the principle of local water supply should be observed.

‘Digital water register’: A digital water register enables data-based water management in the region. All water rights and water law permits are recorded in the register. It also contains information on actual withdrawals from bodies of water and groundwater. The information forms the basis for monitoring water withdrawals and can be used in water law procedures.

‘Enabling cascading use of water’: Cascade use of water can increase the efficiency of water use. It must be clarified which water can be used for which purposes. Technical prerequisites for the reuse of water must be created.

‘Restrict water use in hot summers’: Hot days are associated with high peak demands on the public water supply. In view of low groundwater recharge and frequent hot summers, water suppliers and local authorities should look ahead and consider restrictions and bans on use. Supply bottlenecks can generally be avoided, e.g. through resource conservation, changes in land use, emergency networks,

long-distance pipeline systems and demand management. Restrictions and bans on use are one of the last options that can be used in cases of acute water scarcity and a looming supply bottleneck.

Land use and soil:

‘Protect soils’: The cultivation of agricultural land relies on sustainable soil management to support the infiltration, storage and evaporation of water. Soils are covered with plants as much as possible, are rarely driven on and with the lightest possible vehicles.

‘Substrate production for biogas takes soil into account’: Substrate for biogas production often comes from maize monocultures. Alternative plants or seed mixtures improve soil quality, protect against erosion during heavy rainfall and are better for biodiversity.

‘Forest conversion in the interests of climate resilience’: Forests are converted into more climate-resilient mixed forests and maintained in a targeted manner so that a forest with healthy trees, different climate-resilient tree species and a coexistence of small and large plants is created. More forests will become natural forests.

‘Reconstruction of bodies of water’: Rivers and streams are re-naturalized. Wetlands and moors are rewetted. (Irrigation) ponds are created and drainage ditches are used to retain water.

‘Hedges as fixed elements of the cultural landscape’: Hedges are planted as fencing, as erosion protection and for shading along paths and at property boundaries. They regularly interrupt the landscape so that they once again become an integral part of the Bavarian cultural landscape. They are designed to suit their location and maintained as valuable tools for water retention and as habitats.

‘Reduction of substance inputs’: In accordance with the precautionary and polluter pays principle, substance inputs into water bodies and groundwater, in particular nitrate and pesticides, must be further reduced, e.g. by switching to organic farming. The use of pesticides and fertilizers must be reduced in order to achieve better water quality.

‘Maintain rain-fed agriculture and control irrigation’: Agricultural businesses rely on drought-resistant species, thereby increasing their own resilience and reducing the need for irrigation. In this way, rain-fed agriculture can remain the norm. Where necessary, rainwater and water from surface waters and irrigation ponds created for this purpose are used. Water is withdrawn depending on the condition of the water. The suitability of various species for irrigation has been clarified. Water-saving systems and sensors for measuring water requirements are used for irrigation.

‘Cooperation agreements between water suppliers and agricultural businesses take climate impacts into account’: Numerous water suppliers have voluntary cooperation agreements with agricultural businesses in the catchment area of their wells. The aim of these agreements is generally to reduce substance inputs (nitrate and PPPs) through adapted management. As a result of the climate crisis, additional risks to the water supply are gaining in importance, which can be addressed through changes in land use: Reduced groundwater recharge due to reduced precipitation and an increase in heavy rainfall on parched soils, substance inputs during heavy rainfall, soil erosion during heavy rainfall with long-term repercussions on groundwater recharge. Similar to substance inputs, they could be taken into account in cooperation agreements by agreeing further or other measures to protect the water balance and soils.

‘Support programs and subsidies are not an obstacle to climate resilience’: Government support should contribute to climate resilience. Where there are contradictions between the funding objectives of individual programs and water protection, climate change mitigation or adaptation to climate change, these conflicts must be resolved. Funding should contribute as little as possible to climate change, soil compaction and water pollution.

‘Introduction of a drainage charge outside of settlements’: In the region, more water should be absorbed locally and stored by the landscape, and incentives must be provided for this. In residential areas, split wastewater charges have been used for years to encourage residents to design their properties in such a way that precipitation can seep away on site and does not flow into the sewer system. A similar approach should be considered beyond the networks of wastewater companies.

‘New drainage management’: Drainage is recorded in a central drainage register to provide an overview of which areas are drained and where. Drainage systems are gradually being dismantled or converted so that more water remains in the region. The construction of new drainage systems is subject to approval.

‘Lease agreements enable water-sensitive design and management of agricultural land’: Lease agreements have a major influence on how agricultural land is used. By agreeing certain measures for water-sensitive management in the contract, climate-adapted land use becomes possible. The measures are adapted to local conditions and the possibilities of the tenants.

‘Reduce land consumption and unseal areas’: Promote inner development in cities and municipalities, develop open spaces and repurpose vacant buildings by providing support services for municipalities, e.g. in inter-municipal cooperation or planning tools as well as offers for citizens such as advice on the renovation of existing buildings

‘Water-sensitive design and maintenance of urban green spaces’: Green spaces support water retention in cities, protect against heat and provide fresh air, are important habitats and ensure a beautiful cityscape. The multifunctionality of these areas must be taken into account during planning. Where trees are planted, care should be taken to use climate-resistant tree species that are suitable for the location. When irrigating the areas, sensors can be used to measure the irrigation requirements. They can be irrigated with rainwater or treated water from wastewater treatment plants. Volunteers can support the watering of trees in times of drought so that trees can survive very dry periods.

‘Establishment of a Bavarian alliance for green and blue cities’: Heavy rainfall, drought and heat can be countered with targeted rainwater management. An alliance for green and blue cities could be created in the region in order to find a good way of dealing with the alternation of too much and too little rainfall in a timely and comprehensive manner.

‘Municipalities set incentives for green and blue infrastructure’: Existing tools are used to promote green and blue infrastructure. Tree protection concepts or the climate adaptation of municipal open space concepts can ensure more greenery. Ecological criteria can be included in the allocation of municipal land and development plans can specify certain measures. Furthermore, municipal funding guidelines can provide incentives, e.g. for unsealing and greening areas or greening building facades.

‘Crowdfunding and climate funds for local adaptation projects’: Crowdfunding and (municipal) climate funds are financing mechanisms through which local projects can be funded by the local community. They are increasingly being used for climate adaptation. Currently, climate adaptation projects are generally unable to generate financial returns. Crowdfunding and climate funds are instruments that can nevertheless be used to finance local community projects to improve climate resilience. The "return on investment" of the climate fund is the positive impact of the investment on the resilience of the region.

Public awareness and education:

‘Imparting knowledge and skills’: Climate change and sustainability are an integral part of school and vocational education. Teachers are trained accordingly. Curricula are adapted so that the topics have a permanent place in school and vocational education. In this way, young people are taught basic

knowledge and relevant skills. As part of job orientation, students are shown the professions in which they can actively promote climate protection and adaptation.

‘Citizens are involved in local decisions and planning’: Climate change impacts local citizens, and successful adaptation also requires broad social support. Citizens' climate councils are involved in local decisions and planning so that they can shape their environment, measures are adapted to the situation of the people and can be successfully implemented. Round tables on current adaptation issues or participation processes in urban planning can serve as role models. At the same time, the participation of experts in decision-making and planning can be promoted, especially for issues that affect many different groups of people. For example, local heavy rain management can be developed and implemented together with those affected.

‘Volunteering for climate resilience’: Volunteering for climate resilience in the region is supported. Volunteer agencies show options for getting involved in local climate protection and adaptation. The Federal Voluntary Service could be supplemented by a so-called Voluntary Municipal Year. This could give volunteers the opportunity to spend six to twelve months in a local authority, municipal company or other public institution in the service of the general public and work towards climate resilience. Activities in the areas of climate protection and adaptation, energy transition and drinking water protection in particular could be interesting areas of activity on site.

‘Education, training and networking on climate change and climate risks’: In the education and everyday working life of most people in Bavaria, climate change, its consequences and strategies for greater climate resilience have not been an issue to date. At the same time, a development towards more resilience in the face of climate change can only be achieved if qualified specialists and managers recognize and address climate risks. Bavaria needs an education initiative for more resilience to climate change. Children and young people must be taught the basics of climate change at school and, where possible, projects can demonstrate their own options for action. Education curricula must be adapted so that climate impacts and options for action are given space, e. g. job training curricula should be adapted so that climate impacts and options for action are included, for example in environmental engineering professions or at agricultural colleges. Further training opportunities should be created for professionals. Better networking and the sharing of practical experience can further empower and motivate locals.

‘Creative ways of informing consumers’: Consumers are sensitized to the regional challenges of climate change through creative and target group-oriented information offers and are shown options for action. Water footprints on all products raise awareness of the water consumption associated with a product and enable consumers to choose water-saving options. Media regularly provide information on the state of the water balance, e.g. similar to a weather report or in the form of a "water traffic light", which provides information on how much water is likely to be available in the coming weeks. Campaigns in public spaces or competitions such as the search for the driest garden raise awareness of water shortages, drought and site-adapted design of green spaces.

APPENDIX 5: Outputs of CS4 national workshops

Greek working group:

Key themes and associated key sectors	Water-Environment-Biodiversity Tourism
--	---

	Agriculture Forestry Fishery Livestock Farming Employment <i>[list the themes and the sectors associated identified within the Future Narrative]</i>		
Milestones	Description	Timing	Theme(s)/Sector(s)
	<i>[description of the changes/actions identified]</i>	<i>[2045, 2040, 2030 etc.]</i>	
	Planning of educational system & producing educational material	2025	Education-Social Cohesion
	Empowering local society: Local educational activities, including environmental education and traditional local practices, both for children and adults	2030	Education-Social Cohesion, Institutional-Legal Framework
	Participatory governance	2035	Education-Social Cohesion, Institutional-Legal Framework
	Collective work-Environment of collaboration	2025-2030	Education-Social Cohesion, Employment
	Promoting the touristic value of Prespes	2025	Tourism
	Improvement of infrastructure (e.g. road network, pathways), to increase accessibility of POIs and support crisis management (e.g. wildfires)	2025-2030	Tourism, Forestry
	Management of visitors aiming to equal distribution in space and time	2030-2035	Tourism
	Research on agriculture and water consumption	2025-2030	Agriculture
	Increased effectivity in irrigation (reducing water losses)	2030	Agriculture
	Promote grazing around the lakes	2025-2030	Livestock Farming, Fishery
	Research on invasive alien species, especially in lakes	2025-2030	Water-Environment-Biodiversity, Fishery
	Increased quantity of fish to be caught	2030-2035	Fishery
	Synergies among and between sectors (primary sector and	2030	Agriculture, Livestock Farming, Fishery,

	tourism)		Tourism, Employment, Education-Social Cohesion
	Transboundary crisis management (bird plagues, extreme weather events, wildfires)	2030	Water-Environment-Biodiversity, Forestry
	Modification of institutional-legal framework for protected areas	2030	Water-Environment-Biodiversity, Institutional-Legal Framework
	Planning of transboundary monitoring system, inventory of existing data	2025	Water-Environment-Biodiversity
	Operation of transboundary unified monitoring system/ Data Harmonization	2030	Water-Environment-Biodiversity
	Possible river diversion to Small Prespa	2030-2035	Water-Environment-Biodiversity
	Limiting lake vegetation/ countering eutrophication	2030-2035	Fishery, Agriculture, Water-Environment-Biodiversity
	Wet meadows restoration	2035	Water-Environment-Biodiversity, Livestock Farming, Fishery
	Economic incentives for activities in Natura 2000 protected areas	2030	Water-Environment-Biodiversity, Employment
	Study on alien species in the lakes	2025-2030	Fishery, Water-Environment-Biodiversity
	Management of invasive alien species in the lakes, substantially reducing their population	2035	Fishery, Water-Environment-Biodiversity
	Administrative re-organization of mechanism	2025-2030	Institutional-Legal Framework
	Immigration of population, as part of decentralization	2035-onwards	Employment
Outline Innovation Pathways			
List of Selected Innovations**	Innovation	Related Milestone(s)	Associated Actors
	1. Drop Irrigation 2. Smart Irrigation	Increased effectivity in irrigation	

	Systems 3. Diversification of agriculture with less water-demanding crops	(reducing water losses)	
	4. Grazing Management Plan	Promote grazing around the lakes	Public authorities, private companies
	5. Transboundary Crisis Management Plan	Crisis Management Plan (bird plagues, extreme weather events, wildfires)	Ministry of Environment, NECCA
	6. Transboundary updated Management Plan for Protected Areas	Modification of institutional-legal framework for protected areas	Transboundary Park Committee
	7. Advanced grazing systems (NBS)	Promote grazing around the lakes, Wet meadows restoration	
	8. Innovative fishing methods and equipment	Management of invasive alien species in the lakes, substantially reducing their population	
	9. Economic incentives for fishing invasive alien fish (e.g. cat food production from <i>Lepomis gibbosus</i>)	Management of invasive alien species in the lakes, substantially reducing their population	
	10. Educational activities for environmental awareness targeted to professionals, seminars for children, common educational activities	Empowering local society: Local educational activities, including environmental education and traditional local practices, both for children and adults	
	11. Programs of maintenance/ creation of network of pathways for POIs	Improvement of infrastructure (e.g. road network, pathways), to increase accessibility of POIs and support crisis management (e.g. wildfires)	

	12. Subsidies system for specific activities in Natura	Economic incentives for activities in Natura 2000 protected areas	
	13. Transboundary Visitors (Tourism) Management Plan	Management of visitors aiming to equal distribution in space and time	

Macedonian working group:

Key themes and associated key sectors	Institutional-Legal Framework Water-Environment-Biodiversity Education-Social Cohesion Energy Tourism Agriculture Forestry Fishery Natural heritage Cultural heritage Employment <i>[list the themes and the sectors associated identified within the Future Narrative]</i>		
Milestones	Description	Timing	Theme(s)/Sector(s)
	<i>[description of the changes/actions identified]</i>	<i>[2045, 2040, 2030 etc.]</i>	
	Improved common monitoring of used quantity of the water	2025	Water-Environment
	Better Smart irrigation systems	2030	Agriculture-Water-Environment
	Educational activities and better education, for raising awareness on local and national level	2030	Education-Social Cohesion, Institutional-Legal Framework
	Common improved Transboundary Management Plan for the protected areas	2030-2035	Institutional-Legal Framework
	Improved share of clean energy from RES	2035	Energy-Water-Environment
	Data harmonisation between 3 countries	2035	Water-Environment-Biodiversity – Institutional-Legal framework

	Sustainable cultural tourism	2035	Tourism-Cultural heritage
	Innovating fishing and fishery methodologies and equipment	2035	Fishery- Water-Environment
	Less water demanding agriculture	2035	Agriculture-Water-Environment
	Better maintenance of road network pathways on transboundary level	2035-2040	Infrastructure
	Better demography in the region	2040	Demography-Employment
	Raising water quantity and quality in the Prespa region	2040	Water-Environment
	Clean energy balance achieved	2045	Energy-Water-Environment
	Digital twins	2045	Infrastructure
	Climate resilience infrastructure	2045	Infrastructure
	Participatory governance	2035	Education-Social Cohesion, Institutional-Legal Framework

7. Outline Innovation Pathways

List of Selected Innovations**	Innovation	Related Milestone(s)	Associated Actors
	1. Planning of transboundary monitoring system, and inventory of common data 2. Planning of inventory of existing data	Improved common monitoring of used quantity of the water	Ministry of Environment and Physical Planning of North Macedonia, Municipality of Ohrid and Resen
	1. Operation of transboundary unified monitoring system and data harmonization 2. Modification of institutional-legal framework for protected areas	Common monitoring methodology and better monitoring of waters	Ministry of Environment and Physical Planning of North Macedonia, Municipality of Ohrid and Resen, Government
	1. Drop Irrigation 2. Increased effectivity in irrigation (reducing water losses) 3. Diversification of	Better Smart irrigation systems	Ministry of Agriculture, Forestry and Water, Sector of Climate Changes, Municipality of Resen

	agriculture		
	1. Creating educational courses and materials and implementing events and workshops	Educational activities and better education, for raising awareness on local and national level	Public authorities, university, Municipality of Resen, Struga and Ohrid
	1. Transboundary Crisis Management Plan	Common improved Transboundary Management Plan for the protected areas	Ministry of Environment and Physical Planning of North Macedonia, Municipality of Ohrid and Resen, Transboundary Park Committee
	1. Solar panel compatible with agriculture areas	Improved share of clear energy from RES	Government, Municipality of Resen, Struga, Ohrid
	1. Synergies between different sectors on national and transboundary level	Data harmonisation between 3 countries	Government, all ministries
	1. Raising awareness for sustainable in the tourism sector 2. Better promotion of the UNESCO cultural and natural heritage	Sustainable cultural tourism	Ministry of economy, Agency for Promotion and Support of Tourism in North Macedonia
	1. Better innovative fishery methodologies 2. Increased quantity of fish to be caught	Innovating fishing and fishery methodologies and equipment	Government, Fishery Association of N.Macedonia, Municipalities
	1. Building infrastructure, improved road network between 3 countries	Better maintenance of road network pathways on transboundary level	Government, Municipalities in all 3 countries
	1. Economic incentives for the young generations	Better demography in the region	Government, Municipality of Resen, Ohrid and Struga, Chamber SMEs
	1. Raising awareness for the importance of the water 2. Possible river diversion to Large Prespa Lake	Raising water quantity and quality in the Prespa region	Ministry of Environment and Physical Planning, Sector for Water Management, Municipality of Resen,

			Ohrid and Struga
	1. Renewable energy solutions with capacity comparing charged from Ohrid Lake	Clean energy balance achieved	Government, Ministry of economy, Ministry of Environment and Physical Planning, Sector for Water Management, Municipality of, Ohrid
	1. Creation of 3D station climate hydro model software on transboundary level	Digital twins	Government, Ministry of economy, Ministry of Environment and Physical Planning, Sector for Water Management, Municipality of, Ohrid, Resen Struga
	1. Data harmonization	Participatory governance	Government, Ministries, public institutions
	1. Improved smart sensor based system for monitoring of condition of infrastructure	Climate resilience infrastructure	Government, Ministries, municipalities, SMEs in the region

Albanian working group:

Key themes and associated key sectors	Education and Social awareness Legal Framework and Policy Ecosystems Forests and Wetlands Agriculture Fishery Tourism Infrastructure Renewable Energy Founding opportunity		
Milestones	Description	Timing	Theme(s)/Sector(s)
	Area community education/awareness, critical thinking	2025	Education and Social awareness
	Awareness of tourists and visitors with appropriate signage	2025	Education and Social awareness
	Multidimensional Education, Environmental Education	2025	Education and Social awareness

	Monitoring of droughts, amount of precipitation, soil types/fertility, water flows (input/output)	2025	Ecosystems, Framework and Policy
	Creating a common database between 3 countries	2025-2030	Ecosystems, Framework and Policy
	Building infrastructure to withstand the intensity of extreme weather events associated with climate change	2030	Infrastructure
	Improvement of the sewage network	2025	Infrastructure
	Funding	2025	Infrastructure
	Preparation of the Water Basin Management Plan	2025-2030	Ecosystems, Framework and Policy
	Reducing wastewater discharge, capturing and storing rainwater	2030	Legal Framework and Policy
	Protection and restoration of forests and wetlands to guarantee the stability of ecosystems	2030-2035	Forests and Wetlands
	Efficient use of forests	2030	Forests and Wetlands
	Implementation of policies on climate change, protection of water resources and sustainable land use near lakes	2025-2030	Legal Framework and Policy
	Reducing the carbon footprint of tourism activities by promoting sustainable transport options	2030-2035	Tourism
	Awareness of tourists about the threats to the ecosystem of the lake	2030	Tourism, Education and Social awareness
	Implement waste reduction and recycling programs in the tourism sector	2030-2035	Tourism

	Policy documents/papers	2035	Synergies, Legal Framework and Policy, Ecosystems
	Transboundary agreements	2025-2030	Synergies, Legal Framework and Policy, Ecosystems
	Development and implementation of programs for the protection of endangered habitats	2040	Ecosystems, Legal Framework and Policy
	Improving water quality and reducing pollution in aquatic ecosystems	2035-2045	Ecosystems
	Protection of critical habitats for key species	2030	Ecosystems, Fishery
	Transition to renewable energy sources (wind and solar energy)	2045	Renewable Energy
	Programs for waste reduction and recycling in tourism	2040	Renewable Energy, Legal Framework and Policy
	Implementation of sustainable fishing and aquaculture practices to prevent overfishing and habitat destruction	2045-2050	Fishery, Ecosystems
	Encouraging the adoption of climate-smart agricultural practices to reduce water pollution and runoff into lakes	2045-2050	Agriculture
	Intelligent and precise irrigation	2045-2050	Agriculture
	Promotion of agro-processing, agro-tourism	2030-2035	Agriculture
Outline Innovation Pathways			
List of selected Innovations**	Innovation	Related Milestone(s)	Associated Actors
1. 2. 3.	Smart pathogens detection	Improving water quality and reducing pollution in aquatic ecosystems.	Water Resources Agency
	IRRIBIGDATA	Creating a database between 3 countries, intelligent and	Water Resources Agency Municipality

4.		precise irrigation.	Monitoring institute
	Sponge Castell - Securing water resources with the "anyway" strategy using the example of the municipality of Castell	Building infrastructure to withstand the intensity of extreme weather events associated with climate change.	Municipality Monitoring institute
	Tools for selection of irrigation method for water saving resilience - TREATS	Intelligent and precise irrigation, improvement of the sewage network.	Water Resources Agency Local water sewerage system
	PAP.EARTH	Search engine, providing users with accurate and relevant search results	Universities Municipality Protected agency

APPENDIX 6: list of innovations targeted by CSs in the ARSINOE innovation pathways

Water management sector

Table 14: Technological innovations in the field of water management targeted in ARSINOE CS Innovation pathways

CS	Technological innovations in the field of water management	link or example
CS1	Rain Gardens	https://bit.ly/3TBW4Gn
	RESILIO : adaptive rooftops (Roofs for water harvesting)	https://bit.ly/498LZGJ
	RichWater	https://bit.ly/3J0XOEd
	LooPi®	https://bit.ly/3PFCbxc
	vertical ecosystem	https://bit.ly/3TT94sl
	SolarDew	https://bit.ly/3PGPmOu
	Really cooling water bodies in cities	https://bit.ly/49hKwxU
	Water art - fountain - cooling measure:	https://bit.ly/4asEQIO
	The Refreshing Waters (Cooling Station 2.0)	https://bit.ly/4abU8eV
CS2	SenZ2: Monitoring water system infrastructures in real-time	
	3D Presenting Coastal Protection Reefs: to mitigate coastal floods	
	Bufferblock: stormwater drainage and buffering in the urban area.	
CS3	Water Footprint Toolbox: interactive list of concepts, standards, tools, databases, data sets and impact assessment methods concerning water foot printing	https://wf-tools.see.tu-berlin.de/wf-tools/waterfootprint-toolbox/
	Irrigation: innovative strategies for irrigating greenery in public spaces: use of sensors; rainwater and reused water; volunteering for trees during drought	https://www.nuernberg.de/internet/soer_nbg/baumwaesserung.html
	Nutzwasser: use of treated wastewater	https://www.nutzwasser.org/public/index.html
	water-efficient irrigation technologies (drip-irrigation) combined with sensors and schedules where irrigation is necessary; IRRIBIGDATA for integrating solutions	ARSINOE CIW
CS4	WATER4ALL: Real-time groundwater level measurement	ARSINOE CIW
	AQUASmartTech, GreenSense & Solutions: Sensors & IoT Platform with real-time water quality parameters	
	IWRS: Integrated Water Resilience System based on sensors & incl. educational initiative	ARSINOE CIW
	water measurement with digital system	https://www.geo.edu.al/MonitoringForecast/Hydrologic_Meteorological_Forecast/

	raindrop harvesting including training	https://www.watercache.com/education/rainwater-harvesting-101
	real time monitoring and leakage detection and reduction system in water distribution networks	ARSINOE CIW
	Digital Twin of Catchment area, input: in situ observations, satellite data and weather forecasts (Waterjade-)	ARSINOE CIW
	Little Alert Boxes network: real-time data on envir. parameters	ARSINOE CIW
CS5	NBS for domestic wastewater treatment	https://www.agrocabildo.org/publica/publicaciones/sost_470_cuadernillo.pdf
	utilization of brine for resource generation, ceasing to be a waste product	https://www.mdpi.com/2073-4441/15/8/1600
	Irrigation and foliar water using ozonated water	https://www.sciencedirect.com/science/article/abs/pii/S2468584422000502
	water disinfectants system more efficient than Chlorine, generating fewer or no byproducts (i.e. Ozone system)	https://www.watertechnologies.com/products/disinfection-oxidation/ozonia-ozone-systems
	Swarm Robotics Systems (MATRIX) for Pipeline Inspection	https://www.imnovation-hub.com/es/agua/robot-tuberia/
	use sludge generated in wastewater treatment plants as a source of energy	https://www.caib.es/pidip2front/jsp/es/ficha-convocatoria/strongla-agencia-balear-del-agua-inicia-un-proyecto-piloto-de-reutilizacioacuten-de-los-lodos-de-las-depuradoras-como-fuente-de-energiacutestrong
CS6	ENOVA: rapid test for the assessment of organic pollutants in water within seconds.	http://www.enova-h2o.com/
	EMBIO Diagnostics: a multi-use handheld chemical analyzer	www.embiodiagnostics.eu
	Nelen & Schuurmans, Virtual City Systems, and the district of Hof: Digital Twin for flood early warning capable of simulating an emerging flood and its impact on buildings and infrastructure such as roads, bridges, and electricity	https://nelen-schuurmans.nl/en/case/nowcasting-the-weather-using-machine-learning/
	NOAQ Tubewall: mobile freestanding flood barrier	
	Tubebarrier: flood barrier that can be used to temporarily increase the height of a dike,	
	SkyDowser: Groundwater mapping: sensor system, carried by a drone, which is able to map the earth's first 50m of soil at high speeds	https://climateinnovationwindow.eu/innovations/skydowser_(CIW)
	SolarDew: produce clean water from saline, biological or chemically contaminated water: affordable product that is easy to use, robust, extremely low in maintenance and only requires energy from the sun	
	WaterView - IR2: leverages the power of digital cameras to turn them into powerful tools for the real-time and diffuse collection of precipitation data.	https://www.climateinnovationwindow.eu/innovations/waterview-ir2/_(CIW)

	My Water Level: provides a modern-day opportunity to users to set automatic, location-based warnings for self-chosen low and high water levels.	https://www.climateinnovationwindow.eu/innovations/my-water-level/ (CIW)
	All4Elevation: turn smartphones into “smart sensors” being able to conduct elevation measurements for flood prevention	https://www.climateinnovationwindow.eu/innovations/all4elevation/ (CIW)
	RAPID-N for Natech Risk Analysis and Mapping: modelling program for integrated data collection	https://rapidn.jrc.ec.europa.eu/
	Functional models for river - delta and river - sea interaction	Service for Danubius
	Model of pollutant dispersion integrating hydrological conditions	. SWMM-EFDC integrated model
	integrated systems for measure and analyse water quality parameters across Danube River	Service for Danubius
CS7	Improved models for projecting/assessing storm surges and their impacts	ARSINOE
CS8	modelling program for integrated data collection	RAPID-N for Natech Risk Analysis and Mapping
	'Smart' data & AI-based flood warning system	ARGOS, SaferPlaces
	Smart water butts: flood early warning system	(SDS/Our Rainwater)
	Retrofit houses with sustainable water use	
	Rainwater in toilets	
	RainShare: community sharing of harvested rainwater	

Table 15: Social and institutional innovations in the field of water management targeted in ARSINOE CS Innovation pathways

CS	Social and institutional innovations in the field of water management	link
CS4	Prespa lake: Transboundary agreements and Management Plan for all protected areas	https://ppnea.org/strategjia-nderkufitare-e-prespanet/?lang=en
	Integrated Pesticide Management	https://spp.gr/sullogikenwnsiskeuasiwnagroximikwn-2/
	Transboundary Water Monitoring System (based on relevant work of PPMC)	https://spp.gr/wp-content/uploads/2023/04/2011-Expert-proposal-for-the-transboundary-water-monitoring-system-of-the-Prespa-Park.pdf
	Transboundary Forest Monitoring System (focus on wildfire-related parameters)	
	Transb. Wetland Management Committee (representing all sectors), based on the one functioning in GR 2005-2022	
CS6	Prevent flooding by planting techniques that are environmentally friendly	Flood planting at Erzeni river
CS8	Focus on people's relationship to water to co-design natural and rewilding solutions	Water is life project

	Outreach programme with toolkit for grassroots community members. Co-designed with community to ensure accessibility and relevance for communities in need.	Climate literacy
	Use culture & creativity networks in Torbay to help communities to articulate/explore their relationship with water and in particular, the sea. Positioning Water as an entity opens up avenues for real dialogue and collaboration around opportunities, risk and mitigation.	Culture & Creativity Networks -
	(Bespoke nature based solutions identified via pilots within the community; NBS/SuDS co-created with schools	Community SuDS/NBS
	A Social-Permaculture-with-Permaculture initiative working at a neighbourhood level to demonstrate community-led, strengths-based approaches that address real issues of food availability whilst simultaneously addressing social cohesion and wellbeing for community members.	Nature-based problem solving initiative
	for developments where development cannot reduce flood risk on site	Flood risk roof tax
	showing flooding incidents to be used to help utilities, emergency service and public see what's occurring and likely disruption	Website hub/dashboard
	Innovation that activates community observation to capture data that can feed into real time tracking of impacts. Community members as observers provide capacity to capture data, and importantly, become invested in the impacts/meaning for their lives and locality. Data is interpreted and fed back to the people it matters to in ways that non-experts can understand.	Citizen science & observation
	A system to help prioritise best use of resources during a flood for SWISco to prevent them sending to low priority on a first come first serve basis	Emergency responder resource priority allocation model
	Public good/ levy as a mechanism to create a sustainable financial model for communities	
	Flood Action Group: Tools / capacity to keep flood groups alive / legacy	Devon Resilience flood forum
	Green currency	
CS3	training on water and climate change for ppl. in the water sector: apprenticeships cover climate // knowledge exchange on best practices between supply companies	e.g. building on "water neighborhoods", existing online platforms, "Water Resilience Coalition"

	climate resilience audit for new projects at municipal level (e.g. building on existing "climate-audits")	(e.g. building on existing "climate-audits")
	Genehmigungsfiktion" for projects relating to climate resilience of public water sector	
	The world's ugliest lawn : prize for ugliest/driest lawn awarded to draw attention to drought and sustainable water use	https://gotland.com/worlds-ugliest-lawn/
	Water abstraction charge: Introduce water extraction fee and perscribe its use for resource protection	https://www.vku.de/themen/preise-und-gebuehren/artikel/aktualisierte-vku-grafik-zeigt-wasserentnahmeentgelte-der-bundeslaender-im-vergleich/
	Instruments for local climate adaptation in Bavaria: municipalities incentivise water retention: split waste water fees, prohibition of "stone gardens", ecologic criteria as basis for awarding municipal plots of land, "kommunale Freiflächenkonzepte" consider climate adaptation	https://www.bestellen.bayern.de/application/applstarter?APPL=eshop&DIR=eshop&ACTIONxSETVAL(artdtl.htm,APGxNODENR:1325,AARTxNR:stmu_v_klima_016,AARTxNODENR:364795,USERxBODYURL:artdtl.htm,KATALOG:StMUG,AKATxNAME:StMUG,ALLE:x)=X
	Restrict water-use if necessary during drought	https://www.vku.de/themen/preise-und-gebuehren/artikel/gemeinsame-handreichung-zu-einschraenkungen-der-trinkwasserverwendung-in-hitze-sommern/
	Cycling Route: creative public communication e.g. "Tap-water-friendly cycling route" along the Main	https://atiptap.org/projekte/lwfrendlicher-mainradweg/
	Personnell strategy for basic public services and water administration which considers climate resilience	No example
	Water footprint" on all products	Following ISO 14044; or using tools listed in the "Water Footprint Toolbox" ARSINOE CIW

Community engagement and education

Table 16: Technological innovations in the field of "Community engagement and education" targeted in ARSINOE CS Innovation pathways

CS	Technological innovations in the field of tourism community engagement / education	Link
CS7	Web portal/platform for citizen engagement	(Citizenlab platform launched mid 2024/Open call)
	App for direct citizen communication and engagement	(e.g. further developed "Climate Ready Esbjerg" app)
CS6	Proverse: Community-Centric Platforms for Knowledge Sharing	ProVerse's immersive social communication tool

	Web technologies portals/ platforms	(CitizenLab, SPOTTERON, EU.Citizen-science, etc.)
--	-------------------------------------	---

Table 17: Social and institutional innovations in the field of “Community engagement and education” targeted in ARSINOE CS Innovation pathways

CS	Social and institutional innovations in the field of tourism community engagement / education	Link
CS4	Online participatory platform incl. local residents	https://spp.gr/project/poliprespa/
CS6	Organisation of regular sessions where institutions share best practices and review each other’s management strategies to encourage learning and improvement.	
	Danube Living Labs Pilot application Potelu Living Lab Romania	(https://www.climateinnovationwindow.eu/innovations/danube-living-labs-pilot-application-potelu-living-lab-romania/)
CS4	Concepts for involving citizens and the private sector in transformational adaptation and emergency management	ARSINOE LL
CS3	Buergerrat Klima: establish citizen climate councils	https://buergerrat-klima.de/
	Connection Building Programme: Programme of engagement that looks at the commonalities across people who are passionate about and invested in their current positions/perspectives which may be very different and in conflict. Focus on bringing people together for ‘connection-building’	example Moving Conflicts/Humanising the Enemy (locally-based skills on this).
	Filling the Void initiative: Collaborative initiative with other coastal towns facing similar challenges. Leadership Learning Set to explore approaches and build confidence around addressing the ‘unknown’ and providing sufficient information to fill the void otherwise filled by speculative voices (particularly on social media).	

Environment and biodiversity

Table 18: Technological innovations in the field of “Environment and biodiversity” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations needed in the field of environment / biodiversity	Link
CS4	Continuous control and measurement of elements to maintain the balance of common ecosystems	

	Advanced Grazing Systems (NBS) in forest & lake ecosystems	
CS6	Illegal logging monitoring and control	Начало Защити Гората (gorata.bg)
	Poaching - alert system (cameras)	Smarter ways to fight poaching – DW – 04/07/2016
	Integrated seawater pH, pCO ₂ and O ₂ monitoring system	ARSINOE CIW
	Nitrate sensor for wastewater monitoring	https://realtechwater.com/parameters/nitrate/
	Autonomous marine robot, autonomous submarine for monitoring / feeding a Digital Twin of the Ocean	https://www.maritimerobotics.com/ https://www.advancednavigation.com/ https://seaber.fr/
	AI-powered identification of marine and land stocks	https://www.ai-for-sdgs.academy/principles-on-ai-for-biodiversity-conservation
	Waste management: Cost minimizing materials and applications	https://www.conserve-energy-future.com/sustainable-construction-materials.php

Table 19: Social and institutional innovations in the field of “Environment and biodiversity” targeted in ARSINOE CS Innovation pathways

CS	Social and institutional innovations needed in the field of environment / biodiversity	Link
CS4	Citizen science to monitor existing for plants in GR, also birds)	https://www.floraprespaedatabase.gr/en/
CS6	Data collection and monitoring - Joined task force to identify critical data sources and guidelines/rules for sensitivity analysis and accuracy	
	Series of roundtables to determine/develop protocols for data selection and protocol development	
CS3	Soil protection: forest conversion using a variety of drought-resistant species	https://www.lwf.bayern.de/service/publikationen/lwf_merkblatt/334980/index.php
	ACKERWERT: letting agreements incentivise soil protection	https://www.ackerwert.de/
	Green trenches next to fields used for retaining water (L3.1.1)	
	Support volunteering for the environment	"Freiwilliges Klimajahr" instead of FÖJ or FSJ
CS8	Miyawaki forest: unique approach to reforestation	
	Beat the Street: turns towns into giant games - To b adapte to green space equivalent	https://beatthestreet.me/chelmsford/

Soil management and agriculture

Table 20: Technological innovations in the field of “soil management and agriculture” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations needed in the field of Soil management / agriculture	Link
CS3	Organic farming: proliferation of organic farming methods in areas with poor water quality to reduce pesticides, herbicides and nitrates	https://www.dvgw.de/medien/dvgw/wasser/ressourcen/verbaende-beirat-nitrat_information_oekolandbau.pdf
	Silphie, Veitshöchheimer Hanfmix: Biogasproduction using plants with fewer detrimental effects on water and soil quality (+benefits for biodiversity)	https://grundwasserschutz-oberfranken.de/schutz-des-grundwassers/silphieprojekt/
CS4	Continuous measurement of land surface and soil characteristics	https://par.nsf.gov/servlets/purl/10390627
CS5	Tracking distributed system based on blockchain technology	example: https://www.finboot.com/post/how-blockchain-can-hold-the-palm-oil-industry-to-account-and-ensure-sustainable-practices)
	Smart Field Notebook: A tool enabling farmers to maximize the utility of generated information and facilitate its transmission to public administrations through telematic methods (*It will be mandatory in Spain starting from September 1, 2024)	
	Greenhouse plastics for 3D printing of agricultural equipment	https://anarpla.com/2015/eco-compuestos-una-solucion-para-recuperar-los-residuos-plasticos-procedentes-de-la-agricultura/
	AGTECH: smart agriculture technologies	https://www.bbva.com/es/ar/que-es-agtech-la-tecnologia-digital-aplicada-a-la-agricultura
CS6	New machines and tools that reduce GHG emissions	(e.g. spreading tractors and rural machinery with high-efficiency hybrid engines)
	traceability through product certification	UE commercial branding
	Optimizing control tools	food production system)
	ThirdEye: Flying Sensors to support farmers' decision making on crop production - Vegetation resilience to Climate Change and extreme droughts/rains	https://www.climateinnovationwindow.eu/innovations/thirdeye-flying-sensors-to-support-farmers-decision-making/ - CIW
	WeSS Weather smart station: Low-Power IoT agrometeorological station that measures different crucial parameters in various crops in real time to support smart digital agriculture applications	
	MOLE: Soil moisture sensor	https://www.climateinnovationwindow.eu/innov

		ations/mole-an-underground-soil-moisture-sensor-linked-to-the-cloud/
	Remote control of irrigation for water management	MICRO SWITCH, WaPOR Platform / AQUAMAPS, MODIS, Landsat, SMOS, AMSR, ASCAT
	Remote sensing for soil moisture	TDR SM sensors, GNSS reflectometry, Airborne remote sensing
	Adapted technologies for carbon sequestration	Service for Danubius
	Working system for assessing plant–soil feedbacks along soil evolution	Service for Danubius
	Gene database for threatened species	Service for Danubius
CS9	Enhancing innovative circular economy tools	: https://atoka.io/public/it/azienda/concimi-biologici-srl/a46ff6e05004
	driven-assisted tractors, precision drills and spreading machines	https://www.topconpositioning.com/solutions/agriculture

CS	Social and institutional innovations needed in the field of Soil management / agriculture	Link
CS5	Guideline enabling the identification of byproducts obtainable from various agricultural and livestock waste	https://www.fertimanure.eu/es/ https://ruralcat.gencat.cat/documents/20181/7816840/Guia_tractament_dejeccions.pdf/
	Distributed systems where participants make monthly donations to farmers and, in return, they receive a specific production	such as "Adopt an olive" (https://apadrinaunolivo.org/es)
	Agriculture carbon market as a form of circular green economy	https://www.climatefarmers.org/es/blog/question-los-creditos-de-carbono-para-los-agricultores-y-como-benefician-a-tu-explotacion/
	Traditional Knowledge sharing (by Public Administrations)	https://www.miteco.gob.es/content/dam/miteco/es/biodiversidad/temas/inventarios-nacionales/expo_invent_conocimientos_tradicionales_tcm30-164072.pdf
	OFE: On-Farm Experimentation collaborative learning model	https://www.inrae.fr/en/news/farm-experimentation-global-movement-accelerate-transformation-agriculture
CS9	European Branding : Enhancing block chain, panels, participatory certification systems, traceability and supply chain/product certification	https://www.pdopgi.eu/european-certification-system/)
	Spreading conservative agriculture at in-farm level	e.g. minimum tillage; sod seeding
	Collection of organic city waste cities resued in farming activities	https://cabildo.grancanaria.com/r-compostaje-comunitario
	local food production chains involving farmers and end-users	https://www.pastacellino.it/it/ercole-puntozero.html ; https://www.sardosole.it/

Energy

Table 21: Technological innovations in the field of “energy” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations in the field of energy	Link
CS1	Vertical gardens (LeafSkin)	https://bit.ly/4a7pjlvc CIW
	Colorful low-emissivity paints for space heating and cooling energy savings:	https://bit.ly/3VzWcck
	Thermal Assessment Tool	(REACH OUT, H2020): https://bit.ly/4aqwpY6
CS4	Solar panels compatible with agriculture & protection of ecosystems	https://auseusapower.com/#
	Digital Twin of Catchment area, input: in situ observations, satellite data and weather forecasts (Waterjade-)	ARSINOE CIW
CS5	Full operation of desalination plants with Renewable Energy:	https://proyectodesalplus.desalinationlab.com/es/
CS6	Wave power technologies, offshore wind power	https://corpowersocean.com/wave-energy-technology/
	Algae-based bioenergy	https://www.algaenergy.com/
CS9	New sensors and water storage systems with use of Sustainable Energy	https://www.sardaenergia.com/
	In-farm hydrogen micro-generators with energy storage system	https://abinsula.com

Table 22: Social and institutional innovations in the field of “energy” targeted in ARSINOE CS Innovation pathways

CS	Social and institutional innovations in the field of energy	Link
CS1	Establishment of Energy Poverty Office at Municipal level	https://bit.ly/3xeFG7v
	Alternative urban planning strategies and innovative land use governance policies	https://www.blog.urbact.eu/2015/02/the-rise-of-alternative-practices-in-urban-development/
CS9	Energy communities	

CC risk management

Table 23: Technological innovations in the field of “CC risk management” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations needed in the field of CC risk management	Link
CS1 (heat risk)	Citizens’ Accessibility to Green Urban Areas (15-minutes city concept)	https://bit.ly/3VA74qH
	UHI and Heat-related parameters along the Hadrian Aqueduct	ARSINOE project
	AQoAir: blockchain-based system for heatwave management in urban areas	https://bit.ly/4axzFRs
	Modeling future population’s vulnerability to heat waves	https://bit.ly/3IXRm0Z
	AST2.0 (Climate Adapt Platform): Climate Resilient Cities Toolbox	https://bit.ly/43DkSCQ
	REACH OUT, H2020: Thermal Assessment Tool	https://bit.ly/4aqwpY6
	WEO: Environmental Analytics for All from Space	https://bit.ly/3PFCIz1
	Kausal: Digital platform that enables smarter collaboration around key data	www.kausal.tech
	Bitu Green: Tool to access data, simulate, identify strategy for CC mitigation	https://bit.ly/3xvhEVH
	CityClimateX for the Case of Athens: A decision-making tool for public and private space planning and redevelopment in terms of thermal comfort, urban heat islands and air quality	https://www.lf-enviroconsulting.com/
	Heat Stress Tool for Athens	https://bit.ly/3xzfbK4
CS2	Infosequa: Timely and systematic generation of actionable warnings and risk indicators for risk-centered drought management and adaptation strategies.	
	Helpline & Early Warning Messaging System	https://bit.ly/3vkndWx
	Municipality’s website dedicated to extreme heat	https://bit.ly/3vkndWx
	EXTREMA Global: smart app to inform about solutions to tackle extreme urban heat	https://bit.ly/3vsrKWW
	RESpring EDUPark	www.eydap.gr (no informative website available, only through their application form)
	I-REACT (Improving Resilience to Emergencies through Advanced Cyber Technologies): access to an integrated system providing the main emergency management information and data	https://www.climateinnovationwindow.eu/innovations/i-react/CIW
CS6B	InfoSequia: Timely and systematic generation of actionable warnings and risk indicators on the severity and extent of drought and water scarcity impacts.	https://www.infosequia.eu/

	HydroPC: focused on co-development and application of innovative data technologies and comprehensive training of beneficiaries to support water and disaster risk management	HydroPC: Hydrological Forecasting using Publicly available data and free Cloud-based technologies - HKV
	Fire warning system	https://smokedsystem.com/detector/ https://www.globalforestwatch.org/
	Multihazard Early Warning Systems (MHEWS): monitor and forecast various natural hazards, utilizing different types of datasets to provide timely information to mitigate their impact.	Examples include the PTWS (Pacific Tsunami Warning System) and the European Flood Awareness System (EFAS)
	Drone+LiDAR for emergency response	(https://www.climateinnovationwindow.eu/innovations/dronelidar-for-emergency-response/)
CS7	A multifunctional storm surge barrier	the "Green Storm Surge Barrier" projected by Esbjerg Municipality; phase 1 is a low flood wall, phase 2 is a multifunctional dyke
	Identification of potential cascading risks	Cascading risk model developed by University of Exeter, DTU, DCA and Esbjerg Municipality
CS9	Early Warning Systems (EWS) : to prevent extreme events and environmental disasters	https://www.lobelia.earth/ ; https://wmo.int/topics/early-warning-system

Table 24: Social and institutional innovations in the field of “CC risk management” targeted in ARSINOE CS Innovation pathways

CS	social and institutional innovations needed in the field of CC risk management	Link
CS1	Extreme Heat Resilience Alliance	Arsht-Rockefeller Resilience Center: https://bit.ly/49i64dM
CS3	Bavarian alliance for green and blue cities for information sharing, support for project planning, prize for "best blue-green-city-project"; create a "Rainwater Agency"	Similar to "Berliner Regenwasseragentur": https://regenwasseragentur.berlin/

Fishery

Table 25: Technological innovations in the field of “Fishery” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations in the field of fishery	Link
CS6	Remote sensing monitoring of illegal fishery / innovative technologies to monitor over-fishing	https://www.spatialpost.com/application-of-remote-sensing-in-fisheries/
	Technological innovations in the field of fishery	Service forDanubius

	Environment-friendly fish-feed	https://bnnbreaking.com/world/indonesia/indonesia-introduces-eco-friendly-fish-feed-pioneering-sustainable-aquaculture/ https://g2f.no/en/technology/
	Electronic Monitoring Systems (EMS): Remote monitoring of catch fisheries that use GPS and sensors to track vessel movements and activities	
	WUNDERGROUND: weather forecast	https://www.wunderground.com/
	E-logbook that are used to record catch data in real-time.	
	Fisheries Dependent Data (FDD): Real time data monitoring and collection;	
	Fishfinder: Bathymetry for fish finder	https://www.climateinnovationwindow.eu/innovations/bathymetry-measurements-with-fishfinders/
	Sustainable feed for aquaculture	Insect meal, fungi-based protein, ciona meal, by-products from agricultural plant processing and microalgae

Table 26: Social and institutional innovations in the field of “fishery” targeted in ARSINOE CS Innovation pathways

CS	social and institutional innovations in the field of fishery
CS4	Training seminars for fishers (reporting IAS, stop enrichments)

Tourism

Table 27: Technological innovations in the field of “tourism” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations in the field of tourism	Link
CS4	Specific apps with information for tourist, incl. sustainability	https://spp.gr/resources/spp-apps/

Table 28: Social and institutional innovations in the field of “tourism” targeted in ARSINOE CS Innovation pathways

CS	Social and institutional innovations needed in the field of tourism	Link
----	---	------

CS4	Sustainable farms-open for tourism (incl. sustainable water management)	https://www.wildlifeandculture.com/post/
	Transboundary Visitors Management Plan (equal distribution space & time)	
	Transboundary workshops & field trips with youth	ARSINOE activities
CS5	Eco-friendly tour: Immersive and eco-friendly tourism experience, incl. promotion of resp. accommodation (Eco-friendly tour)	
	Implementation of common label for products (already produced in BorPres)	https://borpresproject.eu/
	Tourism organic waste for agricultural compost	https://ashotel.es/noticia/comunidades-turisticas-circulares-convierte-570-toneladas-de-biorresiduos-de-hoteles-en-abono-de-maxima-calidad/

Governance and planning

Table 29: Social and institutional innovations in the field of “governance and planning” targeted in ARSINOE CS Innovation pathways

CS	Social and institutional innovations needed in the field of Governance / Planning	link
CS1	Citizens’ Accessibility to Green Urban Areas (15-minutes city concept)	https://bit.ly/3VA74qH

Port and shipping

Table 30: Technological innovations in the field of “port and shipping” targeted in ARSINOE CS2 Innovation pathway

CS2	
Technological innovations in the field of port and shipping	
Logistic / infrastructure	Road4Water: Road harvesting technology
	ALONGROUTE: Ultra-precise, AI-based marine weather forecasts for weather routing software solutions to achieve greater
	CLEVER TOOL (NOW SYSTEMS): Climatic event registry logger applied in ValenciaPort
	Decision Support System & Early Warning Mechanism
	BID2BOARD: Digitalizing Marine Technical
	SACIP-Valencia (METEOGRID): Service.
	Port Transit: permeable pavement
Air pollution	IoT CO2 cities Monitoring (Everimpact): combines satellite images and measurements, IoT sensors, and AI for accurate measurement of GHG emissions

	EmbioAirBELD: detect and mitigate sources of air pollution
	AirNode and Libelium sensors : Air Quality Station The Air Quality Station to monitor key pollution parameters through Artificial Intelligence.
	DIORAMA LET-Ports (WaltR): monitoring GHG emissions through remote satellite sensing and images analysis.
	Marine Hound: Autonomous emissions sniffer system able to detect the use of illegal non-compliant fuel
	Navisense: track port activities with AIS and calculate emissions and show optimisation potential.
	Solumar: provides new air and gas filtering solutions to directly cut 92-99% of all emissions and collected Black Carbon and CO2 into reusable Carbon powder
Energy	REELEASE: recycling and upcycling of marine waste.
	OBREC: multifunctional device, which combines harbor protection and energy production. https://www.climateinnovationwindow.eu/innovations/obrec/
	Quantum Marineworks: optimize vessel journey for nergy & cost savings.
	BID2BOARDDigitalizing Marine Technical Service
	Rhoe Rhoe : optimization software for sustainable mobility solutions

Table 31: Decision-support tools in the field of “port and shipping” targeted in ARSINOE CS2 Innovation pathway

CS2 Decision-support tools in the field of port and shipping	
AE4RIA metrix	Models and Metrics to measure and report sustainability performance at various scales/levels- National/Subnational/Companies)
Metronamica	vulnerability index which shows which locations might be most vulnerable in the future

Urban greening

Table 32: Technological innovations in the field of “urban greening” targeted in ARSINOE CS Innovation pathways

CS	Technological innovations in the field of urban greening	Link
CS1	Live Tree Check: smart application to Check up on trees, look after them and create your own tree collection	https://bit.ly/4aflqzZ
	SingularRibbon : vegetal awnings, that is, tensioned sails covered with vegetation	https://bit.ly/4aMlaJC
	Urban Biodiversity assessment framework:	https://bit.ly/4cvkFpd
	LeafSkin: Vertical gardens	https://bit.ly/4a7pjlV

	A Square Meter for Butterflies:: enhance green roofs in order to increase their value for biodiversity	https://bit.ly/3TyKTOQ

Table 33: Social and institutional innovations in the field of “urban greening” targeted in ARSINOE CS Innovation pathways

CS	social and institutional innovations in the field of urban greening	Link
CS1	Tiny Forest in Athens:The forests are planted, maintained and monitored with the help of local volunteers, businesses and schools	https://bit.ly/3xdlrG4
	Green Corridors	https://bit.ly/3PDpX8g
	Pocket parks	https://bit.ly/3IUZZJy , https://bit.ly/3Ty0jCV
CS3	innovative strategies for irrigating greenery in public spaces: use of sensors; rainwater and reused water; volunteering for trees during drought	https://www.nuernberg.de/internet/soer_nbg/baumwaesserung.html

APPENDIX 7: Details of barriers and enablers identified for the implementation of each innovations composing the CS Innovation Pathways

CS1

Table 34: CS1- Identification of barriers and enablers for innovation related to Water

Factor/Water	Barriers / Enablers	Innovation 1 Rain Gardens	Innovation 2 RESILIO adaptive rooftops	Innovation 3 RichWater	Innovation 4 LooPi® & VertECO	Innovation 5 SolarDew
Political Factors	Barriers	Possible Reaction by Water Supply and Sewerage Company	-Lack of effective housing policy which could lead to scarcity of social housing complexes. -lack of legislative framework for adoption of such an innovation.	-Conflicts of interest of different water users/lobbies.	-early stages of political maturity to widely adopt such innovative solutions.	-Possible negative reaction by Water Supply and Sewerage Company
	Enablers	Endorsement by municipal and state authorities	Endorsed by experts responsible for policy recommendation, municipal personnel and state authorities	-Water scarcity is already high on EU's political agenda -This innovation follows in the footsteps of the Treat&Use system, a successful EU research project (FP7) approaching the safe and economic reuse of wastewater in agricultural production (GA no. 311943). -This phenomenon is already high on	-Aligned with 4 UN SDGs: 1) Good Health and Well-being 2) Gender Equality 3) Clean Water and Sanitation 4) Sustainable Cities and Communities	Endorsement by municipal and state authorities

				the national political agenda.		
Economic factors	Barriers	-Availability of budget required (although low) for installation & maintenance	-Initial cost of installing a green roof can be double that of a normal roof -Fluctuating maintenance costs -necessary budget for expertise personnel to maintain and operate -lack of cost-benefit analysis justifying the cost for adoption	-Urban water tariffs increases could aggravate water poverty. -Lower profitability than other water sources. -no incentive (financial) for a municipality to adopt such an approach.	-High Cost for installation and maintenance, especially at large scale. -no financial schemes to massively procure and install such approaches.	-Possible reactions/backlash from the bottling companies whose interests would be at stake -cost for larger scale implementation (suitable for small communities, not a solution for large urban communities)
	Enablers	-Saving water for irrigation of green areas, discounts or reduction of fees related to rain water management	-Green roofing can extend the lifespan of a roof by over 200% by covering the waterproofing membrane with growing medium and vegetation - increase the real estate value of an average house - Reduction in energy use by improving the thermal performance of a roof.	-Safe and economic reuse of wastewater	-Loopi can be reused/recycled -Closing the water cycle and the nutrient cycle. -Reduces water consumption by up to 90%. -Enabling gradual replacement of "ageing" and poorly maintained extant public chemical toilets.	-Minimizing manufacturing and transport costs of water -Affordable : reduces the price paid for clean drinking water by 50% or more -Low maintenance and easy to service - Autonomous – no need to buy diesel or be connected to the grid, because it is solar powered.
Social Factors	Barriers	-Resistance to change attitude towards the solution (e.g.: perception that it may	-Ownership - roof surface if not a public property -Voluntary basis of participation -Skepticism of	-reluctance to re-use wastewater by citizens -Conflicts of interest of different water users/lobbies.	-Hesitance of the public to endorse such a radical measure.	-Resistance to change deeply-rooted habits -Prejudice and Psychological barriers,

		attract mosquitos thus to reduce the quality of the area due to this solution).	potential adopters			associated primarily with feeling of disgust.
	Enablers	-Endorsed by citizens 'Millennials' more attentive to 'sustainability' -raised risk awareness in regards to the natural environment, etc.	Endorsed by citizens 'Millennials' more attentive to 'sustainability'	Endorsed by citizens 'Millennials' more attentive to 'sustainability' ->New employment opportunities for younger generations on the city's fringes.	-It is gender neutral and child-friendly, in line with Gender Equality UN Strategic Development Goal. -Transforms people into a living link in the chain of circular economy. -aesthetically pleasant especially compared to current solutions that have not attachment to circular economy.	Self-sufficiency – eliminates dependency on other people. Daily production of clean drinking water
Technological factors	Barriers	Possible problems in case of errors in the design and construction & in case of improper maintenance / operation	-Performance: a specific and locally oriented research is needed to identify choice of vegetation & irrigation adapted to local climate - Not all buildings can be, or are allowed to be retrofitted with green roofs / large strain on the structural support of a building, especially in seismic regions	-Adjustments to regulations to enable wastewater reuse could be deemed necessary to use the technology. -The technology has to be adapted to the nutrients content allowed by legislation in each country.	-Identification of public spaces that fulfil 3 criteria: a) Connection to rainwater drainage nearby b) Connection to energy grid nearby c) Connection to fresh water source nearby (optional). -Technological patents owned by specific contractors.	-The technology focusses on point of use desalination for small scale applications from 4 to approximately 5000 l/day: It cannot apply as a solution for large urban communities, such as Athens, but rather focuses on the provision of drinking water to small communities.
	Enablers	-No particular obstacle in implementing this solution, ease of design and	-Smart city concept is making its way into several urban cities facing climate crises issues, utilising online	-Technology validated in relevant operational environment (TRL5).	-The initiative has been a recipient of 2 awards of international renown in the respective field. -LooPi is designed to be dismantled	-Robust – does not make use of mechanical or electrical components which can be failure prone.

		development	platforms supporting decision making as well as remote control of new concepts and innovations		-It is quite compact in its dimensions. - The technology complies with all of the possible reuse possibilities of the EU-directive for urban waste water treatment 91/271/EC.	-Can be used in times of crisis at local level.
Legal Factors	Barriers	n/a	-Lack of building legislative framework -new building interventions require time to be processed within the current law setting	-Strict health regulations -Adjustments to Regulations to enable wastewater reuse. -The technology has to be adapted to the nutrients content allowed by legislation in each country.	n/a	-Since it favours one community over another it could lead to potential disputes.
	Enablers	n/a	-Pro-climate adaptation of the current legal stakeholder's ecosystem	-Pro-climate adaptation of the current legal stakeholder's ecosystem	-Compliance with EU-directive for urban waste water treatment.	-Compliance with regulations on water use
Environmental factors	Barriers	Effectiveness validation: -Limited treatment area in major flood events -The selected species of plants must be able to survive the periodic ponding that occurs. -Limited space for implementation given the city's infrastructures	-Part of the wildlife they attract may include pest insects which could potentially infiltrate a residential building. -potential drawbacks if no proper installation (selection of plants) is made	-This innovation would be more suitable for smaller urban/rural areas and not for a metropolis like Athens. -Such activities would take place in the outskirts of the city.	Identification of public spaces that fulfil 3 criteria: a) Connection to rainwater drainage nearby b) Connection to energy grid nearby c) Connection to fresh water source nearby (optional)	-Tap water generally meets high-quality standards and is safe for consumption, therefore this innovation could possibly not have a broad appeal.
	Enablers	-New material / knowhow that	-Ability to reduce flood risk -Thermal	-Improve ecological status of water bodies.	-Solution can be reused/recycled -Reduces water consumption by up to	-Solar powered; as a result, it functions

		increases the effectiveness of the innovation -operates along the natural environment's framework.	reduction and energy conservation given the long periods of high temperatures & heat waves -Increased biodiversity within the urban area -Air pollution in urban areas and the mitigating effects this solution provides.	-The system allows to produce high quality effluent meeting the regulatory standards for irrigation of crops to be consumed by humans while preserving the content of nutrients relevant for the fertilization effect -This innovation allows reducing the environmental impacts of contaminating ground water with an excess of nutrients.	90% -Combats urban heat island -Increases biodiversity	best in regions with a high solar radiation -> Athens MA is the ideal setting. -High quality drinking water from biologically, chemically contaminated or saline sources.
Factor Water	Barriers / Enablers	Innovation 6 Really cooling water bodies in cities		Innovation 7 Water art - fountain - cooling measure & Cooling Station 2.0		
Political Factors	Barriers	-First prototypes were released at the end of summer in 2018: No sufficient concrete outcomes. -In the case of Athens: Large Political and Economic Cost in the event of undertaking to make new water bodies and refurbish existing ones, given that almost all water bodies have been concreted over.		-Political stability and agenda of municipal parties		
	Enablers	-The environmental traits and the climate of Athens are pertinent to the Initiative's scope and have been adopted by policy makers. Pro-climate crises adaptation and mitigation at political level.		-The environmental traits and the climate of Athens are pertinent with the Initiative's scope and have been adopted by current policy makers.		
Economic factors	Barriers	-Cost for new infrastructure and cost for maintenance -The implementation phase will be long and consequently the expected results are set in the long term, thus rendering it impossible at this point in time to give precise indications about the amount of damage costs produced in the meantime. -Long time period is needed to yield results, while being high-cost innovation.		n/a		

	Enablers	- Increased needs in terms of heat waves, droughts, flooding, viable long term solution with significant financial benefit for dense urban cities.	-Relatively low cost for installation and maintenance. There are already many paved squares in Athens which could be utilized for fountain installation.
Social Factors	Barriers	-Possible backlash on behalf of property/land owners who might be affected by this initiative. -Lack of co-design procedures making it less acceptable solution despite the benefits.	-Citizens are against this approach and fonder of alternative ways for cooling purposes. -Although culture intense approach, smaller impact in terms of cooling effect. - The cooling station 2.0 is less aesthetically pleasing than the other
	Enablers	-Large pool of urban designers, landscape architects, architects and civil engineers who will apply the design prototypes. -Growing number of people among the local population who advocate the idea of “reclaiming the Athenian landscape” and restoring water bodies.	-Given the artistic dimension of this initiative, the city could draw from a large pool of aspiring artists who could contribute with their creative ideas. -The people acknowledge the aesthetic appeal of fountains.
Technological factors	Barriers	-Recent research indicates a possible misconception as regards the extent to which small urban water bodies actually solve urban heat problems in a drastic manner. -This innovation represents spatial prototypes / design recommendations which will always have to be adapted to a site-specific context. They can thus not be marked as a normal product.	n/a
	Enablers	-Technology validated in lab – against all relevant criteria (cooling, water retention, usability/ functionality, health aspects and aesthetics) - Basic technological components are integrated to establish that they will work together.	Low-cost technology availability.
Legal Factors	Barriers	-Legislative framework in terms of prototypes of water bodies	n/a
	Enablers	-Current trend on adjusting the legal framework towards a more climate friendly development of the city / urban sites.	-No essential regulatory adjustment needed. Ease of implementation.
Environmental factors	Barriers	-The implementation phase will be long and consequently the expected results are set in the long term, thus rendering it impossible at this point in time to give precise indications about the amount of damage costs produced in the meantime.	-Small scale implementation/Limited cooling effect: Fountains do not contribute to cooling at the level of a city or a square, but within a small area.
	Enablers	-The environmental traits and the climate of Athens are pertinent with the Initiative’s scope (especially as regards to heatwaves).	-Creation of cooling enclaves in numerous parts of the city, easily accessible for every citizen. -Promotes the 15’ accessibility to green/blue public infrastructures.

Table 35: CS1- Identification of barriers and enablers for innovation related to the Energy theme

Factor/Energy	Barriers / Enablers	Innovation 1 LeafSkin	Innovation 2 Colorful low-emissivity paints for space heating and cooling energy savings	Innovation 3 Establishment of Energy Poverty Office at Municipal level
Political factors	Barriers	n/a		Populism (it may be considered as a communication effort without offering actual impact)
	Enablers	-New agreements on climate and energy issues	-New legislations & regulations, etc.	Current political perceptions in terms of energy problem
Economic factors	Barriers	-Necessary cost of mass installation	-lost for re-painting at mass scale (private & public sector)	Necessary cost for establishing and operating a full staffed office / identifying motives / benefits to citizens suffering from energy poverty
	Enablers	-Availability of financial schemes for new solutions	-increases benefits in terms of the cost required (positive cost-benefit analysis).	Amount and quality of new funding schemes & programmes currently available at European level
Social Factors	Barriers	-resistance to change	No knowledge on existing solution	Resistance to change
	Enablers	-Citizens more attentive to sustainability issues	Raised risk awareness in regards to sustainability	Citizens more attentive to energy issues
Technological factors	Barriers	Access to innovation	Access to solution at mass scale (access to paints)	n/a
	Enablers	Low-cost technology availability, ease of installation / material required	n/a	
Legal Factors	Barriers	-Current legislative framework in regards to building installations (restrictive to private buildings)	n/a	
	Enablers	n/a		
Environmental factors	Barriers	n/a		
	Enablers	-Energy efficiency (buildings, public space, local temperature) -Increase biodiversity -Air pollution	7.4% energy saving ratio with low-cost for implementation	Medium-long term decrease in energy consumption at city level

Table 36:CS1- Identification of barriers and enablers for innovation related to theme Urban Greening

Factors/ Green	Barriers / Enablers	Innovation 1 Pocket parks	Innovation 2 Green Corridors & Citizens' Accessibility to Green Urban Areas (15-minutes city concept) &	Innovation 3 A Square Meter for Butterflies	Innovation 4 Urban Biodiversity assessment framework	Innovation 5 Live Tree Check

			Tiny Forest in Athens			
Political factors	Barriers	Political stability (change in green urban development agenda)	Effective implementation of EU framework	n/a	Political stability affecting the prioritizing of urban projects that are pro-biodiversity	n/a
	Enablers	-Effective implementation of regulation and existing urban planning legislation -pro green development	Effective implementation of framework, directives & regulations	Endorsement by municipal and state authorities	Existing framework, directives, regulations	Effective implementation of framework, directives & regulations
Economic factors	Barriers	-High-cost of technical infrastructures	-High-cost for implementation -Local temporal disruption of the economic activity -Availability of financing schemes & programmes	-Necessary costs from public local authority budget Funds provided by non-governmental organization (NGO)	-Necessary costs for development of the methodology	n/a
	Enablers	- Amount and quality of new funding schemes & programmes currently at European level -CSR funding	-Availability of European financial programmes supporting urban re-generation	n/a	-Existing funding through European programmes and other funding schemes	n/a
Social Factors	Barriers	Citizens preferences	Resistance to change		n/a	-Resistance to change -Familiarity to smart phones, especially the elderly
	Enablers	Raised climate awareness	Raised climate awareness Citizens preferences	Raised climate awareness Citizens science – engagement levels	Raised climate awareness	Raised climate awareness a Citizen's preferences and engagement
Technological factors	Barriers	n/a				Availability of smart phones/ knowledge / access to App
	Enablers	Access to new innovative designs and materials t		n/a		Ongoing developments and ease of access to technology /

						smart phones / apps, etc.
Legal Factors	Barriers	n/a	Unfavoring to certain activities meets opposition at legal level (lobbying)	Existing legislation in building interventions	existing framework, requires an update to incorporate such analysis	n/a
	Enablers	n/a	Supporting regulations for combating climate change	n/a		
Environmental factors	Barriers	-short-term discomfort due to development	Short-term negative psychological aspects to citizens near these interventions	n/a		
	Enablers	-Increased biodiversity -Access to green spaces -Benefits in local climate conditions, etc.		Increased number of protection areas Increased green space area Increased conservation or restoration of ecosystems Reduced biodiversity loss Increased number of species present Increased protection of threatened species Enhanced support of pollination Increased ecological connectivity across regeneration sites and scales	Increased biodiversity	Increased biodiversity Maintenance of green spaces Climate conditions Air quality, etc.
Factors Urban Greening	Barriers / Enablers	Innovation 6 Singular Ribbon				
Political factors	Barriers	n/a				
	Enablers	-New agreements on climate and energy issues				
Economic factors	Barriers	-Necessary cost of mass installation				
	Enablers	-Availability of financial schemes for new solutions				

Social Factors	Barriers	-Resistance to change
	Enablers	-Citizens more attentive to sustainability issues
Technological factors	Barriers	Access to innovation
	Enablers	Low-cost technology availability, ease of installation / material required
Legal Factors	Barriers	-Current legislative framework in regards to building installations (restrictive to private buildings)
	Enablers	n/a
Environmental factors	Barriers	n/a
	Enablers	-Energy efficiency (buildings, public space, local temperature) -Increase biodiversity -Air pollution

Table 37: CS1- Identification of barriers and enablers for innovation related to theme Heat risk management

Factors / Governance	Barriers / Enablers	Innovation 1 Citizens' Accessibility to Green Urban Areas (15-minutes city concept)	Innovation 2 QoAir	Innovation 3 Modeling future population's vulnerability to heat waves	Innovation 4 AST2.0 (Climate Resilient Cities Toolbox); Climate Adapt Platform	Innovation 5 WEO
Political factors	Barriers	Effective implementation of EU framework	Regulatory uncertainty surrounding blockchain technology implementation	Limited political support or prioritization of climate change research.	Varying political will and priorities across different regions and cities.	Geopolitical tensions affecting international collaboration on satellite data sharing
	Enablers	Effective implementation of framework, directives & regulations	Government incentives for smart city projects and climate resilience initiatives	Policy focus on climate adaptation and resilience planning at local and national levels	International and national policies promoting urban resilience and climate adaptation	Government initiatives supporting space-based environmental monitoring and international climate agreements
Economic factors	Barriers	-high-cost for implementation -local temporal disruption of the economic activity -Availability of financing schemes & programmes	High costs associated with developing and maintaining blockchain infrastructure	Insufficient funding for extensive research and modelling projects	Financial constraints for municipalities to adopt and implement the toolbox solutions	High costs associated with launching and maintaining satellites and data processing
	Enablers	-Availability of European financial programmes supporting urban re-generation	Potential for long-term cost savings in heatwave management and urban cooling strategies.	Availability of grants and international funding for climate-related research.	Access to funding and grants from governmental and international bodies for climate resilience	Increased funding opportunities and investments in space technologies and environmental

					projects	monitoring
Social Factors	Barriers	Resistance to change	Public scepticism or lack of understanding of blockchain technology	Public indifference or lack of awareness about heatwave vulnerabilities	Resistance from local communities due to a lack of awareness or understanding of the tools	Limited public understanding and engagement with space-based environmental data
	Enablers	Raised climate awareness Citizens preferences	Increased public concern about heatwaves and climate change, driving demand for innovative solutions.	Growing public concern about climate change impacts on health and safety	Growing public support and awareness for sustainable urban development and climate resilience	Growing public awareness of climate change and demand for transparent environmental data
Technological factors	Barriers	n/a	Complexity of integrating blockchain with existing urban infrastructure	Need for advanced modelling software and high-performance computing resources	Integration challenges with existing urban infrastructure and systems	Challenges in processing and analyzing large volumes of satellite data accurately and efficiently
	Enablers	Access to new innovative designs and materials development	Advances in blockchain technology and IoT devices that facilitate seamless integration.	Advancements in data analytics, machine learning, and computational power	Rapid advancements in urban planning technologies and data analytics facilitating better integration	Advancements in AI, machine learning, and cloud computing for enhanced data processing capabilities
Legal Factors	Barriers	Unfavoring to certain activities meets opposition at legal level (lobbying)	Compliance with data privacy and security regulations	Restrictions on data access due to privacy laws and regulations	Complex regulatory requirements and bureaucratic hurdles in urban planning and development	Data privacy and security concerns related to the collection and use of satellite imagery
	Enablers	Supporting regulations for combating climate change	Development of clear legal frameworks supporting blockchain use in public services	Legal frameworks promoting open data for research and public benefit	Supportive legal frameworks and policies that encourage the adoption of climate resilience measures	Development of clear regulatory frameworks ensuring data security and privacy while promoting accessibility
Environmental factors	Barriers	Short-term negative psychological aspects to citizens near	Potential environmental impact of energy consumption	Variability and unpredictability of climate data affecting model accuracy	Diverse environmental conditions and challenges across different	Variability in environmental conditions and potential limitations of

		these interventions	associated with blockchain		cities complicating standardized implementation	satellite data resolution
	Enablers	-Increased biodiversity -Access to green spaces -Benefits in local climate conditions, etc.	Contribution to urban climate resilience and reduction in heatwave-related health risks	Increasing availability of high-quality climate data from global monitoring networks	Enhanced ability to tailor solutions to specific environmental conditions and local needs	Comprehensive and real-time monitoring of environmental changes, enabling proactive responses to climate issues
Factors / Governance	Barriers / Enablers	Innovation 6 Kausal platform	Innovation 7 UHI and Heat-related parameters along the Hadrian Aqueduct	Innovation 8 Modelling future population's vulnerability to heat waves	Innovation 9 Thermal Assessment Tool (REACH OUT, H2020)	Innovation 10 Extreme Heat Resilience Alliance, Arsht-Rockefeller Resilience Center
	Barriers	Regulatory barriers and varying political support for tech-driven sustainability solutions	Limited political will or conflicting interests in historical preservation versus modern interventions	Inconsistent climate policies and insufficient political support for long-term planning	Inconsistent political support and regulatory environments across regions	Lack of consistent political will and support for long-term heat resilience initiatives
Political factors	Enablers	Strong government policies favouring digital innovation and climate action initiatives	Government and EU support for climate resilience and heritage conservation projects.	Strong political commitment to climate adaptation and disaster risk reduction strategies	EU policies and initiatives promoting climate resilience and sustainable urban development	Strong advocacy and policy frameworks at local, national, and international levels supporting heat resilience
	Barriers	Financial challenges for widespread adoption, especially for smaller businesses and municipalities	High costs of research and implementation of measures to mitigate urban heat island (UHI) effects.	High costs associated with data collection, model calibration, and implementation	Funding limitations for deploying and maintaining the assessment tool	High costs of implementing comprehensive heat resilience measures
Economic factors	Enablers	Availability of funding, subsidies, and economic incentives for adopting sustainable technologies	Availability of funding from EU programmes and international grants focused on climate adaptation	Availability of funding from international climate funds and grants for resilience projects	Access to Horizon Europe funds and other financial incentives for climate adaptation projects	Funding and investment from philanthropic organizations, governments, and international bodies
Social Factors	Barriers	Resistance to change or lack of digital literacy among	Public resistance to changes in historic areas	Public resistance to change and lack of awareness	Limited public understanding of the benefits of thermal	Public unawareness and underestimation

		potential users.	due to cultural and heritage values	about the importance of proactive measures	assessment in urban planning	of extreme heat risks
	Enablers	Increasing societal demand for sustainable practices and greater awareness of climate issues	Growing public awareness of the impacts of heatwaves and support for climate resilience in urban planning	Increasing public awareness and support for climate resilience and heatwave preparedness	Increased awareness and education on the impacts of heatwaves and the importance of thermal management	Increasing public awareness and community engagement initiatives.
Technological factors	Barriers	Integration challenges with existing systems and potential technical complexities	Challenges in integrating modern technology with ancient infrastructure	Limited access to advanced modelling tools and technologies in some regions	Integration challenges with existing urban planning tools and data sources	Limited access to cutting-edge technologies for monitoring and mitigating extreme heat
	Enablers	Rapid advancements in technology and increasing interoperability standards.	Advances in non-invasive technologies and techniques for monitoring and mitigating UHI effects	Advances in modelling software and greater availability of high-resolution climate and demographic data	Advancements in GIS, remote sensing, and data analytics enhancing tool effectiveness	Advances in heat mapping, predictive analytics, and climate modelling technologies
Legal Factors	Barriers	Compliance with diverse and evolving legal and regulatory requirements across regions	Stringent regulations protecting historical sites that may limit intervention options	Regulatory hurdles and lack of supportive legal frameworks for integrating new models into planning	Compliance with data privacy laws and regulations on environmental data usage	Regulatory hurdles and lack of cohesive legal frameworks
	Enablers	Supportive legal frameworks and regulations promoting sustainability and digital transformation	Legal frameworks that balance heritage conservation with climate resilience initiatives	Legislation promoting climate adaptation and the use of innovative tools in urban planning	Legal frameworks supporting the use of innovative technologies for urban resilience	Supportive legal frameworks and international agreements promoting climate resilience
Environmental factors	Barriers	Potential environmental impact of digital infrastructure and energy consumption	Diverse microclimates along the aqueduct complicating standardized intervention strategies	Variability in local climate conditions and urban characteristics complicating model accuracy	Variability in local climate conditions affecting tool accuracy	Diverse and complex environmental challenges across different regions
	Enablers	Significant potential to improve environmental outcomes	Potential for significant environmental benefits through	Potential to significantly improve urban planning and reduce	Potential to significantly enhance urban planning and	Collaborative and multi-sectoral approaches addressing

		through better data-driven decision making and resource optimization	targeted UHI mitigation and improved heat management strategies	vulnerability to heatwaves through targeted interventions	reduce vulnerability to heatwaves through precise thermal assessments	specific local environmental conditions
--	--	--	---	---	---	---

Table 38: CS1 - Identification of barriers and enablers for innovation related to theme 5, namely Awareness/Social (Health)

Factors \ Awareness / Social (Health)	Barriers / Enablers	Innovation 1 Helpline & Early Warning Messaging System	Innovation 2 EXTREMA Global	Innovation 3 I-REACT	Innovation 4 Municipality's website dedicated to extreme heat	Innovation 5 RESpring EDUPark
Political factors	Barriers	Bureaucratic delays in the implementation of early warning systems	Navigating diverse regulatory environments and compliance requirements in different countries	Political reluctance to invest in technology for disaster management due to competing budget priorities	Political prioritization of other municipal issues over extreme heat preparedness	Political bureaucracy and regulatory hurdles in implementing new infrastructure projects
	Enablers	Government initiatives and policies supporting disaster risk reduction and emergency preparedness	Support from international political bodies promoting technology for disaster risk reduction and public safety	Government initiatives promoting innovative solutions for disaster risk reduction and resilience building	Support from local government officials who recognize the importance of addressing extreme heat as a public health concern	Support from local government officials who prioritize sustainable water management and green solutions
Economic factors	Barriers	High initial costs and ongoing maintenance expenses for the infrastructure and technology required	High development and maintenance costs for creating and updating a sophisticated, globally-operable app.	Limited funding for developing and maintaining a comprehensive emergency management system	Budget constraints for limiting investment in website development and maintenance	High upfront costs for implementing sewer mining infrastructure and aesthetically designed shells
	Enablers	Potential funding from international aid organizations and government grants for disaster management systems	Potential for revenue through partnerships with city governments and global organizations investing in climate resilience	Potential for cost savings through improved coordination and efficiency in disaster response efforts	Potential cost savings in healthcare expenses and infrastructure damage through effective heat mitigation strategies promoted via	Potential long-term cost savings through water conservation and reduced reliance on traditional water sources

			technologies		the website	
Social Factors	Barriers	Public resistance or mistrust towards automated warning systems and helplines	Variability in public trust and willingness to adopt new mobile technologies across different cultures	Variability in public awareness and preparedness for natural disasters across different communities	Limited awareness among residents about the risks associated with extreme heat and the availability of resources on the website	Limited public awareness and engagement with water management issues
	Enablers	Increased community resilience and trust through awareness campaigns and participatory planning	Growing global awareness and concern about climate change, increasing the app's relevance and acceptance	Increased public engagement and empowerment through access to real-time emergency information and resources	Community outreach and education initiatives to raise awareness about heat-related health risks and the municipality's website as a resource	Community involvement and education programs embedded within the EDUPark to raise awareness and promote behaviour change
Technological factors	Barriers	Technological challenges related to integrating various communication platforms (SMS, social media, apps) for seamless messaging	Ensuring compatibility and seamless functionality across various mobile devices and operating systems worldwide	Integration challenges when aggregating data from diverse sources and ensuring interoperability between systems	Accessibility challenges for residents with limited internet access or digital literacy skills	Technological challenges in integrating sewer mining infrastructure with aesthetically designed shells
	Enablers	Advancements in communication technologies and widespread mobile phone usage	Advances in mobile technology and cloud computing that support the development of robust, scalable applications	Advances in data analytics and AI facilitating real-time data processing and decision-making in emergency situations	User-friendly design and mobile optimization to ensure broad accessibility across different demographics	Advances in water recycling and architectural design technology facilitating the implementation of innovative solutions.
Legal Factors	Barriers	Legal issues surrounding data privacy and the use of personal information in emergency messaging	Complexities in data privacy laws and user consent requirements across different jurisdictions	Legal complexities related to data privacy, liability, and cross-border data sharing	Legal considerations regarding liability and accuracy of information provided on the website	Legal considerations regarding water rights, permits, and environmental regulations
	Enablers	Legislation that supports data sharing and privacy	Establishment of international legal frameworks	Establishment of legal frameworks supporting	Compliance with regulations related to	Compliance with local laws and regulations, as

		protections for emergency services	facilitating cross-border data sharing for emergency management	data sharing for emergency management purposes while ensuring privacy protections	data privacy and accessibility standards to ensure the website meets legal requirements	well as advocacy for supportive policies promoting sustainable water management practices
Environmental factors	Barriers	Potential disruptions in communication infrastructure due to severe weather events	Reliability issues due to extreme weather conditions potentially affecting app infrastructure and user connectivity	Dependence on reliable infrastructure and communication systems, which may be vulnerable to damage during extreme weather events	Dependence on accurate weather forecasting data to provide timely heat advisories and alerts	Environmental impact assessments and considerations for ecosystem health and biodiversity
	Enablers	Use of robust, redundant systems and satellite communications to ensure message delivery even during extreme conditions	Enhanced satellite and communication technologies that ensure robust data transmission and app functionality during environmental crises	Use of resilient technologies and redundant systems to ensure continuity of service even in adverse environmental conditions	Integration of real-time weather data and forecasting models to provide residents with up-to-date information on extreme heat events	Implementation of green infrastructure and water management measures that enhance urban ecosystems and promote sustainability

CS2

Table 39: CS2 - Identification of barriers and enablers for innovation related to theme Port Operations/ Logistics / Infrastructure

Factors	Barriers / Enablers	Apply to all innovations for the Port operation / logistic / infrastructure theme				
Political Factors	Barriers	Bureaucratic issues hindering development	Lack of funds/prioritizing such innovations	Adaptation Needs not high in priorities	Lack of mechanism to identify and assess investment plans	Mismanagement of Funds
	Enablers	Allocate governmental funds/prioritize adaptation plans				EU policies
Economic factors	Barriers	lack of generating capital	Lack of mechanism to assess investment plans	Mismanagement of Funds	Financial resources allocated to targets other than adaptation	Poor identification of type of adaptation needs and portfolio of

						financial solutions
	Enablers	Cost savings Allocate governmental funds EU funds aiming to transform ports into green infrastructures and energy hubs by 2050.	Support to better planning, financing and funding of port infrastructure and their connections in the trans-European network. The Commission has integrated ports in the corridor work plans foreseen by Article 46 of the guidelines for the development of the trans-European transport network (Regulation 1315/2013) and provides targeted grants and other forms of financial supports to port infrastructure projects by using the Connecting Europe Facility. More than € 1 billion have already been awarded since 2014 to support rail or inland waterways connecting ports with the hinterland, basic port infrastructure, innovation and green port projects. The new guidelines for the development of the trans-European transport network (TEN-T).			
Social Factors	Barriers	Resistance from labour unions	poor evaluation of adaptation finance needs			
	Enablers	Public- private partnerships	Promotion and support of the European social dialogue between port workers and their employees and of training. The Commission helps the EU Social Dialogue Committee in the Port Sector to work on health & safety, training and qualifications, gender issues and promotion of female employment and attractiveness to young workers. Representatives of port employees and port employers work together for instance to produce common guidelines for training as well as national health and safety requirements. Another project of the Committee, financed by the Commission, is identifying the key challenges that EU ports are facing and how the industry is adapting to change and preparing for the future.			
Technological factors	Barriers	low presence of Innovative firms and innovation systems to apply complex adaptation (transformational) solutions	Poor dissemination due to lack of infrastructure to facilitate synergies	Distinguish the source of GHG Emissions (Port Operation-Infrastructure vs City)		
	Enablers	The new guidelines for the development of the trans-European transport network (TEN-T).	Initiatives to simplify procedures in ports. Improving the digital information flows and reducing administrative burden is vital to ensure efficient ship port calls and throughput of cargo. To contribute to this goal the Commission intends to establish a European Maritime Single Window environment with technical and legal frameworks for the submission and re-use of regulatory reporting information, including the eManifest information for customs. This initiative is currently under assessment and the proposal for the way forward is expected to follow in summer 2018.		EU-funded activities such as PIONEERS provide huge opportunities to support technological enterprises, in developing highly innovative solutions to reduce carbon emissions in the port sector. Ultimately projects such as these aim to transform ports into green infrastructures and energy hubs by 2050.	
Legal Factors	Barriers	Lack of clear regulations for infrastructural or operations				
	Enablers	Streamlined permitted processes	Regulation (EU) 2017/352 of the European Parliament and the Council of Ministers establishing a framework for the provision of port services and common rules on the financial transparency of ports.			

Environmental factors	Barriers	Difficult to integrate new tech in the existing infrastructure	
	Enablers	Reduced emissions lead to lower pollution control costs	Initiatives to raise the environmental of ports by promoting the exchange of good practices. As part of its research and innovation agenda the Commission launched in 2016 the "Port of the Future" call as part of the Horizon 2020 programme to encourage innovation in ports and the links with port cities.

Table 40: CS2 - Identification of barriers and enablers for innovation related to theme Green Port (Environment / Emissions)

Factors	Barriers / Enablers	Apply to all innovations for the Green Port – Emissions theme	
Political Factors	Barriers	Lack of political will to place in force environmental regulations	
	Enablers	Stricter emission regulations for ports	
Economic factors	Barriers		
	Enablers	pricing mechanisms that incentivize green practices	
Social Factors	Barriers	Social Acceptance	
	Enablers	Raised Environmental awareness through campaigns and information	
Technological factors	Barriers	Lack of standardized data	Lack of initial Capital for applying innovative / advanced technologies
	Enablers	Advanced emissions monitoring and control technologies	
Legal Factors	Barriers	Outdated environmental regulations not addressing new operations	The absence of uniformity in green port criteria presents another challenge to development. Research on the green port criterion is expanding. However, ports will find it challenging to determine their development direction due to the abundance of green port requirements.
	Enablers	Streamlined permitting processes for energy projects	
Environmental factors	Barriers	Extreme weather events (e.g. heatwaves) can increase port emissions and air pollution (e.g. due to intense use of A/C units) and increased GHG concentrations (inability of diffusion due to low ABL).	
	Enablers	Reduced pollution improves public health	

Table 41:CS2 - Identification of barriers and enablers for innovation related to theme Green Port (Environment / Energy)

Factors	Barriers / Enablers	Apply to all innovations for the Green Port – Energy theme	
Political Factors	Barriers	Lack of political commitment	
	Enablers	Government incentives	
Economic factors	Barriers	High upfront costs	
	Enablers	EU Funding Programs (CEF Energy) on Mission Adaptation	
Social Factors	Barriers	Lack of public awareness about the environmental impact of port operations	
	Enablers	Public education campaigns promoting renewable energy sustainability	
Technological factors	Barriers	Lack of storage technology for renewables	
	Enablers	Smart grid managing energy demand and integrating renewables	
Legal Factors	Barriers	Lack of clear regulations	
	Enablers	Streamline permitting process	
Environmental factors	Barriers	Extreme weather events (e.g. heatwaves) can increase port's energy consumption (e.g. due to intense use of A/C units).	
	Enablers	Reducing dependency on fossil fuel	

Table 42: CS2 - Identification of barriers and enablers for innovation related to theme Finance

Factors	Barriers / Enablers	Apply to all innovations for the Finance theme			
Political Factors	Barriers				
	Enablers	Promotion of working groups to create synergies (sectorial working groups, technological alliances,...)			
Economic factors	Barriers				
	Enablers	Tax reduction	Facilitating access to public funding		
Social Factors	Barriers				
	Enablers	Improved communication of measures			
Technological factors	Barriers				
	Enablers	Process optimization using AI	Using blockchain for traceability of renewable production or eCO2		
Legal Factors	Barriers				
	Enablers	Negotiation of the terms of concession (extension)			
Environmental factors	Barriers				
	Enablers	Promoting green services as a value-added product			

Table 43: CS2 - Identification of barriers and enablers for innovation related to theme Risk management

Factors	Barriers / Enablers	Apply to all innovations for the smart port and policies theme			
Political Factors	Barriers	Resistance from stakeholders due to concerns			
	Enablers	Public support for smart port initiatives for sustainability			
Economic factors	Barriers				
	Enablers	Data-driven decision-making for optimizing port operations and reducing costs			
Social Factors	Barriers				
	Enablers				
Technological factors	Barriers	Lack of cyber security measures for infrastructure			
	Enablers	Advanced analytics for optimizing operations			
Legal Factors	Barriers	Difficulty integrating legacy systems with new technologies Data privacy concerns			
	Enablers	Streamlined regulations for data collection and sharing			
Environmental factors	Barriers				
	Enablers	Improved transparency and efficiency through smart port technologies			

CS3

Table 44: CS3 - Identification of barriers and enablers for innovation related to theme LAND USE / SOIL

Factors	Barriers / Enablers	L 1.1.1 Bavarian alliance on green and blue cities / support services	L 3.1.1 "Green trenches" retaining water
Political Factors	Barriers		
	Enablers	Funding for support services	Political support for idea
Economic	Barriers		

factors	Enablers	Successful investment in climate change adaptation and mitigation is possibly less costly than failure to mitigate climate change and covering the cost of failed adaptation.	Yields and profits are major motivating factors which is why farmers want to be able to decide independently when to store water in trenches and when to drain them. This allows them to still choose the ideal time to work on fields and maximize yields. Pilot projects allow for this choice to be made independently. Technology needed to restrict runoff is very simple and cheap to manufacture, install and operate. Younger people taking over their parents'/family land may have stronger economic motivation to ascertain sustainable farming/cultivation because their planning horizon extends several decades into the future.
Social Factors	Barriers	Different needs depend on sectors and resources of responsible organizations. Need to identify target groups of support services. Need for highly specialized / localized knowledge may be difficult to meet in a large federal state with diverse "starting positions" on climate adaptation. Support services have to be accessible; a large variety of different information for different target groups makes identifying relevant information difficult. But one dedicated body could also serve as "one-spot-stop" for information.	Skepticism towards new pilot projects: "We know things that work. Creating new pilot projects year after year does not help. We need to concentrate on disseminating proven solutions." Farmers frequently feel mistrusted and want to make their own decisions with less external intervention and less external input on how to work the land.
	Enablers	Support services are likely to be accepted if they make practical change possible and help decrease resource gaps in personnel and knowledge for climate resilience.	Possibility of trial and error. Farmers want to decide on their own. Farmers want to be able to make their own choices about when to drain ditches and when to store water There is a well-established project for spreading measures for protection from extreme rainfall through cooperation between farmers, agricultural administration and municipalities that could be expanded to spread the idea of "green trenches" ("boden:ständig")
Technological factors	Barriers		Installing barriers against water run-off in trenches has revealed that there is more water running off through those trenches than expected. The trenches themselves are unable to retain the water and it flows over barriers. The technological solution with barriers against run-off has limits and more water needs to be stored differently (including with non-technical solutions) ("We have to say goodbye to wanting to store all water with technological solutions.")
	Enablers	Option to build on existing initiatives e.g. for online platforms, databases and	Barriers for holding water in trenches is extremely simple and can be installed and

		climate services	removed easily
Legal Factors	Barriers		Federal structures/national & international funding perceived as hindering (complex, inflexible) Measures supported by state funding cannot be reversed Measures that are legally prescribed cannot be funded/supported through state-funding schemes
	Enablers	The regulatory framework sets out certain standards for vulnerability assessment and adaptation that the design of support services could be based on.	
Environmental factors	Barriers		
	Enablers		Pilot project shows large amount of run-off and the potential of storing water.
Factors	Barriers / Enablers	L 1.2.2 municipal incentives for water retention L 3.1.2 Ökopunktekten	L 1.2.1 unsealing soils (monitoring) L 1.2.3. planning includes mandatory water retention areas L 2.2.2 Doppelte Innenentwicklung (Planning standards)
Political Factors	Barriers	Need to have political will or electorate demanding positive incentives for climate adaptation Budget negotiations (national, Bavarian and municipal level) can lead to a reduction of funding for climate adaptation as can associated decisions (e.g. decision of the German constitutional court on the national budget; debate about restricting national debt, submission deadlines) Political disagreement about the economic viability of planning rules that would reduce sealed surfaces and introduce greenery e.g. at the cost of traffic and parking. "If we reduced traffic in the city center it would harm the shops there" vs. "If we introduce more greenery the area becomes more attractive and people want to live there." Creating additional local standards or planning rules may create bureaucracy which is costly and unpopular.	
	Enablers	Political alliances across party lines on setting standards and progressing climate adaptation Linking climate adaptation measures to other issues can broaden support e.g. linking financial support for climate adaptation and social justice or health. Projects supported by the Bavarian state with consultations and development of projects Need to build political alliances over party boundaries and with civil society organizations that hold expertise	Need to build political alliances over party boundaries and with civil society organizations that hold expertise
Economic factors	Barriers	Financial incentives, e.g. for creating green roofs or installing water tanks, can only be granted by municipalities with sufficient funding. High financial stress on some municipal	Co-funding of water retention projects through support programs can determine whether a project is happening. Funding programs from different sources (national

		budgets e.g. because of the energy crisis, the need to ensure provision of childcare, or pressure to renovate public buildings limits their ability to set incentives such as financial support programs or counseling.	level v. Bavarian level) differ in funding requirements and quotas, i.e. how much of the project will be funded externally. Continuation of such programs is partially dependent on budget negotiation in parliaments. Application windows for co-funding are often very short, applications are lengthy and bureaucratic as is the controlling during the project. Large recipients with specialized staff for applications and project design have much better chances of receiving funding through these channels. Competition of using surfaces for other purposes: Transforming areas into green spaces means that they can no longer be used for other purposes that may more obviously and directly result in economic benefits e.g. development of housing or business areas. Implementation of measures may compete with plans of investors in new construction areas but there is disagreement as to whether that is really the case. Some argue local standards, e.g. for the development of new settlements with space for greenery or water tanks, do not seem to necessarily act as a deterrent to investors as they ultimately lead to more attractive projects that will generate more revenue. Obligatory measures can no longer be supported financially e.g. if a rule is created that all new houses need to install a cistern the city can no longer offer financial support for installing cisterns.
	Enablers	Design funding schemes that allow for climate mitigation and adaptation measures at the same time (e.g., PV and green roofs together). People might be more interested in funding for climate change mitigation initially since those measures are usually connected to financial benefits (e.g. saving energy cost by installing solar power). State supports the drafting of climate adaptation strategies by municipalities that can briefly outline plans for different measures. Younger people taking over their parents'/family farms may have stronger economic motivation to ascertain sustainable farming and implementing measures with positive effects on the long-term because their planning horizon extends several decades into the future.	State supports the drafting of climate adaptation strategies by municipalities that can briefly outline plans for different measures. Financial support from the state to municipalities could be linked to ecological standards e.g. support for large construction projects need to include standards for greenery if they are co-funded Ability to attract well-educated and qualified personnel for planning and designing measures given in a mid-sized city. Differs from municipality to municipality as does municipalities' ability to offer higher wages or additional benefits such as compensating for higher cost of living in cities

Table 45: CS3 - Identification of barriers and enablers for innovation related to theme 1 WATER/WATER BALANCE

Factors	Barriers / Enablers	W 1.1.1 Personnel strategy W 1.2.1 Education on water and climate change for people in the water sector	W 2.1.1 local or regional climate funds
Political Factors	Barriers	Number of positions created, and personnel assigned to water administration is decision of Bavarian parliament Funding for different parts of administration and thus how much money they have for projects is choice of Bavarian parliament	
	Enablers	Amount of personnel assigned to water administration is decision of Bavarian parliament Funding for different parts of administration and thus how much money they have for projects is choice of Bavarian parliament	Climate funds are a source of funding for projects which could not be funded through the municipal budget e.g. because of limited funds or restrictions due to debt.
Economic factors	Barriers	Cost of designing and implementing strategy and Impact of budget negotiations (see political factors above)	Unlike other investment funds so called "Climate Funds" do not offer financial returns on investments. Rather they argue that the ROI is in environmental quality and safety. Thus, they are fundamentally different from other investment funds and closer to crowdfunding. So far, the amounts raised through these funds remain somewhat limited.
	Enablers		Financing needs for climate resilience remain high. Many solutions are not well-funded or connected to business models. Using climate funds can help raise funds for local projects from alternative sources. Donations to climate funds can be reported on tax statements to reduce income tax
Social Factors	Barriers	Current solutions for dealing with staff shortages and qualifications are working relatively well for now (project-based positions, improvement of the work-life-balance). This might create the impression that there is little need for a long-term strategy. Moreover, issues with staffing and qualifications are not pertinent everywhere. Personnel is a challenge that is slowly emerging: "There are fewer applicant now than there were a few years ago but as long as there is one qualified applicant I do not really have a problem." Staff shortages are a challenge in most sectors in Germany at present with many	Acceptance may be a problem if climate funds are used to fund projects that "should" be financed by the state or private companies

		calling for dedicated strategies for attracting workers. All sectors developing similar strategies for attracting personnel might not solve the issue.	
	Enablers	Opportunity to build on existing initiatives for education such as water neighborhoods, associations and similar initiatives as they are experienced in communicating “new” issues and offer training and a platform for exchange. Existing cooperations with universities to get qualified personnel could be expanded. There are some activities to publicize job opportunities in water administration and the larger water sector that could be built on	There are several projects where these funding instruments are used successfully. There is research and counselling on how to set them up. Projects funded through climate funds are usually implemented locally and funded locally. This creates a close connection between the communities financing and benefitting from financed measures. Donations to climate funds can be used to generate positive publicity for businesses. Inform citizens through good PR
Technological factors	Barriers		
	Enablers		
Legal Factors	Barriers	Total number of positions in water administration is decided on by Bavarian Parliament. Administrative bodies cannot just create additional positions.	
	Enablers	Administrative bodies can create temporary positions when they launch projects.	
Environmental factors	Barriers		
	Enablers	Progression of climate change and increasing relevance of climate adaptation and solutions connected to water increase the need for qualified staff and a coordinated approach to securing personnel for the water sector.	Extreme events like droughts and floods make climate change visible and maybe motivate people to invest in local or regional climate funds.
Factors	Barriers / Enablers	W3.1.1 – W 3.1.4, W 4.1.1 Regulatory changes water	W 4.1.2 support services for climate resilience strategies critical infrastructure
Political Factors	Barriers	Openness to acknowledge challenges caused by climate change and land use for water supply and to address them Inscribing the priority of public water supply in Bavarian law could impact contentious resource conflicts that some politicians are not willing to decide (in favor of public water supply)	
	Enablers	Political will to implement changes which would strengthen critical infrastructure and water sector as a whole Reliably functioning basic public services such as water supply at an appropriate cost for consumers are highly valued by citizens/voters. Their provision is one of the key responsibilities of municipalities.	Importance assigned to critical infrastructure
Economic factors	Barriers		Funding for support services
	Enablers	The proposed regulatory changes are not	Successful investment in climate change

		connected to increased spending for the state	adaptation and mitigation is possibly less costly than failure to mitigate climate change and covering the cost of failed adaptation.
Social Factors	Barriers	Little interest in the details of laws and regulations	Different needs depending on sectors, resources of responsible organizations Need for highly specialized / localized knowledge Support services must be accessible; large variety of different information for different target groups makes identifying relevant information difficult
	Enablers	Reliably functioning basic public services such as water supply at an appropriate cost for consumers are highly valued by citizens/voters.	Support services likely to be accepted if they make practical change possible and help decrease resource gap in personnel and knowledge for climate resilience Use of services should be voluntary. Many operators of critical infrastructure will be asked to partake in the vulnerability analyses of municipalities they are operating in and developing measures for increasing resilience with them. Resources for these tasks are limited.
Technological factors	Barriers		
	Enablers		Option to build on existing initiatives e.g. for online platforms, databases and climate services
Legal Factors	Barriers		
	Enablers		The regulatory framework sets out certain standards for vulnerability assessment and adaptation that design of support services could be based on.
Environmental factors	Barriers		Exposition and vulnerability of critical infrastructure highly dependent on local factors such as local effects of climate change.
	Enablers		
Factors	Barriers / Enablers	W 5.1.2 – W 5.1.3 administrative and regulatory changes on water protection and water rights procedures	W 5.1.4 IT-systems information sharing W 6.1.1. Digital water registry
Political Factors	Barriers	political will and courage to communicate need for change Conflicting interest and competition for water and land between stakeholders Populist narrative about climate change and “green ideology” not being what “people with common sense” want Long-standing paradigm of “the Bavarian way” of creating water protection areas as large as necessary but as small as possible to balance conflicting interests	Political will to create a public record Different lower water authorities in charge of granting water rights and permits work with slightly different systems processes (federalism as a barrier)

	Enablers	political initiatives on water protection (National, Bavarian, European) Civil society demands At present the creation of a new water protection area usually takes several years due to the high demands on data collection, citizen involvement and long administrative processes. The problem is well-known and can be put back on the political agenda following very visible climate change impacts e.g. drought.	Lively and controversial debate in the region Resource-conflict could increase pressure to create digital and public record (opposition) parties argue for creating a “digital water book”
Economic factors	Barriers	Increasing water protections can restrict the economic benefits of influential actors such as land users e.g. because mining is no longer possible, or land can no longer be used as pastures Resources for water protection (funding, personnel) needed	Project cost of digitizing records and introducing new tools
	Enablers	Lacking resource protections can limit economic benefits / wealth in the mid to long term	Digitized processes may lead to lower cost in the long term
Social Factors	Barriers	The creation of water protection areas is contentious because it limits how the area covered by a protection area can be used. Thus, it may be opposed by those who believe that increasing water protection will limit their freedom to use their land or profit from it. If water protection areas are set up in rural areas to supply cities rural populations often lack understanding for the new protection areas and oppose them. They have to live with the limitations/rules connected to stricter water protection while urban populations get to use the clean water.	Introduction of new systems and processes may be met with opposition by those using them / used to old systems
	Enablers	Water protection areas are ideally placed within or close to the community that is supplied with the water sourced there. Consequently, people protect “their” water and “benefit” from the limitations set by rules for water protection.	Social pressure e.g. from press, environmentalists and water-users to create a digital and public record Intrinsic motivation of administration to create modern systems
Technological factors	Barriers	Extensive data collection for project applications; need to supply new data if applications are not processed in a timely manner	Especially old records are frequently kept in paper form and have not been digitized with water rights sometimes lasting up to 30 years some rights awarded decades ago have not been recorded digitally
	Enablers		Ongoing digitization process in administration can act as facilitator (potential for synergies when overhauling databases, administrative processes)
Legal	Barriers	Extensive data collection for project applications; need to supply new data if	Questions about privacy remain: need to find a balance between public interest and

Factors		applications are not processed in a timely manner Requirement to look at alternatives even in cases where protection areas and wells exist, and protection areas are supposed to be continued or enlarged	privacy. However, there is precedent of how these rights can be balanced. (see. Legal factors - enablers)
	Enablers	There is precedent. Critical infrastructure for energy supply has been of outstanding public interest during the energy crisis, which allowed for the speedy construction of energy infrastructure. The same could be done for water protection areas.	Bavaria has the "Umweltinformationsgesetz" which allows citizens to request information about environmental questions from the state and creates transparency. Here a balancing of public interest and other concerns including privacy is already taking place. This may be a precedent.
Environmental factors	Barriers	The region and its soils are very diverse. Whether and how a protected area can truly be protected is a case-to-case decision because of the natural conditions found there.	
	Enablers		Faster identification of and reaction to environmental risks.
Factors	Barriers / Enablers	W 6.1.3 + W 6.1.5 communication on water resources W 6.1.2 Water footprint on all products	
Political Factors	Barriers		
	Enablers		
Economic factors	Barriers	Public water suppliers often have no or very limited funds for communication and public relations	
	Enablers		
Social Factors	Barriers	Communication needs to be target group specific Information like water consumption for specific products must be understandable and stand out in variety of product labels and information on sustainability, climate impact and health/nutritional information (danger of information overload: permanent exposure to the topic may raise awareness but can also result in disinterest or even induce defensive reactions) Need to generate trustworthy system for declaring water footprint so it cannot be considered "green washing" or "just another label claiming something".	
	Enablers	Support education for sustainable development to empower consumers to understand and evaluate information Structuring information on the current state of water like the weather report provides a familiar (and trusted) format to the public. The playful character of, e.g., prizes, incentivizes some people to comply with (potentially) unpopular requests. Additionally, it attracts attention when communicated broadly (e.g., in local newspapers).	
Technological factors	Barriers	Standardized methods for determining water footprint (directly + indirectly used water) For customers, it may be difficult to assess the validity of seals claiming, e.g., low water footprints. Therefore, the producers are required to provide transparency on how they calculate their footprints. Standardized methods for calculating/measuring water balance components required in all relevant catchments (e.g., for cross-border aquifers, surface water etc.). These data form the basis for communication purposes.	
	Enablers	Common media channels (e.g., mobile phones, television, newspaper, radio, internet) can be used to provide a "water balance report" akin to the weather report. This would not require new technology.	

Legal Factors	Barriers		
	Enablers		
Environmental factors	Barriers	While measurements are conducted within a certain region, cross-border catchments or aquifers result in very complex hydrological behavior that cannot be described fully on isolated locations.	
	Enablers	Better understanding of water resources may lead to more sustainable use, especially in regions of water scarcity	
Factors	Barriers / Enablers	W 6.1.2 Framework for irrigation W 6.2.4 Water efficient irrigation systems	W 6.2.1 monitoring of water withdrawal and uses in the region
Political Factors	Barriers	Strong agricultural lobby favors irrigation and opposes regulating it. Some agricultural lobbyists link irrigation to the issue of nitrate pollution in groundwater which may be a hurdle to introducing standards for or limiting irrigation. The standards set by the nitrates directive are not met in large parts of the case study region with nitrate levels being too high and little progress being made to reduce them (particularly in groundwater, but also surface water bodies). Lobbyists argue that those levels will rise if fertilizer-use continues but irrigation is difficult. They claim plants would be unable to absorb fertilizers which would be washed into surface or groundwater. They consider this an argument for increasing irrigation ("irrigation is groundwater protection") rather than for reducing fertilizer-use. Nitrate pollution is an extremely controversial issue in the region and leading political parties are opposed to further regulating and restricting fertilizer-use. In the past stronger standards for reducing nitrates pollution happened after legal action by the European Commission against Germany for non-compliance with the nitrates directive. Fearing legal repercussions and public opposition to stronger regulation of fertilization may ease the way for irrigation with little restrictions. Some leading political parties prefer enabling irrigation rather than prescribe or enable alternative nature-based solutions. Competencies and responsibilities are split between water and agricultural ministries and administration which might be a barrier to quickly defining standards. Agricultural water users often downplay how much water is used for irrigation by pointing towards other users who, allegedly, use more water. However, they	Political will to create a (public) record is lacking; Some politicians doubt that monitoring will bring major changes "there will always be people with criminal energy who take more than their allotted amount" Increasing state capacity to monitor water withdrawals would require the allocation of funds and personnel to administrative bodies and possibly improved cooperation between different departments. Project may be perceived as bureaucratic

		exclude the differentiation between “consuming” and “using + returning to water cycle”. Political incentives are often oriented towards the time horizon of 4-5 years (election terms). But adapting requires longer planning periods (guarantee of stable guidelines, investments etc.).	
	Enablers	Pressure from local politicians affected by the problem, opposition parties and environmental interest groups. “Expert commission” created by the Bavarian government has recommended that irrigation should be the exception, regulated and monitored closely to ensure sustainability (Bericht Expertenkommission Wasser)	(opposition) parties argue for better monitoring of water extraction and uses There is precedent of another federal state of creating a public system for monitoring water rights and extractions. Whether that should happen in Bavaria is ultimately the decision of the Bavarian parliament.
Economic factors	Barriers	“sustainable” irrigation is made less likely by the fact that the question whether a crop should be irrigated in principle is a purely economic consideration. If it makes financial sense to irrigate e.g. to increase quality or yields a crop will be irrigated (Even if they are not in imminent need of irrigation). This leads to water-intensive crops being planted in arid regions suffering from water scarcity. If irrigation infrastructure already exists or is being subsidized by the state irrigation becomes an economically sensible option for more crops and more affordable than alternative measures such as investing in soil quality. Produce standards for buyers of crops e.g. supermarkets. For some produce irrigation impacts the quality significantly. If farmers want to meet the standards set by those buying and selling their crops they must irrigate to ensure the quality of their crops. If they do not meet standards, they might not be able to sell their produce. Financing irrigation infrastructure for private companies cannot be the responsibility of the government. Currently, large pilot-projects are government funding, but alternative mechanisms have to be found. A very strong agricultural lobby favouring irrigation over alternative (nature-based) solutions. Limited resources in water administration and increasing demand for water rights and permits conflict. This led to parts of the water administration favouring the creation of irrigation clubs that would be responsible for assigning water and would be the single point of contact for the administrative bodies. However, they	Project cost of digitizing records and introducing new tools Budget negotiations in parliament are very controversial and funding for projects such as digitization of processes in administration is frequently cut.

		would be in charge of supplying water to large areas and not work otherwise. Creating these clubs of irrigating businesses may cause lock-in effects and more irrigation.	
	Enablers	Irrigation infrastructure is expensive. Having clear rules on irrigation may help prevent misguided investments. However, the state is funding large irrigation projects for farms and vineyards in the region as “pilot projects” and taking on the cost and risks.	
Social Factors	Barriers	Farmers are often opposed to regulation and prefer free choice of methods. Thus, they oppose strong standards or rules for irrigation. “Farmers know best what is right for their businesses.”	Authorities strongly publicly criticized for lack of monitoring of water rights and extractions which can be frustrating for those employed there who work for change Lack of experience with big digitization projects and how to speed them up.
	Enablers	There is a lively debate about irrigation and how it is regulated with a variety of positions. Active interest and civil society groups may enable the well-informed drafting of rules. Moreover, there is demand for a regulatory framework.	Social pressure e.g. from press, environmentalists and water-users to create a digital and public record
Technological factors	Barriers	Disagreement about which technologies should be used, e.g. some disagree that drip-irrigation is always the best choice in regions with (regular) rainfall	Not all water extractions are monitored using digital water clocks that can be used for remotely monitoring water extractions. Many water clocks / water meters are analogue and require owners to read/note values. Currently used technology for recording water rights is very old, paper records are common. This makes it harder to ensure that extractions are in line with water permits and rights.
	Enablers	Creation of infrastructure is funded by the state in some pilot projects.	There is precedent of monitoring the water extractions of public water suppliers. They self-report their water-use regularly and digitally to the authorities. Similar approaches could be introduced for other water users. Pilot project using digital water clocks that can be monitored remotely has been started in arid region for monitoring of irrigation
Legal Factors	Barriers	There are some guidelines and non-binding standards for irrigation that should for example be considered when granting water permits for irrigation. However, they are not strictly binding. Nevertheless, they could act as precedent or a basis for rules. The creation of new “irrigation clubs” which are comprised of multiple farms in one region and organize irrigation as a collective would require changes to the legal framework they are based on. This	Different rules/standards for self-reporting water extraction: public water suppliers have to report their water extractions and to what extent they use their water rights regularly through an established system. Other users do not self-report their water-use in the same frequency and not as thoroughly. Unclear whether data on water extraction and use of enterprises can be collected, shared or published or if privacy regulation

		legal basis could theoretically include standards concerning the tasks and responsibilities of “irrigation clubs”. Questions about how responsibilities are split between different parts of administration (environmental and agricultural) with regards to irrigation may have to be clarified.	or corporate secrets are concerned.
	Enablers	There are some rules which could serve as precedent or basis for a regulatory framework e.g. on water permits and rights, the monitoring of wells and technical standards.	Monitoring water extractions could improve compliance with rules and regulations connected to water rights and permits. There is precedent of another federal state of creating a public system for monitoring water rights and extractions. Whether that should happen in Bavaria is ultimately the decision of the Bavarian parliament.
Environmental factors	Barriers	There are regions with very little rainfall because of geographic factors where irrigation through rain cannot be the standard practice. In addition, precipitation is projected to decrease during summer months in the case study region due to climate change. A regulatory framework would ideally consider geographic differences and changes caused by climate change. Increasing resource competition because of water scarcity (available volume and quality) makes discussions about regulating water use more difficult. Water availability is not only limited by climate change but also by preexisting problems such as pollution with nitrates, pesticides and herbicides.	
	Enablers	Progression of climate change makes questions about irrigation and efficient water use more pressing.	
Factors	Barriers / Enablers	W 6.2.2. Switch to drought resistant crops	W 6.2.3 innovative strategies for greenery in public spaces
Political Factors	Barriers	Focus of political debate on irrigation and ensuring continuation of current practices rather than change to alternatives. Political will of decision makers	Budget negotiations (national, Bavarian and municipal level) can lead to a reduction of funding for climate adaptation as can associated decisions (e.g. decision of the German constitutional court on the national budget; debate about restricting national debt). Diverse political interests: considering climate change as highly important vs. one topic among many.
	Enablers		Political alliances across party lines on setting standards and progressing climate adaptation. Linking climate adaptation measures to other

			issues can broaden support e.g. linking creating greenery and social justice.
Economic factors	Barriers	Switching crops may impact yields. Less typical crop varieties may be harder to sell because there is no market (locally). Economic impact of changing crops on subsequent parts of the value chain. For example, if farmers switch from sugar beets to other crops sugar manufacturers and traders in the region will be affected by that choice, too. Hesitancy to try out new things, change routines and business models that are currently working or have worked for years/decades.	Cost and labor can be prohibitive but sometimes measures can be combined with other projects or little projects can be realized (Sowieso-Maßnahmen). Co-funding of water retention projects through support programs can determine whether a project is happening. Funding programs from different sources (national level v. Bavarian level) differ in funding requirements and quotas, i.e. how much of the project will be funded externally. Continuation of such programs is partially dependent on budget negotiation in parliaments. Application windows for co-funding are often very short, applications are lengthy and bureaucratic as is the controlling during the project. Large recipients with specialized staff for applications and project design have much better chances of receiving funding through these channels. Competition of using surfaces for other purposes: Transforming areas into green spaces means that they can no longer be used for other purposes that may more obviously and directly result in economic benefits e.g. development of housing or business areas. Municipality with low budgets do not apply for certain funding schemes (e.g., when their own financing quotas would be too high).
	Enablers	Longterm interest in ensuring yields	Ability to attract well-educated and qualified personnel for planning and designing measures not given in all towns and cities. The same is true for the ability of municipalities to pay higher wages, compensate for the higher cost of living in cities or offer additional voluntary benefits.
Social Factors	Barriers	Hesitancy to try new things and change routines. Grown crops may be linked with peoples' or entire regions' identities e.g. if their families have been growing certain things for generations or if a region is known for growing certain crops and subsequent products. Need to acquire new specialized knowledge when changing crops or varieties. New crop varieties may require new methods or techniques creating a need for learning and education.	Diverging interests and mind-sets in the population. For example, many people still consider green spaces with a variety of different grasses and flowers that grow relatively tall unkempt and would prefer mowed lawns.
	Enablers	Multiple research initiatives and pilot projects into alternative crops and methods improving knowledge and creation of a research institute on	Active local civil society can help by participating in demanding, developing and implementing projects. Can get social support for greenery if people can volunteer

		drought and farming in the region. International partnerships with arid regions	for their green space e.g. by watering “their local tree” or by using an unused green space for urban gardening. Support does not only stem from the volunteers themselves but also from adding signs showing others that a plot of land is designed and cared for by neighbors Cooperation with researchers in pilot projects can be very useful for generating funding, attention and evidence that certain measures work e.g. installing climate stations throughout the city to show how greenery affects heat islands and air quality. Learn from other cities; adapt creative concepts.
Technological factors	Barriers	Depending on crop choice new machines may be needed. Large machinery is sometimes owned by collectives and loaned to farmers. Collectives would have to make choices to change available technology and invest in new machinery.	Greenery can only be created where there are no strong conflicts with subterranean infrastructure or its care. For example, trees should not be planted closely to waterpipes, broadband cables or heat pipes since the roots may damage the infrastructure or the tree might have to be dug up if repairs must be made. Identifying potential spaces for greenery can be tough because there is so much infrastructure underground.
	Enablers	Crops which are more suited for the emerging climate have been grown in other regions. Technology and methods for growing them can be imported or copied from those regions.	Having localized information about climate change and its impact or the benefits of greenery helps with planning and when arguing for new/additional projects. Can use technology to increase resource efficiency e.g. sensors and LoRaWan to determine when green spaces should be watered. Can find creative technical solutions e.g. for watering greenery: using machinery that is normally used in winter for irrigation in the summer / using cleaned water from public pools when it is changed.
Legal Factors	Barriers		Greenery has to be cared for in line with its purpose and different rules apply e.g. for playgrounds, public squares and public parcs.
	Enablers		Municipalities can set their own rules and standards (local self-government)
Environmental factors	Barriers		Water scarcity limits the irrigation of new green spaces (high amount of water required). For some irrigation of public green spaces can only be an intermediate solution until water infiltration and retention throughout the city is improved.
	Enablers	In water scarce regions the population already faces water conflicts. Drought resistant crops produce more crops per drop of water and can therefore be an	Effects of climate change on urban green spaces are often very visible e.g. when trees die or lawns in parks dry out. At the same time the effects of greenery can be felt very

		option for sustainable food security with minimal use of water.	directly e.g. when reducing the effect of the urban heat island or improving air quality.
Factors	Barriers / Enablers	W 6.2.5 restrict water-use if necessary	W 6.3.1 use of treated wastewater for irrigation
Political Factors	Barriers	Public water supply is a cornerstone of basic public services. As are security of supply at adequate cost. Restricting water use can only be an emergency measure and temporary. Decision-makers may fear making such drastic choices.	Use of treated wastewater may be unpopular with voters who are only coming to terms with the local effects of climate change. Politicians may be hesitant to suggest such “extreme” measures depending on the composition of the local electorate. Equipping water treatment facilities with the technology to treat wastewater until it is fit for irrigation (drinking water standard) would be very costly. The cost of treating wastewater is usually directly borne by customers who are also voters. Hesitancy to roll-out new and very expensive technology on a large scale and bear the (political) consequences of potential failure
	Enablers	Decision-makers are taking additional measures to address water scarcity such as investing in water supply infrastructure or water protection. It helps if restrictions affect uses that can be “substituted” e.g. if filling private pools is not allowed having a public pool, which is open to all, increases acceptance. Close cooperation between public water suppliers and political decision makers e.g. through frequent updates about groundwater situation.	The need for solutions for resource conflicts is pressing. Introducing new technologies and launching projects may be perceived as actively trying to solve the challenges by voters. Given the high nutrient load in many shallow aquifers and an agreed-upon restriction of using deep aquifers with slow recharge rates, alternative water resources become highly attractive.
Economic factors	Barriers		The cost of technology for treating water until it has drinking water quality is prohibitive. Energy intensive procedures. The price of treated water for irrigation would be very high. Large-scale use of treated wastewater would require the creation of an additional network of water pipes for treated water (effort, cost for construction and maintenance and space restrictions). In some cases, irrigation is only an intermediate solution, e.g. in cities which are irrigating public green until they have improved their infrastructure to retain more rainwater or switched out plants to more drought resistant species. For them investing in wastewater treatment for irrigation and the associated infrastructure is not economically sensible.

	Enablers	No economic repercussions are known e.g. companies not coming to towns that have restricted water use.	High demand for water and increasing acceptance for high cost
Social Factors	Barriers	Restrictions can hardly be controlled. People need to trust that they are necessary and follow them because they believe them to be appropriate.	Public acceptance for treated wastewater and its use for irrigation of crops Hesitancy to roll-out new and very expensive technology on a large scale
	Enablers	Good communication and PR are key: define clearly what is allowed and what is not. Explain why restriction is necessary in the current situation (also see below "environmental factors"). Make clear how long it will be in place. Announce restriction well in advance of it taking effect. Trust in decision-makers and technical expertise of water suppliers who advise on when to restrict water use. Civil society organizations representing cities, towns and water suppliers have formulated guidance documents on the temporary restriction of water-use for specific purposes to offer guidance on good implementation of this "innovation".	Research into technology, necessary regulatory framework and inclusion of stakeholders in projects The trust in technological and engineering solutions is high.
Technological factors	Barriers		Large-scale use of treated wastewater would require the creation of additional treatment states at water treatment facilities and an additional network of water pipes for treated water (effort, cost for construction and maintenance and space restrictions). Treatment of wastewater until it is drinking water quality requires a lot of energy. If the technology was rolled out across the region energy demand would increase as would the demands on power grids.
	Enablers	Reliable data about available water resources and rainfall of the last years. (Because of climate change periods for which average precipitation is calculated can be shortened).	Possibility to learn from other parts of the world
Legal Factors	Barriers		Treated wastewater is currently not considered in guidelines/rules for irrigation. Need to define standards for reuse and irrigation of water to generate trust and avoid negative environmental and health impacts.
	Enablers	There are different options to formulate legally sound restrictions. The law already provides the basis for doing so.	
Environmental factors	Barriers	Coincidence of drought and heatwaves with peak demands causes additional water stress. In the future these situations are likely to occur more frequently.	Even with treatment preceding the application of wastewater, the risk of pathogens and heavy metals in the soil may prevail. Traditionally wastewater would arrive at a

			treatment facility and would be directed into a nearby stream after sufficient treatment. If wastewater is treated and used for irrigation it is not directed to such streams and is unavailable for sustaining riverine ecosystems downstream from the water treatment facilities.
	Enablers	In regions with low precipitation levels or groundwater recharge rates, water use is limited physically. In this case, the low water availability imposes the need for restricting water use permanently. Coincidence of drought and heatwaves with peak demands causes additional water stress. Water stress means that certain uses must be restricted to ensure sustainable levels of water extraction from local wells. Thus, water uses which are not deemed essential e.g. washing cars or filling pools are prohibited for a limited time i.e. until water stress has decreased.	Important macro- and micronutrients are added to the soil. This could reduce the need for using organic fertilizers.
Factors	Barriers / Enablers	W 7.1.1 proliferation of organic farming	W 7.2.1 "toolbox" for adapting cooperation agreements to climate challenges
Political Factors	Barriers	State funding schemes and support programs primarily support conventional production methods. Agricultural policy often directed at compliance with global market standards and being able to compete globally on price rather than creating an agricultural sector that is focused on quality of products and sustainable agriculture that considers its impact on the environment and climate.	Need political will locally The Bavarian government has been planning the introduction of a water extraction fee for years. It remains unclear whether it will be created and what it will be used for. Some may hesitate to enter private agreements on water protection if there is a chance that the state may use the income from the water extraction fee to fund such projects.
	Enablers	Bavaria has an official goal for organic farming: by 2030 30% of agricultural land is supposed to be used for organic farming. Creation of strategy for reaching that goal "BioRegio 2030". States institutions could switch to exclusively using organic products e.g. in their staff cafeterias. State-owned agricultural enterprises could switch to organic methods.	Need political will locally The approach has been proven to work in other regions and for the reduction of nitrates pollution.
Economic factors	Barriers	Switching methods requires investment, skill and changing routines. Different profit margins for conventionally produced products and organically produced products. Consumers are switching to conventionally produced products because of rising prices and inflation. Organic farms need more land to produce the same volume of products (because of smaller yields) which can lead to	Need to find agreement on adequate funding of different measures. Cost is passed on to the public via water fees. Thus, water suppliers want to limit spending to an appropriate amount that covers costs of measures but does not go beyond that.

		competition for land with other uses. Yields of organic farming can be lower because of restriction of fertilizers, herbicides and pesticides.	
	Enablers	Use of smaller machinery, different methods and more manual labor creates jobs. However, a shortage of potential staff may turn this into a barrier. Restricting use of artificial fertilizers reduces energy consumption for fertilizer production	Models offer the option to reimburse the cost of “additional” measures to support water balance which would usually not be taken by farmers e.g. because they have long-term effects and farmers only rent fields for limited time periods.
Social Factors	Barriers		Mistrust between potential partners e.g. farmers might not want to discuss with water suppliers and other people how they should use / work on their land
	Enablers	Organic farming is well-established in Bavaria; option to spread knowledge and experience through networks and training. Well-organized civil society can spread knowledge about methods, support switch to different methods and convince farmers. Increase resources for counselling on organic farming by the state. Direct research grants for agriculture more strongly towards organic agriculture. Change curriculums and training of young farmers to include more information about organic farming.	The approach has been proven to work in other regions and for the reduction of nitrates pollution and is trusted by water suppliers and farmers. Hiring a moderator/external expert to advise on measures and adequate prices can help. Good preexisting relationships with local community help
Technological factors	Barriers		
	Enablers		There may be benefit in identifying a catalogue of adequate measures that address challenges for the water cycle caused by climate change and to define under which conditions they can be applied. Current agreements usually aim to limit nitrate pollution of groundwater and include measures for that purpose.
Legal Factors	Barriers		
	Enablers		Necessary contracts are relatively simple and can be drawn up quickly. There are templates from other regions that have been used for years and that are legally sound.
Environmental factors	Barriers		
	Enablers	Synergies with other goals such as biodiversity, animal welfare and long-term profitability of agriculture. Healthier soils and water resources due to less pesticide and herbicide use can lead to better food security in the future.	
Factors	Barriers / Enablers	W 7.2.2 Biogas production using plants w. fewer detrimental effects	W8.1.1. Water extraction fee
Political	Barriers		Water extraction fees have been shown to not induce behavioral changes in water

Factors			users. They just increase the cost for them. The water extraction fee that applies to all water uses (including irrigation) is extremely unpopular with the influential agricultural lobby.
	Enablers	Currently, there is a general attempt to reduce the dependence on fossil/natural gas imports, especially from Russia. This provides a window of opportunity to support biogas in general. The state grants financial support for establishing certain crops for biogas production that are better for the environment.	Political will to create extraction fee proclaimed repeatedly (since 2021) by governing parties and prior to that by some opposition parties. While most political parties in parliament support the creation of a water extraction fee their ideas for its design vary substantially. Pressure from national level to create water extraction fee in all federal states
Economic factors	Barriers	Need reliable partners who will use the plants for energy production after the harvest. Even if harvest does not coincide with that of more typical plants for energy production. Especially initially lower yields than when using corn or other more typical means of producing biogas but the gap between the yields of corn and e.g. hemp decreases especially in dry years as hemp develops deeper roots. Moreover, differences in yields are compensated through state support for establishing alternative plants for biogas production.	Influential special interest groups oppose water extraction fee and its use for resource protection.
	Enablers	Structure of local energy production using biogas: small plants, frequently owned by farmers or local communities that can decide relatively independently which plants they use and where they get them. Option to oversee and design value chain.	Source of income for the state e.g. for resource protection. However, the introduction of a fee could also generate costs for the state, e.g. if it was connected to improving the monitoring of water extraction.
Social Factors	Barriers	Need to try new methods and crops and make experiences with new practices and methods. Changing routines. Effort for creating local networks that reliably ensure functioning of the value chain Switch requires a commitment for several years to see full effects	A water extraction fee for all water users would also impact those who can no longer reduce their water consumption, e.g. low-income households. Using water extraction fee for resource protection or other clearly defined purposes may be difficult because of the high demand for funding for a variety of issues and from different interest groups.
	Enablers	Long-standing projects demonstrating that switching to alternative plants is possible and beneficial Need for cooperation between providers of plants for biogas production and plant owners. Plant mixes are often more popular with local communities and neighbors of fields and increase acceptance of the use of agricultural land for energy production (rather than food production). Public recognition of projects using alternative plants e.g. through press coverage, prizes, etc.	

Technological factors	Barriers		Monitoring of water extraction is lacking, especially for private wells (e.g. for irrigation). This poses problems for calculating fees. (also see “monitoring of water extraction”)
	Enablers		
Legal Factors	Barriers		
	Enablers	Fields where seed mixtures with proven benefits for soil, water, biodiversity and climate are used could be considered “compensation areas”.	Most other federal states have water extraction fees. Different approaches could be learned from.
Environmental factors	Barriers		
	Enablers	Synergies with other goals include soil quality, biodiversity and water protection	
Factors	Barriers / Enablers	W 8.2.1 “climate resilience audit” for new projects	W 8.2.2 fee for unnecessarily draining soils (Entwässerungsentgelt)
Political Factors	Barriers	Populist narrative about parties and activists who focus on climate change mitigation and adaptation wanting to make climate policy a priority without regard for other interests. (“green ideology”, “climate dictatorship”) “Climate checks” may produce more bureaucracy and prolong processes/decisions. Need to balance different interests e.g. climate change adaptation and mitigation with social justice, economic interests, etc.	Unpopularity of introducing new fees. Drainage fee would be opposed by powerful interest groups. Creation of more bureaucracy.
	Enablers	Ambitious goals for climate neutrality and climate change adaptation exist and have to be supported with measures. Recognition that climate change mitigation and adaptation should be considered in different administrative departments. The principle of municipal self-government gives municipalities the flexibility to introduce and experiment with “climate checks” locally. “Climate checks” can be planned in municipal climate strategies. Once included in the climate strategies there is a strong basis for introducing them later.	Fee could be used for L 4.2.2 or L 4.3.1.
Economic factors	Barriers	Cost of additional bureaucracy	
	Enablers	Climate checks may help reduce costs caused by climate change and help include mitigation and adaptation measures into projects which would be carried out anyways. Thus, reducing the need to design and finance additional projects.	Possibility to generate more income for the state. Fee would be an economic incentive for not draining soils where it is not necessary. At present there is no economic incentive to not drain soils. Drained soils are often easier to work on and can produce more reliable yields.
Social Factors	Barriers	Lack of popularity of bureaucracy Climate checks would require people working in administration to carry out additional tasks that they might lack the	Unpopularity of introducing new fees. Drainage fee would be opposed by powerful interest groups.

		time for. People need to be qualified and motivated to carry out climate checks.	
	Enablers	Possibility to learn from front-runners who have introduced climate checks	Lively debate about water origins, uses and what is/should be possible in the region.
Technological factors	Barriers	It can be difficult to accurately describe the impact a single project has on climate resilience.	Can only be calculated accurately if drainage systems are identified and assessed (see other innovations on drainage systems). Runoff through drainage systems is difficult to estimate. At present there is no system that would allow for good estimates or accurate measurements.
	Enablers	Simple climate checks can be set up with easy technological means and do not necessarily require new tools or data. Research projects and municipalities have developed tools that can be used for free and can be adapted to local conditions.	
Legal Factors	Barriers		
	Enablers	"Climate checks" are usually non-binding. They only offer additional information about a project before it is either carried out or not. Thus, they do not take away from the competencies of decision-makers and do not conflict with other regulations.	There is a similar financial incentive in settled areas. Wastewater fees for properties connected to the wastewater and sewage system are partially dependent on the surface area of those properties and how much of the surface area of those properties is sealed and impermeable. Property owners who allow for more infiltration on their properties pay lower water fees. Where runoff into water infrastructure is higher, fees are higher.
Environmental factors	Barriers		
	Enablers		
Factors	Barriers / Enablers	W 8.2.3 – W 8.3.1 revision of funding programs conflicting with climate resilience	
Political Factors	Barriers	Need for funding program reform across all levels (EU, national, federal states, municipal). The large volume of different state funding schemes and support programs makes identifying a possible starting point more difficult. Different types of support programs e.g. directly designed and managed by the state vs. programs designed and managed by (partially) state-controlled actors such as KfW. Opposition to reducing or changing state support from beneficiaries. Conflicts of interest e.g. because of partially state-owned energy companies using fossil fuels. State financial support for activities impeding climate change mitigation and adaptation also impedes the achievement of political climate goals and limits the effectiveness of climate policy.	
	Enablers	State financial support as a key instrument of affecting change. Budgetary power of parliaments. Faster transition towards a social and sustainable market economy. Political insistence to maintain debt ceiling for national budget creates need to reallocate funds from the budget towards the transition to climate neutrality and resilience. State aid conflicting with these goals could be one source.	

Economic factors	Barriers	Consequences for businesses depending on state aid, employment and local economic situation.
	Enablers	Potential savings for state budget from reducing state support for conflicting purposes Financing needs for creating climate neutral economy which is also socially just and can continue to generate wealth. Reforming state aid in line with climate goals is good industrial and economic policy.
Social Factors	Barriers	
	Enablers	Research on possible approaches to reducing state aid that conflicts with climate goals while ensuring wealth and social justice.
Technological factors	Barriers	Need a system to identify if and to what degree measures are conflicting with climate resilience (also see "climate checks").
	Enablers	
Legal Factors	Barriers	
	Enablers	
Environmental factors	Barriers	
	Enablers	

Social Factors	Barriers	Citizens have to know what programs exist / have been created by their municipality. Cooperation with researchers in pilot projects can be very useful for generating funding, attention and evidence that certain measures work. People may be hesitant to use support services/incentives set by municipality because people who conduct pilot projects or implement new measures in a certain area may have personal reservations against "being the first" ("what would the neighbors think of me doing that?")	Some measures aim at reversing the effects of land-reforms from the 1970s e.g. when returning streams to their natural form. -> limits of public understanding Some municipalities may not have experience with drafting certain documents e.g. rules for tree protection and therefore be cautious -> dependence on courage to try new things, political support and supportive network with examples Smaller projects are often more contentious than others e.g. when an existing area is changed, and people have to change their habits. The development of larger areas from scratch i.e. of new residential areas is often easier, especially when co-benefits of different uses occur (e.g., housing, green spaces and business). Working across disciplines and departments can be challenging because climate is an additional and a new issue for many e.g. those in charge of city planning (lack of time and expertise). Need municipal climate managers who mediate between different departments and disciplines. Many tasks e.g. in city planning are highly specialized and local which is why some measures fail e.g. creating a generalized "climate-resilience checklist for city planning" Sufficient and qualified personnel to fulfill
	Enablers		

			requirements can be a barrier e.g. when planning offices are understaffed. Not all local rules and regulations can be controlled/monitored e.g. about the protection of trees on private property. Need to find other ways to ensure compliance e.g. understanding from the public and occasional surprise controls/inspections.
	Enablers	Strong links in the region (which is very dry) and exchange of experiences with different measures helps. However, initiatives cannot simply be copied. They often have to be adapted to local conditions e.g. to account for special requirements for historical buildings or UNESCO heritage status Training for people in administrations, planners, etc. so they can develop projects Make clear that every little bit helps and that everyone can do something Press coverage helps people understand situation Incentives set by the municipality are well-received and usually all funds assigned to the programs are used e.g. financial support for creating green roofs Reaching people where they are, e.g. at city festivals. Education for sustainable development can empower people to form opinions about measures and follow incentives if they consider it correct Support from citizens can be generated by showing good local examples (e.g., including local press)	Strong links in the region (which is very dry) and exchange on experiences with different measures helps. However, initiatives cannot simply be copied. They often have to be adapted to local conditions e.g. to account for special requirements for historical buildings or UNESCO heritage status Training for people in administrations, planners, etc so they can develop projects Cooperation with researchers in pilot projects can be very useful for generating funding, attention, baseline data describing the local problem and evidence that certain measures work. Press attention helps people understand situation and accept new standards Support from citizens can be generated by showing good local examples e.g. through before-after-pictures
	Barriers		Structural properties of existing buildings may hinder the implementation of certain measures (e.g., green roofs, PV to steep roofs)
	Enablers	Can find synergies between issues and design incentives accordingly e.g. by offering information about the creation of green roofs when financially supporting the installation of solar panels. Available data and maps on the status quo (e.g., regarding green spaces) and development options of different city districts support the subsequent development of measures and incentives. Early collection and compilation and analysis of information can be very beneficial. "We are lucky to	Available data and maps on the status quo and development options of different city districts support the subsequent development of measures and incentives. Early collection and compilation and analysis of information can be very beneficial. "We are lucky to have started data collection years ago."
Technological factors			

		have started data collection years ago."	
Legal Factors	Barriers		Newly created rules have to consider existing regulation e.g. rules for creating green roofs have to consider rules for the protection of historic buildings. (e.g., "Gestaltungssatzung")
	Enablers	Implementation of national climate adaptation law creates framework for further climate adaptation at the municipal level; Bavarian climate law includes the (non-binding) recommendation that municipalities should consider advancing climate adaptation Some incentives such as local funding programs and other incentives are well-developed in some municipalities and can be copied and adapted to fit other municipalities	Implementation of national climate adaptation law creates framework for further climate adaptation at the municipal level; Bavarian climate law includes the (non-binding) recommendation that municipalities should consider advancing climate adaptation Some standards are well developed in parts of the region and can be adapted to fit local conditions
Environmental factors	Barriers	Climate change is abstract for most people. During and after extreme events public interest surges and people are more demanding when it comes to local climate action. This effect does not seem to last.	During and after extreme events public opinion often changes and people are more demanding when it comes to local climate action. This effect does not seem to last long.
	Enablers	Progression of climate change in the region may lead to public pressure on municipalities to create supporting structures/incentives for adaptation Synergies with other goals e.g. greenery and biodiversity	Progression of climate change in the region may lead to public pressure on municipalities to set rules for adaptation Synergies with other goals e.g. greenery and biodiversity
Factors	Barriers / Enablers	L 3.1.3 Forest conversion with drought resistant species	L 3.1.4 Hedges, field groves
Political Factors	Barriers		Consultations by authorities have been reduced in recent years which led to farmers turning to consultations from farming supply companies who often advise measures linked to selling products (rather than nature-based solutions, as e.g. hedges or field groves). The reduction of "impartial" consultation by state authorities was a political choice.
	Enablers	Pressure from environmental groups State and municipalities own forested areas Links with other issues may act as pull-factor e.g. forests as storage for nitrates or forests as key elements of the water cycle or wood being considered a sound choice for heating Public participation in designing the future state forest	
Economic	Barriers	Cost of investing in changes in forest management and more uncommon plants	Maintenance of hedges requires time and money

factors		Marketability of “alternative” wood may be limited	Lessens surface of fields: might decrease profits in the short/mid term
	Enablers	Younger people taking over their parents’/family forests may have stronger economic motivation to ascertain sustainable and/or resilient cultivation because their planning horizon naturally extends several decades into the future. Generally, longer planning horizons in forestry mean that forest owners/investors have look further into the future Research on forestry and international partnerships offer the possibility to learn from local/regional research projects and other regions that have a climate that is close to what is to be expected for the region	If the creation of hedges or field groves is supported by a state program, they cannot be removed soon afterwards. Funding programs by the state and EU significantly shape agricultural practices and the sector reacts to economic incentives: “We worked this way in the past prior to land reform and before economic incentives encouraged more intensive farming and creating larger fields” There is precedent of landowners who rent their land to farmers, include ecological requirements in letting agreements and lessen the rent in return. Younger people taking over their parents’/family farms may have stronger economic motivation to ascertain sustainable farming because their planning horizon extends several decades into the future
Social Factors	Barriers	Lack of personnel (qualifications and numbers) for forest conversion	Mistrust that measures will have desired effect and that scientific findings can be transferred to Bavarian agricultural land from other regions with somewhat different traits Lack of understanding regarding the changes in land use paradigms (current situation was created due to prior incentives) Lack of impartial consultation services: Consultations by authorities have been reduced in recent years which led to farmers turning to consultations from farming supply companies who often advise measures linked to selling products (rather than nature-based solutions). The reduction of “impartial” consultation by state authorities was a political choice. People who conduct pilot projects or implement new measures in a certain area may have personal reservations against “being the first” (“what will the neighbors think of me doing that?”)
	Enablers	Good experience from other regions Research into forestry and climate-resilient forests Healthy forests as very popular and valued by the public broad public agreement that forest conversion is necessary	Some farmers are more open to trying “new” things than others; some only implement changes if their usual methods no longer work e.g. if they are sufficiently strongly impacted by climate change Organization of knowledge exchanges and “field days” for swapping experiences. Some farmers have experience with

			hedges/field groves and other nature-based solutions. Having made own experiences or witnessing colleagues' experience helps.
Technological factors	Barriers		Machinery has often been optimized for large fields, where less turning is necessary. Hedges and field groves make it harder to use them.
	Enablers	(AI-) models for tree-species detection to push forest conversion forward Use of sensors to determine tree growth, soil humidity, etc. to optimize forest conversion	
Legal Factors	Barriers	(Traditional) Inheritance law has led to strongly fragmented ownership of forests ("Realteilung"). Consequently, more forest owners have to be reached and educated about necessary measures.	Some farmers rent the land they work on. Oftentimes they cannot implement long-term measures e.g. because planting a hedge would mean that the owner or subsequent farmer renting the land would have to maintain it after the first rental agreement has ended. (See L 4.1.2. for a suggestion to change letting agreements to consider environmental and long-term measures.) Measures that are legally prescribed cannot be funded/supported through state-funding schemes. Thus, mandating the planting of hedges or field groves would limit financial support for farmers. Environmental regulation applies to hedges and is seen as a deterrent to planting them
	Enablers	Forest conversion is part of official governmental plans (e.g., in consulting owners and supporting schemes)	Once hedges or field groves are created and become valuable habitats they cannot be removed without intervention by the state which might prohibit their destruction. HOWEVER, this can also be a barrier as farmers are unwilling to create them in the first place. Measures supported by state funding cannot be reversed. Thus, when the creation of hedges or field groves is supported financially by the state, it is ensured that they will be maintained.
Environmental factors	Barriers	Rapid climate change makes forest conversion increasingly difficult: "We should have started years ago." "We need to restrict climate change. The climate is changing more quickly than we can adapt." Some young forests have to be irrigated to stop young trees from dying off	Hedges have to be maintained and taken care of Parts of the region have smaller field sizes than other regions. Here, hedges or field groves would be significant barriers to working quickly and with large machinery.
	Enablers	Sprucedieback (e. g. bark beetle) forces to change something	Positive environmental impact on biodiversity, water balance and soil erosion e.g. less nutrients in runoff, soil erosion because of wind et cetera. More responsible and sustainable use of

			the soil as a natural resource Existing landscape structures (e.g., trenches for drainage) could be co-used for planting hedges. Given that these structures exist already, they do not impede the use of large vehicles on agricultural areas.
Factors	Barriers / Enablers	L 4.1.2 Letting agreements incentivise soil protection	L 4.2.1 increase humus content of soil and reduce times without plants on fields
Political Factors	Barriers	Political will to intervene in (private) letting agreements	Political will to communicate that land use and methods have to change significantly to address challenges associated with climate change. Populism and political animosity: Some political leaders brand such measures as “green ideology” or projects of a “green elite” and suggest that agricultural enterprises can continue to work as they have previously.
	Enablers		Recommended by the Bavarian governments expert commission on water security Use popular votes for measures, leading typically to highly accepted results. The questions decided upon in those votes should be phrased neutrally.
Economic factors	Barriers	When landowners introduce ecological criteria or requirements into their letting agreements they usually have to reduce the rent, limiting their income from the land.	Long-term vs. Short-term thinking: Soil protection takes time and “experiments” with new methods may reduce yields in the short term. Switch of methods associated with cost for farmers: voluntary measures can be supported financially by the state. Measures which are obligatory cannot. Sunk-cost-fallacy: Farmers may have already invested in machinery and supplies necessary for other practices
	Enablers	In the long-term including environmental requirements into letting agreements can protect soil quality and maintain the high value of a piece of land which might deteriorate otherwise.	Long term benefits of maintaining soil health Intercrops can be marketed
Social Factors	Barriers	Lack of awareness that and how environmental criteria or requirements can be introduced into letting agreements. Pilot projects exist but are not widespread. Landowners and those working on the land have to find and agree on measures that make sense for a specific plot of land and can be carried out. This requires knowledge and experience.	Some land users may want to try measures themselves and see benefits rather than believe (scientific / peer) reports. Changing how land is worked on means changing daily work and routines which can be difficult Pilot projects as excuses for buying time instead of disseminating successful measures more broadly
	Enablers	There is an increasing number of people who inherit land but have no ability to or interest in working on it themselves. Thus they leave it to others and may require counseling on how to do this. This could be	Many successful pilot projects show which measures could work. Dissemination is sometimes lacking but there are established “field days” and knowledge exchanges that can be used by

		an opportunity to educate those landowners. There are pilot projects for this solution that could be used to draw inspiration from or for help. Some farmers have cited short term letting agreements as barriers to implementing resource protection measures that take a long term to take effect. This barrier could be overcome by requiring such measures in the agreements. It being cited points towards the existence of a group of farmers who would welcome changes to such agreements.	those interested. Having positive experiences with change enables uptake of measures. "Seeing positive outcomes from measures can be more motivating than receiving support funding from the state." Some farmers are already familiar with measures as they used to be popular in the past before intensive farming practices were popularized and strongly co-funded through support schemes.
Technological factors	Barriers		
	Enablers		
Legal Factors	Barriers	Landowners may be insecure about drawing up contracts that differ from traditional agreements.	Some farmers have cited short term letting agreements as barriers to implementing resource protection measures that take a long term to take effect. This barrier could be overcome by requiring such measures in the agreements. It being cited points towards the existence of a group of farmers who would welcome changes to such agreements.
	Enablers	There is precedent of letting agreements being linked to environmental measures in exchange for reducing the rent.	Requiring measures for increasing hummus content in letting agreements or including them in cooperation agreements between water-suppliers and farmers.
Environmental factors	Barriers	Not all criteria and measures are sensible for each plot of land. Appropriate measures have to be identified.	
	Enablers		Synergies with other goals like biodiversity, protection against soil erosion, flood protection, drought protection, water resource protection With legumes as cover crop less fertilizer is needed due to their ability to fix nitrogen into the soil.
Factors	Barriers / Enablers	L 4.2.2 create registry of drainage systems L 4.3.1 demolition of and changes to drainage systems	L 4.1.1 Education on soil protection (farmers, forestry, city planners, etc.)
Political Factors	Barrier	A new approach to managing agriculturally used drainage systems would be very unpopular with farmers Creating a registry of drainage systems would be a large project and considered very bureaucratic.	funding for education and education reform Populist style pitting water sector and farming against one another
	Enablers	An "expert commission on water management" created by the Bavarian government has recommended "a new approach to managing drainage systems" in the past	strong agricultural lobby (could) advocate for change to curriculums
Economic	Barrier	Not draining fields would restrict the times	Resources for education are often limited.

factors		when they can be worked on and may be bad for crops planted there. Farmers may lose profits. Identifying and possibly removing drainage systems is considered expensive. Farmers say there is no business-model that allows land-owners to benefit from fields that are no longer used as such because they are too wet after re-wetting measures took place. Marketing of alternative products (paludi culture) missing, less customer	
	Enablers		Land-users should be interested in protecting soil, especially if their profits depend on it. Thus, they may push for better education on soil protection.
Social Factors	Barrier		Consultations by authorities have been reduced in recent years which led to farmers turning to consultations from farming supply companies who often advise measures linked to selling products (rather than nature-based solutions). They do not offer impartial information about soil protection but few alternatives are available. Adjusting curriculums takes time. Businesses training young professionals can only teach what they themselves are experienced in. Professionals would have to make time for continuing their education while running their businesses.
	Enablers		In agriculture there are established “field days” and knowledge exchanges that can be used by those interested. They could be used to spread information about soil protection. Parts of Germany’s younger population are highly interested in matters surrounding climate change and sustainable development. They may push for the change of curricula for their chosen field.
Technological factors	Barrier	Some drainage systems were built decades ago and there may not be a record for where they are. Records are often kept in paper form instead of digitally.	
	Enablers	Some drainage systems could be identified through aerial observation because they are linked to drainage trenches.	There is some experience with creating apps and online platforms for spreading knowledge e.g. about irrigation which could be used to create similar services about soil protection Experience with methods exists in some businesses and could be spread from there. Research on methods exists and could be drawn from to create content for teaching

Legal Factors	Barrier		Changing curricula takes time.
	Enablers		
Environmental factors	Barrier	<u>Removing drainage systems would not necessarily add to groundwater renewal because soil has been compressed and impermeable layers have formed. For the removal of drainage systems to have the desired effect the soil would have to be changed, too.</u> Mapping and changing drainage systems cannot be a standalone measure. For it to have the maximum desired effect it has to be combined with other innovations.	
	Enablers		Drought and extreme rainfall pose significant risks to maintaining soil coverage and quality. At the same time high quality soil can act as a sponge and protection from climate change impacts.

Table 46: CS3 - Identification of barriers and enablers for innovation related to theme Public awareness and education

Factors	Barriers / Enablers	P 1.1.1 change curriculum to include mandatory teaching of CC and room for projects	P 1.1.2 education of teachers and "role models" like sports trainers on climate change and adaptation
Political Factors	Barriers	Bavaria suffers from a teacher shortage. Creating new obligations and subjects would require additional teaching positions that would have to be financed. Among education policy makers, current understanding of education rather follows the idea of "environmental education", instead of a holistic perspective on sustainable development (including social, environmental and economic aspects)	
	Enablers	Some political support for changing curricula and integrating education for sustainable development. Political interest in pilot projects and front-runner-schools.	Political decisions can boost interest in certain issues e.g. climate neutrality goals and means of reaching them.
Economic factors	Barriers		The development of attractive education programs, material or events requires staff, time and funding.
	Enablers		
Social	Barriers	Modern approaches to education for sustainable development have to be	Full-time jobs leave only marginal temporal resources to be dedicated to informing/training

Factors		taught to educators. This is currently not the norm. One way to get more teachers trained is to create an official standard and recognition for training in this area. Being certified in a new area is an additional official qualification young professionals could cite in their applications. Currently, teachers who implement education for sustainable development do so in addition to their official duties and voluntarily. They do not receive additional resources or teaching time. German curricula are structured along subjects. Education for sustainable development would ideally span all subjects and thus might be more difficult to implement. Among parents and many teachers, current understanding of education rather follows the idea of “environmental education”, instead of a holistic perspective on sustainable development (including social, environmental and economic aspects)	adults. There is a need to approach people from different target groups where they are in their education and physically e.g. by offering information/training in public places or in cooperation with companies during working hours (like fire safety training, first-aid courses) Sustainable development and climate change have been viewed and portrayed as niche-topics by many in the region for a long time. Now it is harder to reach certain target groups. Education for sustainable development has been neglected for years. Now people in the region should form opinions about how they want to deal with climate change and which policies they support but they do not necessarily have the information or skills.
	Enablers	Need to include education for sustainable development in existing structures and subjects rather than creating a completely new thing. Schools are usually eager to offer new or special qualifications to their students or extracurricular activities e.g. in student clubs. Parents, students and teachers in training are eager to learn more about the issues	Finding “allies” in potential target groups can help establish productive dialogue and projects with new partners. People need to see how climate change and what they are learning about affects their lives (knowledge and skills; positive effect of role models). Education about sustainable development and climate resilience through multipliers and role models can help if it is positive and action-oriented rather than crisis-focused and fear-based. Need to show people what they can do and how they can benefit. Might need “climate communication trainers” who train multipliers.
Technological factors	Barriers	Implementing new teaching formats may require additional technological equipment at schools and teacher training.	
	Enablers		
Legal Factors	Barriers	Including education for sustainable development in school curricula should also entail the introduction of new/modern teaching formats like excursions. Those can be difficult to organize because of insurance requirements and perceived risks to students. Current curricula are very full and contain topics that must be covered.	
	Enablers	Current curricula already contain some mandatory teaching on issues around climate change and sustainability that	

		could be added to / revised.	
Environmental factors	Barriers		
	Enablers		
Factors	Barriers / Enablers	P 2.1.1. climate councils	P 2.1.2 Support volunteering for the environment ("Freiwilliges Klimajahr")
Political Factors	Barriers	Need to decide on a design and purpose of the council and give it a role (advisory v. decision-making) and determine who can participate (experts or citizens, selection of members, etc.). Decisions when designing council can be controversial. Councils that are pure discussion forums but without influence may be seen as "green washing" or ineffective and lead to frustration with (climate) politics among participants Council will have positions on projects or policy and may be a source of criticism, trusted by the public	
	Enablers	Climate councils can increase identification with the local community as well as social trust and is an opportunity to affect change locally -> trust in democracy and its institutions Councils can add expertise and support to controversial decisions Councils can aid the design and implementation of projects e.g. if it includes actors who should participate in implementation of projects or who can mobilize people	Official recognition for volunteers can come from politicians, state schemes such as prizes and volunteering days Supporting volunteering for climate resilience can increase interest in a career connected to the issue and contribute to solving staff-shortages which are considered a major political challenge Volunteering can increase identification with the local community as well as social trust and is an opportunity to affect change locally
Economic factors	Barriers		Volunteering between school and joining the labor force is primarily an option for those who can postpone earning an income Depending on the offer, communities, organizations or companies will have to nominate supervisors (i.e., additional workload) or hire personnel (i.e., costs) for supporting or training volunteers in their tasks Given the current shortage of labor force and shortages in funding, volunteers might be misused as replacements for professional positions and services.
	Enablers		The general interest and recruiting strategies of hosting institutions in gaining new employees: When completing their time as volunteers, participants already gained insights into the work flow at their hosting institution. This may raise their interest in working with the community, organization or company after graduating. When designing projects for volunteers, cooperation with the recruiting departments/persons responsible for recruiting may create more attractive offers for

			volunteers.
Social Factors	Barriers	Need to decide on a design and purpose of the council and give it a role (advisory v. decision-making). Councils that are pure discussion forums but without influence may be seen as “green washing” or ineffective and lead to frustration with (climate) politics among the broad public.	Competition for volunteers with other sectors e.g. many young volunteers work in the health sector or care homes where they help reduce staff-shortages Competition with other options for young people leaving school/including sabbatical as e.g. work & travel (advertisement required) In some milieus, engaging in environmental topics is perceived as being obscure; thus, young people may face considerable opposition from their social environment which can affect the decision for volunteering in an environmental context.
	Enablers	Increase education for sustainable development to generate interest in becoming active and gaining knowledge about possibilities for volunteering. Public recognition for volunteering on climate councils Interest in climate change high	Increase education for sustainable development to generate interest in becoming active and gaining knowledge about possibilities for volunteering “volunteering offices” in some municipalities collect information about possibilities for volunteering in the local community and match interested people to organizations Recognition for volunteers through public respect Clear definition of responsibilities and possibility to set boundaries to avoid burn-out of volunteers Volunteering cannot replace professional positions and services. Volunteers should not be used as cheap labor to fill staff-shortages and insufficient funding Large movement (especially among youth and young adults) who are interested in climate change could serve as pool for potential volunteers Volunteers develop skills while volunteering
Technological factors	Barriers		
	Enablers		Online platforms informing about options for volunteering locally and in general
Legal Factors	Barriers	Legitimacy of decision-making by climate councils questionable -> need for well-considered design	
	Enablers	Legal framework for climate change mitigation and adaptation requires development and implementation of measures, including the drafting of strategies and the monitoring of their implementation. Climate councils can support the fulfillment of those requirements	Clear regulatory framework for volunteering schemes that replaced conscription. “Voluntary social years” and “voluntary ecologic year” could be used as examples and expanded upon.
Environmental factors	Barriers		
	Enablers		

CS4

Table 47: CS4 - Identification of barriers and enablers for innovation related to sector 1: Water Supply-Environmental Monitoring -

Factors	Barriers / Enablers	Real-time groundwater level measurement -> predict lake water level -> alerts (WATER4ALL)	Transboundary Water Monitoring System	Sensors & IoT Platform with real-time water quality parameters (AQUASmartT ech, GreenSense & Solutions)	Platform for information exchange & common database	Citizen science applications
Political Factors	Barriers		Time-consuming since agreement of all ministries is needed Only one out of three countries in EU (already complying to WFD)	Limited human resources in public services to manage results	Possible obstacles in data considered as sensitive, due to border region	Possible distrust from authorities to data collected through citizens
	Enablers	Existing transboundary structure in Prespa (WGWM)	PPMC already prepared drafts, included in WGWM roadmap AL & NMK on their way to EU accession, hence committed to implementing WFD	Existing transboundary structure in Prespa (WGWM)	Already included in the WGWM roadmap, agreed between three countries	
Economic factors	Barriers			Funding necessary for maintenance of devices		
	Enablers	Economic sectors dependent on water level, need data		Based on data, sectors (fisheries, agriculture, tourism) can increase quality of their product and save money		Can motivate sustainable tourism -> additional income
Social Factors	Barriers	Possible distrust in validity of water level predictions from local society (especially if	Different languages	Decreasing young population (main potential users, as familiar with new	Different languages	Decreasing young population (main users of apps)

		restricting water abstractions)		technologies) Vandalism risk for deployed equipment		
	Enablers		Prespa Water Forum already operated (volunteers)			Environmental awareness already existing due to long protected area status
Technological factors	Barriers	Dependent on the physical features of the aquifer environment	Difficult to harmonize existing data: not even basic requirements are common, such as sampling depth	Internet connectivity not guaranteed everywhere in the area Unclear compatibility with existing systems		
	Enablers	Models developed and tested in country (North Macedonia)	Already operating in GR in compliance with WFD, can train partners in other countries	Already tested technology		Apps already developed (iNaturalist, Flora Prespae, MINKA)
Legal Factors	Barriers			Installation of equipment requires approval (especially protected areas)	Laws on data sharing	Careful not to make personal data public without consent
	Enablers		WFD defining water monitoring procedure		Supported by Art. 6 of Agreement	
Environmental factors	Barriers		Sampling must not disturb biodiversity	Installed equipment could influence ecosystems, if not done carefully		Some protected areas/ species sensitive to human presence
	Enablers		Results will be useful to various environmental projects	Through early warning -> contributes to biodiversity protection	Envir. NGOs in three countries experienced in cooperation (international projects)	Support to environmental monitoring and raising awareness
Factors	Barriers / Enablers	Integrated Water Resilience System with sensors &	Integrated Pesticide Management	Raindrop collection (incl. training programmes)	Little Alert Boxes network: real-time data on env.	Early warning system on transb. level

		educational initiatives (IWRs)			parameters	
Political factors	Barriers	Limited human resources in public services to manage results and educate	Bureaucratic delays, as cooperation of three states is required		Limited human resources in public services to manage results and educate	Bureaucracy, responsible authorities in three countries need to be defined
	Enablers	Existing transboundary structure in Prespa (WGWM)	Existing transboundary structure in Prespa (PPMC)			Already cooperation in PPMC and other areas
Economic factors	Barriers	Limited resources for maintenance of equipment	Agriculture relying on pesticides	Requires subsidies, to be installed in households	Limited resources for deployment and maintenance of equipment	Possible costly infrastructure, not all countries have same resources
	Enablers	Economic use and financial savings due to efficient water	Other sectors (e.g. fisheries, tourism) will profit from improved water and soil quality	Financial benefits of optimized crop arrangement and irrigation schedule	Can save money, through limiting damage in extreme events	Possible funding through EU projects, save money from compensations
Social Factors	Barriers	Possible reactions from professional sectors (e.g. fishers), if their activity is monitored	Distrust from farmers (perception of env. legislation not fairly implemented)	Population possibly reluctant to accept interventions in their houses	Possible reactions from population, if they feel being monitored	
	Enablers	Awareness and positive attitude towards water as a scarce resource	Awareness for healthy food (organically raised)	Raising awareness about water scarcity	Inclusion of a wider community	Increasing trust among population of three countries
Technological factors	Barriers	Necessary detailed calibration, making it vulnerable to env. changes/malfunctions		Study needed on use of collected water	Dependent on internet/satellite connectivity	
	Enablers	Identified issues related to interoper. & compatibility	State of the art technologies	Existing technologies	Technological innovation rapidly increases in this field	
Legal Factors	Barriers	Extensive drone scanning might raise legal issues	Differences on pesticide legislation in 3 countries (specific pesticides are		Possible concerns on data captured (privacy, security)	Possible obstacles to staff from different countries, as no free

			allowed in one country, but forbidden in another)			movement and not all under the same law
	Enablers		European regulations on pesticides			
	Barriers		If not well implemented in one country, will also influence env. in others, as water bodies are common		Careful not to have effect in protected species or habitats	
Environmental factors	Enablers	Can ensure allocation of water for env. purposes	Reducing threat to biodiversity in lakes and wetlands	Reduction of water consumption		Many hazards (e.g. wildfires) can be prevented

Table 48: CS4 - Identification of barriers and enablers for innovation related to theme / sector 2: Forest & Wetland Protection

Factors	Barriers / Enablers	Transboundary agreements and Management Plan for all protected areas	Advanced Grazing Systems (NBS) in forest & lake ecosystems	Transboundary Forest Monitoring System	Transboundary Management Plan for Crises related to Climate Change (wildfires, floods, bird pandemics etc)
	Barriers	Long-lasting bureaucratic procedures (approval from ministries in three countries) Accessibility of data to all needs to be ensured, to prevent distrust and conflict	Limitations due to protected area status	Possible bureaucratic obstacles in coordination between authorities in three countries	Possible bureaucratic obstacles, needing approval from three national governments
Political factors	Enablers	PPMC as support, common River Basin Management Plan foreseen in roadmap of WGWM	Mentality changing in favor of allowing specific human intervention in protected areas	Already existing cooperation of forest authorities (INTERREG projects)	Signed protocols for mutual aid, e.g. wildfires GR-AL
Economic factors	Barriers		Economic sectors can't fully rely on it, as env. protection has priority (e.g. by necessary high water level, no grazing will be possible)		Not all three countries have same resources for purchasing necessary equipment

	Enablers	International funding sources exist (PONT)	Livestock farming can profit from it, also fisheries (carps need clean meadows for reproduction) Reducing cost of wetland management	Can support sustainable forestry, generating stable income	Can reduce cost of dealing with damages, especially in agriculture
Social Factors	Barriers	Distrust of people to environmental measures (unfair implementation)	Coordination between different sectors necessary, need to overcome distrust between them	Possible reactions if related to limiting individual collection of wood for heating purposes	
	Enablers	Active NGOs in three countries, networking between them (PrespaNet), having ties to local stakeholders	Grazing with buffalos implemented in the past (GR) and value acknowledged by local society	Increased awareness of risks (especially focus on wildfires) in population, due to recent extreme events	Increased awareness of risks in population, due to recent extreme events
Technological factors	Barriers	Harmonization of data and methodologies necessary		Forest mapping: missing in AL?	Missing equipment to implement crisis management (e.g. large boats are needed for bird pandemics) Not good accessibility in all areas (e.g. regarding wildfires), infrastructure is required
	Enablers	Already existing in Greek Prespa (Natura area)	Existing know-how and experience on grazing with buffalos and local cattle	Draft already designed as part of TMS	Already research carried out on estimation of risks (e.g. drought and wildfires in GR) Already existing Plan for Bird Pandemics in GR (NECCA)
Legal Factors	Barriers		Intervention in Natura area must be clear	Different legislation	Different national legislation must be taken into account
	Enablers	Prespa Park Agreement (Art. 3)	Grazing Management plan already drafted (GR)		
Environmental factors	Barriers		Intensity and selection of animals needs to be done carefully, to avoid negative impacts		
	Enablers	Protection of	Protection of	Control of measures	Can improve

		ecosystems will become more effective	habitats and biodiversity (keeping/restoring wet meadows)	for protection of forest ecosystems	conservation of habitats and biodiversity (e.g. reducing risk and vulnerability in wildfires)
--	--	---------------------------------------	---	-------------------------------------	---

Table 49: CS4 - Identification of barriers and enablers for innovation related to theme / sector 3: Fishery

Factors	Barriers / Enablers	Training seminars for fishers (reporting IAS, stop enrichments)	Making products of IAS and other small-sized species (e.g. cat food)
Political factors	Barriers		
	Enablers		
Economic factors	Barriers	Time necessary to see effects e.g. in fish quantity: fishers can't wait, may turn to agriculture	Possible investors concerned due to environmental restrictions (protected area)
	Enablers	Better knowledge on IAS presence will enable management & increase populations of indigenous commercial species	Generate income for local society, directly and indirectly (higher populations of indigenous commercial fish) Can be marketed abroad, competitive product (low price)
Social Factors	Barriers	Fishers generally think of enrichments as necessary, possible negative attitude	
	Enablers		Can keep young people in fishing and prevent them from turning to agriculture Species such as <i>L. gibbosus</i> have a good taste, can be consumed
Technological factors	Barriers		Difficult to fish due to small size and prickles (especially to remove from nets)
	Enablers		Already some work done, realistic to implement in 4-5 years
Legal Factors	Barriers	Different laws on fisheries in three countries, differences in implementation (e.g. no-fishing season not in the same way)	Prohibited to use it for feeding larger fish (trouts)
	Enablers		
Environmental factors	Barriers		Even small industry might affect protected area, transport outside of area for processing: GHG emissions Environmental NGOs concerned about it
	Enablers	Important for protection of biodiversity, environmental NGOs can help	Reducing IAS populations supports conservation of endemic species

Table 50: CS4 - Identification of barriers and enablers for innovation related to sector 4: Agriculture

Factors	Barriers / Enablers	New crop varieties - Rediscovery of old ones	Innovative irrigation techniques based on agro-ecological practices, with resp. training
---------	---------------------	--	--

Political factors	Barriers		
	Enablers	Can be included in agricultural policy recommendations to the Prespa Park Authorities	Can be included in agricultural policy recommendations to the Prespa Park Authorities
Economic factors	Barriers	Initial investment required	No guarantees for permanent and enough economic support
	Enablers	Diversification reduces economic risk for farmers	Possible funds from Rural Development Programm (CAP -> Strategic Plan)
Social Factors	Barriers	Many farmers of older age, maybe unwilling to learn new practices	Many farmers of older age, maybe unwilling to learn new practices
	Enablers		
Technological factors	Barriers	Soil mapping as a prerequisite (difficult to cover the whole region)	
	Enablers		Many NBS already existing, can be developed further
Legal Factors	Barriers		
	Enablers		
Environmental factors	Barriers	Careful not to introduce IAS	
	Enablers	Reduction in water consumption (species/varieties less water-demanding) will improve protection of habitats	Reducing water consumption (& soil evaporation) will improve protection of habitats

Table 51: CS4 - Identification of barriers and enablers for innovation related to sector 5: Tourism & Cultural Heritage

Factors	Barriers / Enablers	Specific apps with info for tourist, incl. sustainability (especially in water man.)	Sustainable farms-open for tourism (incl. sustainable water man.)	Transboundary Visitors Management Plan (equal distribution space & time)	Immersive and eco-friendly tourism experience, incl. promotion of resp. accommodation ((Eco-friendly tour)
Political factors	Barriers		No border crossings within watershed yet -> restricted number of visitors	Bureaucracy	No border crossings within watershed yet -> difficult to make it transboundary
	Enablers		A Working Group on Sustainable Tourism has been suggested in PPMC: can be included in discussions	A Working Group on Sustainable Tourism has been suggested in PPMC: can work on that	
Economic factors	Barriers			Possible reduced income for highly touristic areas Steady and enough funding is	

				required for implementation	
	Enablers	Higher income from tourism through promotion	Additional income for sustainable (less water-demanding) agriculture	Increased income for not so highly touristic areas	Increased income for sustainable tourism
Social Factors	Barriers	Different languages	Young people leave from primary sector, older farmers probably not so open to new concepts	Local societies will not trust it, if they are not involved in drafting it, in an adequate way	Involvement of local population not guaranteed (few people left, of older age)
	Enablers		Possible motivation for young people to stay in area and primary sector	Already common events/festival with three countries	Can create synergies with other sectors
Technological factors	Barriers	Information to be collected for three countries (time-consuming)	Sustainability must be ensured in all aspects (must be done carefully)	Carrying capacity for visitors must be estimated in a valid way	Incomplete local infrastructure (also limiting accessibility to POIs)
	Enablers	Already some apps developed from SPP (GR)	Some initiatives already exist		
Legal Factors	Barriers			No common regulations in three countries e.g. in fishing & hunting	
	Enablers				
Environmental factors	Barriers	High numbers of tourists can affect biodiversity (careful not to enter areas of absolute protection)			
	Enablers	Can close gaps in env. awareness and reduce negative effects of tourism	Can reduce water consumption and negative effects on biodiversity, and so can be supported by env. NGOs	Negative impacts of tourism on ecosystemic services will be avoided	Activities contributing to cleaning the environment, can be supported by env. NGOs
Factors	Barriers / Enablers	Implementation of common label for products	Transboundary sightseeing tours: emphasis on protected areas, round tours across whole of Big Prespa (over land and water)	Common econ. activities (e.g. fishing tourism)	
Political factors	Barriers	Needs to be approved from all three countries	No border crossings yet inside Prespa watershed, for water: passport control necessary		

	Enablers		Already project for border crossing (BorPres)	
Economic factors	Barriers			
	Enablers	Better for marketing	More income for touristic sector, promotion for Prespes area	Can generate income to keep young people in primary sector
Social Factors	Barriers			No mentality for synergies
	Enablers	Creates feeling of belonging together	Motivation for cooperation between three countries	
Technological factors	Barriers		Bad accessibility to POIs (road network)	Incomplete local infrastructure (also limiting accessibility)
	Enablers	Already developed in BorPres project	Nearby international airport (Ohrid)	
Legal Factors	Barriers		Intervention in Natura area is problematic (border crossing)	
	Enablers			
Environmental factors	Barriers		New border crossing requires intervention in protected area, tours in water might influence biodiversity, careful to avoid areas of absolute protection	Possible impacts on biodiversity from human activity to be avoided
	Enablers	Can be linked to sustainability		

Table 52: CS4 - Identification of barriers and enablers for innovation related to sector 6: Education-Social Cohesion-Social Awareness & Economy

Factors	Barriers / Enablers	Transboundary workshops & field trips with youth	Transboundary multidimensional & multifunctional hub, incl. data collection	Innovative education workshops for children & adults (also professionals)	Climate-adaptive education platform (EcoLearn)
Political factors	Barriers	No border crossings yet inside watershed			Limited human resources in public bodies
	Enablers		Existing cooperation of local public authorities (Prespa Park)		
Economic factors	Barriers				Not ensured that new practices to be proposed in the platform have no cost for local population (worries about unfair implementation)
	Enablers				
Social	Barriers	Different	Different	Competitive	Many people of older

Factors		languages, different pop. numbers (very few young people in GR)	languages, not everybody speaking English	mentality even among children (no ability to work in groups)	age with limited digital literacy
	Enablers	Can create feeling of belonging together	Existing transb. cooperation in many areas	Children can get an example from adults	Local schools willing to collaborate
Technological factors	Barriers		Difficult accessibility of many places, not enough border crossings, some social groups may have less access to Internet	Missing educational material	Needs to be constantly updated Possible limited access from parts of population
	Enablers				
Legal Factors	Barriers				
	Enablers				
Environmental factors	Barriers				
	Enablers	Can promote sustainability	Can support new ideas/ innovations related to sustainability	Effects on environment can be observed	Can promote sustainability

Table 53: CS4 -Identification of barriers and enablers for innovation related to sector 7 Institutional-Legal Framework-Policy

Factors	Barriers / Enablers	Transb. Wetland Management Committee (representing all sectors)	Online participatory platform incl. local residents
Political factors	Barriers	Bureaucracy (approval needed from all three countries)	
	Enablers	WGWM already exists under PPMC	
Economic factors	Barriers		
	Enablers		
Social Factors	Barriers	Possible distrust among groups in different countries	Many people of older age with limited digital literacy
	Enablers	Already applied in GR , widely accepted locally and regionally	Already projects promoting citizen participation (e.g. LPPT)
Technological factors	Barriers		Internet connections not in all households?
	Enablers	Know-how from GR case	Already part of a project in GR (PoliPrespa)
Legal Factors	Barriers	Different laws in each country	Data protection (personal opinions from residents)
	Enablers	EU accession procedures foster standardization	
Environmental factors	Barriers		
	Enablers	Positive effects on biodiversity demonstrated in GR	Can make env. restrictions on use of resources more acceptable

Table 54: CS4 - Identification of barriers and enablers for innovation related to sector 9: Infrastructure/Renewable Energy

Factors	Barriers / Enablers	Financial instruments for renewable and efficient energy	Digital Twin of Catchment area, input: in situ observations, satellite data and weather forecasts (Waterjade)	3D twins in the transb. Region
Political factors	Barriers	Still work to be done in the filed of technical codes and standards	Bureaucratic obstacles in obtaining data (different conditions in each country)	Not identified
	Enablers	Harmonization with EU Directives on implementation of renewable energy sources	Willingness of governance and water management bodies to obtain and share relevant data	The raising trend of including new data technologies in processing and management of resources
Economic factors	Barriers	Low awareness and knowledge about availability of financial support mechanisms	Rather high investment costs	High costs of installation and maintenance
	Enablers	Stimulating and supportive measures by financing institutions (banks) and government agencies	Can mitigate losses due to damages in extreme events	Proven effectiveness of use of water and lowering prices of water use
Social Factors	Barriers	Low knowledge of all available methods for an increased use of clean energy and energy efficiency	Possible unwillingness to digitize water management, as population is old (GR)	Reluctance towards information technologies at some users from a wider span of stakeholders
	Enablers	Awareness of advantages of clean energy and energy efficiency	Responsible attitude towards rational use of water	Interest for availability and accessibility of information on real time status of water bodies
Technological factors	Barriers	The best and most efficient technologies are not sufficiently affordable for all interested stakeholders	Gaps in data (very different situation in each country)	Low affordability, high costs
	Enablers	Availability of state of the are technologies, on - line information and updates in the filed of RES and EE	Progress in measurement and data exchange technologies	In favor of digital twins development
Legal Factors	Barriers	Regulations to be improved, for demand of competence designer and workers in the filed of RES and EE	Locations of installation issues	Licenses (concessions) required for some types of facilities

Environmental factors	Enablers	Regulations in force, in favor of clean energy and energy efficiency	Harmonization of water and environmental legislation	Correlation of regulative related to water and environment
	Barriers	Landscape issues with installations, possible effects on ecosystems and biodiversity	Locations of installation issues	Constrains related to impacts on flora and fauna, of some of the RES types
	Enablers	Conformed low carbon footprint of the clean energy technologies	Can limit environmental damage in extreme events	Obvious benefits from availability of trustful information, as a basis for alerting. Prevention, preservation of biological ecosystems

CS5

Table 55: CS5 - Identification of barriers and enablers for innovation related to theme 'Water'

Factors	Barriers / Enablers	Innovation 1: NbS wastewater	Innovation 2: Brine	Innovation 3: Ozone	Innovation 4: Renewable energy	Innovation 5: Robotic systems
Political Factors	Barriers	Fragmentation of competences	Lack of resources	-	Lack of mandatory use of renewables in water cycle facilities	-
	Enablers	-	-	-	-	-
Economic factors	Barriers	A lot of investment to create the necessary infrastructure	-	-	Energy monopoly	A high level of public investment is required
	Enablers	-	Commercial use of brine as a new product	-	-	-
Social Factors	Barriers	Population growth	-	-	The society does not yet demand an increase in renewables in the electric mix	-
	Enablers	-	Awareness of the problem on the coast	-	-	The society is very aware of the losses, and they would positively appreciate an improvement in this aspect
Technological	Barriers	Lack of space		Necessary to	Water losses	-

factors				install a device that generates ozone in the facility		
	Enablers	-	Possibility of creating new technology that generates a new source of economy	-	The technology exists to implement this change	-
Legal Factors	Barriers	The wastewater cannot be used for all purposes	-	-	-	-
	Enablers	-	Illegal discharges of brine are not allowed	-	-	The law requires that the losses in distribution networks be below 10%
Environmental factors	Barriers	-	The regional law allows the mixing of brine with wastewater for discharge into the sea	-	-	-
	Enablers	-	-	It is a disinfectant without by-products	Reduction of CO2 emissions	Water savings

Table 56: CS5 - Identification of barriers and enablers for innovation related to theme 'Primary sector'

Factors	Barriers / Enablers	Innovation 1: Crop mapping	Innovation 2: Distributed systems	Innovation 3: Online monitoring	Innovation 4: Carbon market	Innovation 5: Blockchain
Political Factors	Barriers	-	-	-	-	-
	Enablers	There is something similar in Grafcan, but something more practical is needed for citizens	-	-	Easy to implement	-
Economic factors	Barriers	-	-	-	-	A high level of public investment is required
	Enablers	-	People receive a product from their monthly contribution	Having an online record of agricultural activity surely translates to an improvement in the farmer's economy	-	-
Social	Barriers	This tool may	-	The profiles of	-	-

Factors		not reach the general public		farmers are diverse, and older individuals may need training to implement online monitoring		
	Enablers	-	It contributes to cohesion and solidarity initiatives	-	-	-
Technological factors	Barriers	-	-	-	-	Powerful platform is required to implement the blockchain
	Enablers	-	-	-	-	-
Legal Factors	Barriers	-	-	-	-	-
	Enablers	-	-	-	Potential to have control over regional emissions	-
Environmental factors	Barriers	-	-	-	-	-
	Enablers	It benefits waste management	-	-	Reduction of CO2 emissions	Promotes product traceability and prevents food alerts

Table 57: CS5 - Identification of barriers and enablers for innovation related to theme 'Research, Education and Technology'

Factors	Barriers / Enablers	Innovation 1: Traditional knowledge	Innovation 2: OFE	Innovation 3: Greenhouse plastics	Innovation 4: Agricultural machinery	Innovation
Political Factors	Barriers	-	Need of support from institutions to develop it	-	Possible pressures from major companies manufacturing fuel-based machinery	
	Enablers	The ease of creating a platform to promote, provide technical support, and collect this cultural wealth	Ability to deploy technicians dedicated to this task	-	-	
Economic factors	Barriers	-	It is a new initiative that requires the time of the farmer and an initial	New alternatives may be more expensive than plastic initially	-	

			investment that perhaps cannot be borne, hence the need for support from public institutions			
	Enablers	-	-	Grants for individuals using sustainable materials	-	
Social Factors	Barriers	-	-	-	-	
	Enablers	Highlighting traditional knowledge so that young people can have that perspective	Co-Learning	As awareness of microplastics and plastics in the sea grows, society would welcome the shift to alternative materials in greenhouses	-	
Technological factors	Barriers	-	Infrastructure technology is required that currently does not exist to carry out the project	-	A complete model change is required to rely solely on electric machinery	
	Enablers	-	-	-	-	
Legal Factors	Barriers					
	Enablers					
Environmental factors	Barriers	-	-	-	-	
	Enablers	Returning to traditional farming practices where fertilizers are not used, crops are rotated, and consideration is given to the crops that thrive best in each area, consuming less water, would open a new agricultural paradigm in the Canary Islands	The experiments are driven by the farmer's questions and are carried out collaboratively, involving, at a minimum, both the farmer and scientists	Degradable materials will be environmentally friendly, unlike the plastics currently used	Reduction of CO ₂ emissions	

Table 58:CS5 - Identification of barriers and enablers for innovation related to theme 'Tourism'

Factors	Barriers / Enablers	Innovation 1: Organic waste	Innovation 2: Touristic tax
---------	---------------------	-----------------------------	-----------------------------

Political Factors	Barriers	The odors that can be emitted when placing a container like that on the streets.	The main economic driver of the Canary Islands is tourism, and there is no desire to 'disturb' the tourist.
	Enablers	The ability to create a community composting project	-
Economic factors	Barriers	-	-
	Enablers	Compost is quite expensive; producing it as a community would be a tremendous economic saving for local farmers	It would be positive to use that money to promote the sustainability of the island.
Social Factors	Barriers	The smell	-
	Enablers	The ability to create community projects	The Canary Islands society would appreciate if a portion of the money stayed here, as many times tour operators bring tourists with all-inclusive packages, resulting in limited spending on the island while consuming significant resources.
Technological factors	Barriers	-	-
	Enablers	-	Easy to implement in hotels
Legal Factors	Barriers	-	It could not be applied to vacation rentals
	Enablers	-	Environmental regulations will support it
Environmental factors	Barriers	-	-
	Enablers	It would promote awareness of creating compost and its benefits for the soil	Incentives for taking care of the environment

CS6 Romania

Table 59: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector: Water quality - Monitoring and data management

Factors	Barriers / Enablers	Innovation 1: Design monitoring platforms	Innovation 2: Design modelling program for integrated data collection	Innovation 3: Model of pollutant dispersion integrating hydrological conditions	Innovation 4: Early warning system for eutrophication	Innovation 5: Alert system for local pollution
Political Factors	Barriers					
	Enablers	Favourable political strategies in accord with Natura 2000 regulation				
Economic factors	Barriers	Inflation and the global economic crisis			Lack of concrete educational planning	
	Enablers	Profits created by sensor developer				
Social Factors	Barriers	May rise questions within the local communities	Aged population that is not trained in sharing data	Lack of education and proper training		

		regarding the installed sensors				
	Enablers		Might attract younger generations to be involved		NGOs and citizen organisations observe illegal fish farming	
Technological factors	Barriers					
	Enablers	Already in use by some countries		Understanding hydrology and barrier impacts on pollutant migration		
Legal Factors	Barriers					
	Enablers	Existing national and international agenda				
Environmental factors	Barriers					Poor control of river discharges
	Enablers	The demand for more nature-based model		prediction of pollutant concentrations in natural streams	The frequency of lower water quality and quantity	The frequency of severe droughts with rise of pollutants concentration

Table 60: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 2: Aquaculture and Fisheries

Factors	Barriers / Enablers	Innovation 1: Design genomic-based tools for understand adaptation capacity of species	Innovation 2: Bathymetry for fish finder (CIW weblink)	Innovation 3: Sustainable feed for aquaculture
Political Factors	Barriers		Political strategies in election years	
	Enablers			
Economic factors	Barriers	Long period for implementation	Additional costs that might affect small business	Additional cost that might affect small business
	Enablers	Existing public-private collaboration	Need for optimised fishing practices	
Social Factors	Barriers	Lack of education and proper training		Lack of concrete educational planning
	Enablers	planning incorporating genome information regarding key habitats	Connectivity restoration for migratory fish	
Technological factors	Barriers		cumulative effects of consecutive barriers in mainstem rivers	Investments in new facilities for new markets – might depend on state aids
	Enablers	Control the decline in many fish populations		Growing interest in advanced technology that integrated local resources
Legal Factors	Barriers		Poor logistics to manage wide development	
	Enablers		coordinated attempt to reduce /eliminate	

			aggressive fishing from a watershed	
Environmental factors	Barriers			
	Enablers	The demand for secured fish heritage		Improved environmental regulation on nutrients load

Table 61: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 3: Agriculture

Factors	Barriers / Enablers	Innovation 1: Development of new biofertilizers	Innovation 2: Remote control of irrigation for water management	Innovation 3: Remote sensing for soil moisture	Innovation 4	Innovation 5
Political Factors	Barriers	Political strategies in election years				
	Enablers	Government policies aiming on better cooperation of research institutes and private companies				
Economic factors	Barriers	Considerable new investment	Difficult adaptation to new production and marketing systems			
	Enablers	The EU framework on rational chemical fertiliser	Already in use by some countries			
Social Factors	Barriers	social and cultural factors that influence farm economics and structure		division of labour raises questions about the long term-viability		
	Enablers	Farm dynamics and socio-cultural values	taking advantage of advanced technologies	individuals with specific skill-sets grows		
Technological factors	Barriers	Need for significant change of existing practices	Lack of technical assistance programs	production systems disconnected from farm business-cycle		
	Enablers	New technologies and technological advancements	Existing innovations that can be easily deployed			
Legal Factors	Barriers	Might require new regulation				
	Enablers	Legal framework for reducing chemicals in agriculture				

		practices				
Environmental factors	Barriers					
	Enablers	Enhance circularity of bioresidue	The frequency of lower water quality and quantity	The frequency of severe droughts		

Table 62: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 4: Citizen science

Factors	Barriers / Enablers	Innovation 1: Web tools - Knowledge management portals	Innovation 2: Operational Training Service for small businesses	Innovation 3: Web technologies portals/ platforms (Citizen Lab)
Political Factors	Barriers	Variability in political will		Data-sharing protocols
	Enablers	Existing platform for sharing best practices	National and EU Framework for helping small businesses development	The EU Framework for citizen implication in environmental issues
Economic factors	Barriers		Lack of concrete educational planning for aged population	Need for adaptation to local condition
	Enablers	The need to develop local and national sustainable tourism		
Social Factors	Barriers			
	Enablers	societal push towards web tools	a growing demand for training services in social sciences	
Technological factors	Barriers			Challenges in data selection for local conditions
	Enablers	Rapid advancements and accessibility of user-friendly platforms	Widespread availability of smartphones and internet connectivity	Advanced tools and platforms already exist
Legal Factors	Barriers			
	Enablers		Existing support for small size enterprises (spin-off, start-up)	
Environmental factors	Barriers			
	Enablers	Already installed climate change effects boost local communities' engagement		Existing dedicated national and international projects for information platform

Table 63: CS6 Romania - Identification of barriers and enablers for innovation related to theme / sector 5: Political initiative

Factors	Barriers / Enablers	Innovation 1: Work plan for Danube Delta management	Innovation 2: Quotas systems and catch shares for fishery in Danube Delta	Innovation 3: Elaboration and Implementation of ecosystem regimes	Innovation 4: Institutional framework - Administration of the Danube Delta Biosphere Reserve	Innovation 5: Clear policies regarding the environment
Political Factors	Barriers	Political changes / changed priorities			Possible conflict with the economic development	
	Enablers	Predictable		Supporting	Biodiversity is	Government

		actions for managing the protected area		terrestrial and aquatic biodiversity	on the front actions	policies aiming on better management
Economic factors	Barriers		Differences in economic status of different localities			
	Enablers		Controlled catchment in respect with natural levels		The long-term profits created	
Social Factors	Barriers					
	Enablers					
Technological factors	Barriers					
	Enablers					
Legal Factors	Barriers					
	Enablers					
Environmental factors	Barriers					
	Enablers					

CS6 Bulgaria

Table 64: Bulgaria PESTLE analysis: Innovations code names for theme A 'Sustainability'

LEGEND: Identified Innovations	
Sector A: Sustainability	
A1	Development of a decision-support system
A2	Water monitoring
A3	Vegetation resilience to climate change and extreme droughts/rains
A4	Fire warning systems
A5	Organisation of regular sessions where institutions share best practices and review each other's management strategies to encourage learning and improvement.
A6	Risk management
A7	Groundwater mapping
A8	Annual multi-stakeholder review meetings to assess progress and make adjustments based on collective insights and consensus.

Table 65: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector A. Sustainability

Factors	Barriers / Enablers	A1	A2	A3	A4	A5	A6	A7	A8
---------	---------------------	----	----	----	----	----	----	----	----

Political Factors	Barriers	Policy instability	Lack of strategic support for innovations	Lack of policy for integrating innovative solutions		Lack of political will / initiative	Lack of policy for integrating innovative solutions		Lack of political will / initiative
	Enablers	EU support	National legislation on water	Supportive governance and policies			Developing policies with focus on complex risks	Supportive governance and policies	
Economic factors	Barriers	Raised costs for involved actors	Operational costs	Budget constraints	High installation cost	Experts and effort allocation	Budget constraints		
	Enablers	Planning for and identifying funding opportunities	Cost saving in the long-term	Automation of processes and better management of the area		Best practices implemented	Automation of processes and better management of the area		Stakeholders invested in the process
Social Factors	Barriers	Resistance to new approaches and ideas	Lack of public pressure / negative connotation of monitoring	Lack of information on available solutions		Resistance to change	Lack of information on available solutions	Investments not connected to direct results	Not enough stakeholder engagement
	Enablers	Increased understanding of complex Climate change issues	Community engagement	Raising awareness		Organisational changes in terms of culture	Raising awareness	Ever increasing importance of protecting water resources	Active community and stakeholders
Technological factors	Barriers	Potential tech complexity	Required new tech and technical skills			Resistance to change and missing regulatory framework	Technical challenges in adopting complex risk solutions	Technical complexities	Technical adoption hurdles for setting up the meetings
	Enablers	Access to better communication options	Improved sensors and methodology for collecting data	Innovations lower costs and increase productivity	Innovations in connectivity and on-time alerts enable	Advances in data analysis	AI powered solutions enable more complex	New methods emerging provide new solutions	Technological support for collaboration

					new solutions		solutions - Advanced risk modelling tools	for mapping - Advances in water sensing tech	
Legal Factors	Barriers	Regulatory compliance		Environmental regulation regulating access and allowed actions		Different compliance requirements	Regulatory hurdles to implement joint risk evaluative	Legal challenges to data collection	Legal barriers to sharing data
	Enablers	Supportive regulations	Enabling water legislation	Bulgarian legislations aimed at conservation	Existing emergency response protocols and frameworks	Existing review practices in public entities	Existing detailed plans for managing natural disaster risks	Joint legal framework for resource mapping would help	Legislation changes to support joint work
Environmental factors	Barriers	High variability in environmental data	Monitoring needs variability due to changing climate	Extreme weather impact	Lack of connectivity in remote areas	-	-	-	-
	Enablers	Integration with climate adaptation strategies	Need to provide sustainable management	Increase climate change awareness to support better measures	IoT, satellite and 5G connectivity, along with solar for power outside the grid	-	-	-	-

Table 66: Bulgaria PESTLE analysis: Innovations code names for theme B High level of awareness

LEGEND: Identified Innovations	
Sector B: High level of awareness	
B1	Digital twin for forecasting
B2	1) Identification of critical points for information gathering 2) Engaging communities to understand the planning process for future conditions using narrative storytelling.
B3	1) Implemented standardised data exchange protocol across participating agencies. 2) Capacity building and training of teams in individual institutions 3) Councils/working groups that meet regularly to ensure data sharing protocols are maintained and adapted to each agency's needs and capabilities.

LEGEND: Identified Innovations

B4	Enhancing stakeholder communication and data transparency continues to be the underlying requisite.
----	---

Table 67: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector B. High level of awareness

Factors	Barriers / Enablers	B1	B2	B3	B4
Political Factors	Barriers	Policy gaps	Lack of policy support	Inter-agency conflicts	Political reluctance
	Enablers	Support from climate policies	Government support would help	Supportive data sharing laws would help	Active policy support can help
Economic factors	Barriers	High development cost	No specific funding identified	-	-
	Enablers	Funding for innovative climate projects/ technologies	Secured funding	-	-
Social Factors	Barriers	Scepticism about accuracy	Lack of interest for participation	Resistance to data sharing	Privacy concerns
	Enablers	Increased public interest in forecasting	Community engagement in data collection	Organisational culture supporting data sharing	Public demand for transparency
Technological factors	Barriers	Complexity of digital twins	Challenges in data aggregation	Technical barriers for data integration	Data security concerns
	Enablers	Using ready solutions adapted to BG	Technological framework to support the data collection	-	New technologies support secure data exchange (i.e. blockchain)
Legal Factors	Barriers	Compliance with data protection laws	-	-	-
	Enablers	Changes in legislation to support innovations	-	-	-
Environmental factors	Barriers	Impact of climate change on accuracy	-	-	-
	Enablers	Adaptation strategies developed as part of modelling	-	-	-

Table 68: Bulgaria PESTLE analysis: Innovations code names for theme C Integrated approach

LEGEND: Identified Innovations
Sector C: Integrated Approach

C1	Flood Early Warning
C2	1) Events (for example, forums) to openly discuss and design the best institutional collaboration models, focusing on mutual benefits and shared objectives 2) Analysis to predict potential friction points and as a result - proposal of optimal collaborative frameworks.

LEGEND: Identified Innovations

C3	Workshops that focus on iterative testing and feedback for allocation strategies, encouraging adaptive adjustments based on shared experiences.
C4	Policy co-development workshops - multiple stakeholders must be involved in the policy development process to simulate and discuss potential impacts before enactment.

Table 69: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector C. Integrated Approach

Factors	Barriers / Enablers	C1	C2	C3	C4
Political Factors	Barriers	-	Inter-agency conflicts	-	Lack of political will / initiativeness
	Enablers	-	National government support	-	Supportive governance and policies
Economic factors	Barriers	-	-	-	-
	Enablers	-	-	-	-
Social Factors	Barriers	-	Resistance to change	Resistance to change	Lack of public interest
	Enablers	-	Public support	Public support	Active stakeholder engagement
Technological factors	Barriers	Technical complexity	Tech integration issues	-	-
	Enablers	More advanced tech and AI use	Potential to use ready solutions from other countries	-	-
Legal Factors	Barriers	Regulatory compliance	Legal restrictions	-	-
	Enablers	Supportive regulations	Adapted legal frameworks	-	-
Environmental factors	Barriers	Climate change variability	-	-	-
	Enablers	Adaptation strategies	-	-	-

Table 70: Bulgaria PESTLE analysis: Innovations code names for theme D Activated Civil Society

LEGEND: Identified Innovations
Sector D: Activated Civil Society

D1	Potential use of VR for public engagement. The aim - to showcase the potential outcomes of environmental policies, allowing citizens to visually and interactively understand and discuss proposed changes.
D2	Illegal logging monitoring and control Начало Защити Гората (gorata.bg)
D3	Poaching - alert system (cameras) Smarter ways to fight poaching – DW – 04/07/2016
D4	1) Exploring good practices and their implementation in Bulgaria 2) Implement local initiatives that focus on transparency, frequent communication, and community involvement in decision-making to build trust.

LEGEND: Identified Innovations	
D5	1) Analysis of existing public participation apps and work to provide an official integrated app 2) Potentially creating new work positions - experts who facilitate communication and engagement between communities and institutions, using available tools and local meetings.
D6	1) Develop collaborative approach where institutions and communities can map and request resources as needed, ensuring a transparent and equitable distribution. 2) Soft measures to stimulate civic participation: communication, campaigns, online presence, open days

Table 71: CS6 Bulgaria - Identification of barriers and enablers for innovation related to Sector D. Activated Civil Society

Factors	Barriers / Enablers	D1	D2	D3	D4	D5 / D6
Political Factors	Barriers	Slow policy adoption of new idea	Lack of policy support	See A4	Lack of policy support	See D2 and D4
	Enablers	Raising awareness on actual benefits of implementing	Enforcement policies / support	See A4	Enforcement policies / support	See D2 and D4
Economic factors	Barriers	High development cost	-	See A4	-	See D2 and D4
	Enablers	Funding for innovative climate projects/ technologies	-	See A4	-	See D2 and D4
Social Factors	Barriers	Public scepticism	Public is not interested enough	See A4	Public is not interested enough	See D2 and D4
	Enablers	Increase in public interest	Massive community engagement, incl. the younger population	See A4	Massive community engagement, incl. the younger population	See D2 and D4
Technological factors	Barriers	Complexity for setting up and implementation	Tech integration issues	See A4	Tech integration issues	See D2 and D4
	Enablers	Advances in VR make tech more accessible	Bulgaria has great experience in creating IT products, and we have already a very good working solution	See A4	Bulgaria has great experience in creating IT products	See D2 and D4
Legal Factors	Barriers	-	Legal framework not in place	See A4	Legal framework not in place	See D2 and D4
	Enablers	-	Strong	See A4	Strong	See D2 and D4

			framework would boost the initiative		framework would boost the initiative	
Environmental factors	Barriers	-	-	See A4	-	See D2 and D4
	Enablers	-	-	See A4	-	See D2 and D4

CS6 Turkey

Table 72: CS6 Türkiye - Identification of barriers and enablers for innovation related to monitoring

Factor s	Barriers / Enablers	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures	Identification /monitoring of marine waste source(s) using remote sensing and other data processing technologies	Integrated seawater pH, pCO ₂ and O ₂ monitoring system	Digital Twins	Electrochemical, fast responding seawater nitrate and phosphate sensor	AI-supported, intelligent and responsive underwater sensing and monitoring platforms smartly reacting to extreme climate events and ecosystem shifts	Underwater E-DNA analyzer capable of rapidly assessing biodiversity shifts - powered by AI and big data analytics
Political Factors	Barriers							
	Enablers				a) Increasing Demand from politicians for DTOs and Decision Support Tools b) EU and global-level initiatives on the DTOs		a) data sharing being prioritized by global initiatives like UN Ocean Decade	a) Co-developed by the Black Sea countries, this issue is prioritized at the national level and included in the Black Sea SRIA Implementation Plan
Economic factors	Barriers	a) cost of development and regular maintenance and calibration				a) cost of development and regular maintenance and calibration) Needs investment in the integration with existing structures		
	Enablers			a) reduces the need for frequent manual sampling	a) National and International Funds, and co-funding schemes for advancing and integrating the different DTOs and demos	a) reduces the need for frequent manual sampling		a) increased commercialization of bio-tech based technologies developed through e-DNA technologies
Social Factors	Barriers	a) misconception on the possible impact on marine life						
	Enablers	Increased public awareness Strong NGOs		a) can help with identifying the pollution	a) lack of capacity of b) they can be available for general public	a) can help with identifying the pollution events immediately helping public health	a) lack of expertise	

				events immediately helping public health	to use			
	Barriers	a) requirement of Robust data management systems to handle data generated	Lack of data		a) Requirement of significant computing resources for high resolution models b) lack of data to feed in to the models			a) lack of specific data processing and management procedures
Technological factors	Enablers	Existing technology	Introduction of advanced recycling techniques			a) they can be integrated in seawater, as part of fixed monitoring stations or on mobile platforms like buoys, AUVs, research vessels.		
Legal Factors	Barriers	N/A						
	Enablers							
	Barriers				-			
Environmental factors	Enablers				a) Potential to make long-term predictions to be used for preventative measures			

Table 73: CS6 Türkiye - Identification of barriers and enablers for innovation related to waste management

Factors	Barriers / Enablers	Autonomous underwater vehicles (AUVs) capable of detecting and tracking	Identification/monitoring of marine waste source(s) using remote sensing and other data processing technologies	Wave power technologies, offshore wind power	Cost-minimizing materials and applications	Innovative, carbon neutral building materials
----------------	----------------------------	---	---	--	--	---

		pollutants				
Political Factors	Barriers					
	Enablers			a) Achieving energy security		a) EU level and Global policies (EU Bauhaus initiative)
Economic factors	Barriers	a) Inflation or stagnation that increases the cost of investments b) cost of technology		a) cost of technology b) Fossil subsidies c) Conflicts with fisheries in terms of marine use	a) Inflation or stagnation that increases the cost of investments b) cost of production and renovation	
	Enablers	a) reduces the need and therefore costs for frequent manual sampling		a) Renewable subsidies b) Carbon trade	a) Incentives for green materials and efficient use of resources	
Social Factors	Barriers	a) despite the enablers (see below), social acceptance of new technologies can still take time especially in rural areas.				
	Enablers	a) Growing public awareness and cultural shift b) health benefits that will stem from early detection of pollutions, use of natural products and renewable energy sources				
Technological factors	Barriers	a) Patent rights hindering the use of technology and material b) requirement of Robust data management systems to handle data generated	a) Lack of data b) requirement of Robust data management systems to handle data generated	a) Lack of smart grid b) Low TRL storage technology	a) making these materials as durable as traditional materials	
	Enablers	a) Existing technologies	a) Introduction of advanced recycling techniques	Existing technology		
Legal Factors	Barriers			Land use plans		
	Enablers			Introduction of new energy code	a) Introduction of new building code	
Environmental factors	Barriers	a) Corrosion		a) Problems with mining and processing rare earth elements b) Frequent extreme events		

			threatening system and structure integrity		
	Enablers		Improved air quality	A) waste reduction b) resource sustainability	

Table 74: CS6 Türkiye - Identification of barriers and enablers for innovation related to cultural/historical heritage

Factors	Barriers / Enablers	Acoustic monitoring technologies for monitoring underwater biodiversity and man-made structures	AI-fed regional planning
Political Factors	Barriers		
	Enablers	a) Technologies in support of cultural heritage are prioritized in the Black Sea SRIA Implementation Plan and Common Maritime Agenda for the Black Sea that are both supported by national governments of the riparian countries b) existence of political will towards environmental protection and planning at the national level c) Convention on Biological Diversity , BBNJ Agreement and national legislation supporting biodiversity and protected areas e) EU level initiatives supporting planning and smart cities / dtos	
Economic factors	Barriers	a) Inflation or stagnation that increases the cost of investments b) Lack of R&D capacity in the private sector c) Needs investment in terms of equipment and computing sources	
	Enablers		a) increasing market demand
Social Factors	Barriers		a) adoption of such technologies may need re-skilling & upskilling existing workforce
	Enablers	a) potential for exploiting the underwater cultural heritage of the Black Sea b) ensuring the continuation of recreational activities (diving etc.) by ensuring the biodiversity	a) possibility to engage communities in the planning processes b) adoption of such technologies in the long term will lead better urban living conditions and public services
Technological factors	Barriers	a) requirement of Robust data management systems to handle data generated	a) Lack of data
	Enablers	a) Existing technologies	
Legal Factors	Barriers	a) Privacy and security of the data collected in terms of national interest	a) ethical considerations
	Enablers		
Environmental factors	Barriers	a) corrosion of the equipment b) high level background noise due to maritime activities	
	Enablers	a) preserving ecosystem and biodiversity	

Table 75: CS6 Türkiye - Identification of barriers and enablers for innovation related to fish farms

Factors	Barriers / Enablers	Early warning system against epidemic in fish farms	Environment-friendly fish-feed
Political Factors	Barriers		
	Enablers		a) EU Green Deal's farm to fork strategy
Economic factors	Barriers	a) Lack of R&D capacity in the private sector c) cost of equipment, deployment, maintenance	Inflation or stagnation that increases the cost of investments Lack of R&D capacity in the private sector
	Enablers	a) increased demand disease-free fish can drive the adoption of such systems b) economic downside of epidemics as a strong motivation to use such systems	a) increased market demand for sustainably farmed fish b) Economic Incentives for sustainably farmed fish
Social Factors	Barriers	Lack of cooperation among the fish farms	
	Enablers	a) Increased public concern on health hazards b) Consumer Awareness and Preferences c) increase awareness on animal welfare issues	
Technological factors	Barriers	Lack of data	
	Enablers	a) existing automation and AI technologies	a) Innovation in Feed Ingredients: plant-based alternatives such as algae or by products from other industries
Legal Factors	Barriers	a) regulations regarding Data Privacy and Security	
	Enablers		
Environmental factors	Barriers	a) changing ecosystem dynamics can increase the risk of disease outbreaks	
	Enablers	a) preventing the spread of pathogens.	

Table 76: CS6 Türkiye - Identification of barriers and enablers for innovation related to catch fisheries

Factors	Barriers / Enablers	AI-powered identification of marine and land stocks	Remote sensing monitoring of illegal fishery / innovative technologies to monitor over-fishing
Political Factors	Barriers		
	Enablers	a) Convention on Biological Diversity , BBNJ Agreement and national legislation supporting biodiversity and protected areas and marine resources	
Economic factors	Barriers		a) cost of production, maintenance and deployment
	Enablers		
Social Factors	Barriers	a) adoption of such technologies may need re-skilling & upskilling existing workforce	
	Enablers	a) food security	
Technological factors	Barriers	a) Lack of data, and data sharing practices	
	Enablers		a) integration with other technologies: underwater vehicles AUVs, ports
Legal Factors	Barriers	a) lack of legislation c) data security and privacy in support of	

		national interest	
	Enablers		
Environmental factors	Barriers		
	Enablers	a) restoring biodiversity, increased resilience to the climate change and other stressors	

Table 7: CS6 Türkiye - Identification of barriers and enablers for innovation related to biodiversity/conservation

Factors	Barriers / Enablers	Autonomous marine robot, autonomous submarine	New identification techniques such as eDNA to monitor marine biodiversity	AI-powered identification of marine and land stocks	AI-fed regional planning
Political Factors	Barriers				
	Enablers	a) Convention on Biological Diversity, BBNJ Agreement and national legislation supporting biodiversity and protected areas and marine resources b) Blue Economy related Technologies in support smart observation, monitoring and AI are prioritized in the Black Sea SRIA Implementation Plan and Common Maritime Agenda for the Black Sea that are both supported by national governments of the riparian countries c) Existing political will to protect marine ecosystems			
Economic factors	Barriers	a) cost of production, maintenance and deployment		a) costly computing sources	
	Enablers				
Social Factors	Barriers			a) adoption of such technologies may need re-skilling & upskilling existing workforce	
	Enablers				
Technological factors	Barriers	a) Patent rights hindering the use of technology and material	a) Lack of data b) integration with other technologies: underwater vehicles AUVs, ports	a) costly computing sources	
	Enablers	a) Existing technology			
Legal Factors	Barriers			a) lack of legislation, b) lack of data, and data sharing practices c) data security and privacy in support of national interest	
	Enablers				
Environmental factors	Barriers				
	Enablers	a) restoring biodiversity, increased resilience to the climate change and other stressors			

Table 8: CS6 Türkiye - Identification of barriers and enablers for innovation related to planning

Factors	Barriers / Enablers	Autonomous marine robot, autonomous submarine	AI-powered identification of marine and land stocks	New identification techniques such as eDNA to monitor marine biodiversity	AI-fed by monitoring data used for planning to better identify needs	AI-fed regional planning	Identification/monitoring of marine waste source(s) using remote sensing and other data	Cost minimizing materials and applications	Three dimensional digital twins for MSP developed at a high TRL level.
---------	---------------------	---	---	---	--	--------------------------	---	--	--

							processin g technolog ies		
Political Factors	Barrie rs								
	Enabl ers	a) Blue Economy related Technologies in support smart observation, monitoringa and AI are prioritized in the Black Sea SRIA Implementation Plan and Common Maritime Agenda for the Black Sea that are both supported by national governments of the riparian countries							
Economic factors	Barrie rs	a) costly computing sources			a) costly computing sources			a) costly computing sources	
		a) cost of development and regular maintenance and calibration b) Needs investment in the integration with existing structures							
	Enabl ers							a) potential for commerciali zation	
Social Factors	Barrie rs	a) adoption of such technologies may need re-skilling & upskilling existing workforce							
	Enabl ers	a) Increase in local/national job opportunities and employment							
Technolog ical factors	Barrie rs	Patent rights hindering the use of technolog y and material	a) Lack of data and data sharing practices				Patent rights hinderin g the use of technolog y and material	a) Patent rights that may hinder commerciali zation	
	Enabl ers	Existing technolog y					Introduc tion of advanced recycling techniques		
Legal Factors	Barrie rs		a) lack of legislation, b) data security and privacy in support of national interest						
	Enabl ers							Introduc tion of new building code	
Environm ental factors	Barrie rs								
	Enabl ers	a) restoring biodiversity, increased resilience to the climate change and other stressors							

CS6 – Regional – Black Sea level

Table 77: CS6 regional level: PESTLE analysis: Innovations code names for theme A Monitoring / Data collection

LEGEND: Identified Innovations

Sector A: Monitoring/Data collection

LEGEND: Identified Innovations	
A.1	Joined task force to identify critical data sources and guidelines/rules for sensitivity analysis and accuracy
A.2	Series of roundtables to determine/develop protocols for data selection and protocol development
A.3	Remote monitoring of catch fisheries (Electronic Monitoring Systems (EMS), that use GPS and sensors to track vessel movements and activities Vessel Monitoring Systems (VMS), that provide data on the location, course and speed of vessels E-logbooks, that are used to record catch data in real-time. Fisheries Dependent Data (FDD), collected through various means, including logbooks, sales notes and observer programs. Real-Time Data Collection, enabling the collection of real-time data from fishing vessels)
A.4	WUNDERGROUND
A.5	Exploitation of social media for environmental monitoring/measurements
A.6	Training, educating citizens on the importance of climate data & funding the installation of DIY stations
A.7	Multihazard Early Warning Systems (MHEWS)
A.8	Standardised sensors - both in terms of measurement and in terms of deployment - will be needed
A.9	Drone+LiDAR for emergency response (https://www.climateinnovationwindow.eu/innovations/dronelidar-for-emergency-response/)
A.10	Application Framework Drone System (https://www.climateinnovationwindow.eu/innovations/application-framework-with-drone-system/)
A.11	Monitoring platform for water quality (pollution, eutrophication)
A.12	WaterView - IR2 (https://www.climateinnovationwindow.eu/innovations/waterview-ir2/)
A.13	Establishment of an Interdisciplinary Scientific Group working on climate forecasting for the Black Sea region
A.14	WG of experts to assess and observe the functionality of the collection systems (<i>to establish functional data-collection system and diagnosis</i>)

Table 78: CS6 regional level - Identification of barriers and enablers for innovation related to Monitoring and Data Collection

Factors	Barriers / Enablers	A.1, A.14 & A.15	A.2, &	A.3	A.4	A.9	A.6	A.7
Political Factors	Barriers	a) Different political status and strategies in the Black Sea countries b) The lack of a clear agenda focusing on sustainability in the Black Sea and the political will for the agenda to be followed by all c) Dependency on “stronger” states (economically, strategically etc) not allowing independency in decision making						
	Enablers	a) Existing International Organisations focusing on		a) Existing innovations that can be easily deployed b) Already in use by some countries				

Factors	Barriers / Enablers	A.1, A.14 & A.15	A.3	A.4	A.9	A.6	A.7
		the cooperation of research institutes and organisations . b) International alliances that can be utilised to foster a closer cooperation between the Black Sea countries allowing them to jointly work in data collection and monitoring c) Provides opportunities for closer cross-country cooperation					
Economic factors	Barriers	Differences in the general economic status of the Black Sea countries and dependencies on “stronger” states		Taxation and inflation hinder the installation and connection of sensors, stations and monitors	Inflation and the global economic crisis have led to investing in other sectors and not in monitoring	As it is a relatively new technology, it may need a great amount of research and investment to be finally used	
	Enablers	The profits created by the activities within the Black Sea area in every economic sector					
Social Factors	Barriers	The Black Sea is a multi-cultural region with differences in educational level and in	Fisherman Associations	a) Lack of education and proper training for the importance of	a) Societies may oppose in governments investing in meteorological stations and not in education, health or	Citizens are not trained in sharing data in a specific way. As a result, society’s	Difference in the education systems and their

Factors	Barriers / Enablers	A.1, A.14 & A.15	A.2, & A.3	A.4	A.9	A.6	A.7
		societal needs. Thus, there are differences in the way “sustainability” is comprehended		monitoring and the installation of environmental sensors b) May rise questions within the local communities regarding the installed monitors	other civil works b) Lack of education on the importance of meteorological stations	contribution may be misleading without prior information and proper training.	direction between the countries
	Enablers	Younger generations share similar mindsets, due to the rise of social media use and globalisation. Thus, they can influence governments by their choices.	NGOs and citizen organisations observe illegal fish farming	Younger generations are more “alert” and eager to join global networks		People of all ages are used to share their concerns and their daily lives online, providing data for meteorological events	Same as A.4
Technological factors	Barriers	Not all countries share the same technological level		Some monitors may not be sold within the countries (need to ship from abroad)	Existing databases may need a reforming/restructuring	a) Using data shared online may be misleading, as great filtering and evaluation is needed to trust an online information as data b) Social media data exploitation for environmental monitoring and measurements is not yet established at a company level or a	Same as A.4

Factors	Barriers / Enablers	A.1, A.14 & A.15	A.2, &	A.3	A.4	A.9	A.6	A.7
							public-sector level.	
	Enablers	Broadband connection and fast internet is common in the Black Sea countries allowing research as well as the communication among peers through online meeting platforms, such as Zoom, Teams etc		Technology already in place	a) Technology already in place b) Social Media and global forums about meteorology aid in communicating the efforts and properly installing the needed monitors	New technologies with increased accuracy exist	Social media platforms are widely used and provide a vast amount of data at an hourly basis	Same as A.3
	Barriers	Political strategies followed by the Black Sea countries		Personal data protection frameworks	The legal framework for installing weather monitoring stations		a) Personal data protection frameworks b) Policies followed by the companies about openly sharing data	
Legal Factors	Enablers	Agenda 2030, the Paris Agreement and National Sustainability Strategies describe a resilient sustainable liveable future		Required to be in-use by the EU				
	Barriers							
Environmental factors	Enablers	The demand for more renewable energy The vulnerability of the Black Sea against global warming and			The frequency of severe weather events has risen		Severe weather events such as serious storm events, abnormal snowfalls and droughts	

Factors	Barriers / Enablers	A.1, A.14 & A.15	A.2, &	A.3	A.4	A.9	A.6	A.7
		the results climate change has in the blue economy of the countries					spike social media posts allowing the collection of vast amount of data	
Factors	Barriers / Enablers	A.8	A.10	A.11	A.12	A.13		
Political Factors	Barriers	Lack of political will as investing in MHEWS does not correspond to direct political benefits	Growing support for technological advancements and disaster management		Lack of enforcement & possible bureaucratic delays			
	Enablers		a) Existing UAV technology that does not require manpower, meaning that it is cheaper and safer b) Proven solution to map the condition and deformation of flood defences		Environmental protection policies and international cooperation			
Economic factors	Barriers	Inflation and economic instability hinder the improvement of already existing Systems	Initial investment and maintenance costs		a) Costs for advanced monitoring equipment and data analysis are usually high b) inflation and economic instability	Needs investment in the integration with existing data		
	Enablers		Cheaper and safer than man power		Funding opportunities from environmental grants	Cost-effective solution for high-resolution precipitation data		
Social Factors	Barriers		Concerns about privacy		Society may oppose to monitoring platform investing due to limited public understanding of eutrophication and pollution issues	Same as A.10/A.11		
	Enablers		Increased public safety and awareness		a) public demand for clean water and healthy ecosystems b) younger	Younger generations are used to taking photos and uploading		

Factors	Barriers / Enablers	A.1, A.14 A.15	A.2, &	A.3	A.4	A.9	A.6	A.7
							generations more "alert" in environmental issues	them. They are also more "alert" and "sensitive" towards environmental issues
Technological factors	Barriers			Challenges in data accuracy	Challenges in integration and data accuracy	Technical issues may arise due to the need for sensor calibration, data integration and real-time data collection		a) Same as A.12 b) Quality depends on different hardware used, light conditions and user's reliability
	Enablers		Technology already in use		Advanced drone and sensor technologies	Advancements in sensor technology and data platforms		Technology ready
Legal Factors	Barriers			UAV and aerial space legal framework (needs compliance with complex and varying international regulations)		There may be legal challenges in cross-border water management		Compliance with data privacy and usage laws
	Enablers			Development of supportive regulations for drone operations		Legal frameworks for environmental protection are in place		Growing support in legal frameworks for AI and monitoring
Environmental factors	Barriers			Needs caution in environmental sensitive areas (i.e. local bird groups)		Potential disruption to ecosystems due to poor design/placement of the platform		
	Enablers		Extreme events take place more frequently at alarming rates		Improved environmental monitoring and disaster mitigation			

Table 79: CS6 regional level: PESTLE analysis: Innovations code names for theme B AI/Machine learning

LEGEND: Identified Innovations

Sector B: AI/Machine Learning

B.1	Joined task force to evaluate the existing models and their compatibility & performance to AI/Machine Learning
-----	--

LEGEND: Identified Innovations

B.2	Establishment of an International/Interregional Working Group (WG) of Experts and Society to draft clear guidelines about data used for AI
B.3	Development of innovative VET programmes specifically targeted at machine learning education

Table 80: CS6 regional level - Identification of barriers and enablers for innovation related to AI/Machine Learning

Factors	Barriers / Enablers	B.1 & B.2	B.3
Political Factors	Barriers	a) Different political status and strategies in the Black Sea countries b) Dependency on “stronger” states (economically, strategically etc) not allowing independency in decision making	a) Differences in the curricula of each country may lead to several difficulties in integrating innovative VET programmes b) Governmental goals differ from each country
	Enablers	The EU Framework for AI eases political cooperation as it sets the basic guidelines.	a) Same as B.1 & B.2 b) Upskilling and reskilling is discussed within the EU
Economic factors	Barriers	The establishment of a task force is expected to require high initial funding	High initial costs for developing and maintaining up-to-date curricula and training facilities
	Enablers	a) Growing Funding Programmes for AI b) Potential cost savings through improved efficiency and predictive capabilities of AI/ML models	a) Increased funding opportunities for educational programs b) Potential high economic returns through a skilled workforce
Social Factors	Barriers	Public scepticism about AI/ML technologies and concerns over job replacement	
	Enablers	a) Younger generations are more familiar (and even seek) with AI. b) Curricula is reformed across the region and in the EU, trying to integrate new technologies, broadening the pool of future researchers	a) Same as B.1&B.2 b) There is a growing demand for Machine Learning skills among students and professionals
Technological factors	Barriers		Rapid technological changes require continuous updates to the curriculum and training materials
	Enablers	Rapid advancements in AI/ML and data processing technologies enhance model accuracy and capabilities, emphasizing the need to establish a region task force	Advanced tools and platforms already exist for practical ML education
Legal Factors	Barriers	Different regulations between the countries	Regulatory challenges in accrediting new VET programs and ensuring compliance with national and international educational standards
	Enablers	The EU Framework for AI sets the basis for new laws, paving the way for the discussion of the creation of a new joined task force	
Environmental factors	Barriers		New training centres and technological infrastructure must be planned carefully as to not create any drawbacks in sensitive ecosystems

Factors	Barriers / Enablers	B.1 & B.2	B.3
	Enablers	AI/ML technologies can be used for environmental monitoring and management, highlighting the need for immediate action	

Table 81: CS6 regional level - CS6 regional level: PESTLE analysis: Innovations code names for theme C Community inclusion

LEGEND: Identified Innovations	
Sector C: Community Inclusion	
C.1	My Water Level (https://www.climateinnovationwindow.eu/innovations/my-water-level/)
C.2	All4Elevation (https://www.climateinnovationwindow.eu/innovations/all4elevation/)
C.3	Crowdsourcing of Flood Multimedia for Hydrological Models in the Black Sea
C.4	New kind of games (including toys) to facilitate game and teach science or research methodology
C.5	Education system restructure for citizen engagement and participation
C.6	Innovative STEAM education (including games, challenges etc)
C.7	Danube Living Labs Pilot application Potelu Living Lab Romania (https://www.climateinnovationwindow.eu/innovations/danube-living-labs-pilot-application-potelu-living-lab-romania/)
C.8	Open Database for good practices (evaluated by experts -public & private sector)

Table 82: CS6 regional level - Identification of barriers and enablers for innovation related to Community Inclusion

Factors	Barriers / Enablers	C.1 & C.2	C.3	C.4	C.5	C.6
Political Factors	Barriers	Data-sharing protocols between jurisdictions	a) Same as C.1&C.2 b) Variability in political will and regulatory frameworks across different regions	Regulatory approvals for educational toys can be complex and time-consuming.		a) Same as C.4 b) Lack of concrete educational planning and continuity
	Enablers	Governments take measures to improve disaster preparedness and early warning systems		Government policies aiming at educational reformation, promoting STEM education		
Economic factors	Barriers	Potential high initial investment if an app-governmental-support is decided	a) Potential initial costs for the development of a common platform b) Potential costs	High production cost for quality toys & games VS market saturation		High initial costs for developing and implementing innovative educational tools and

Factors	Barriers / Enablers	C.1 & C.2	C.3	C.4	C.5	C.6
			associated with verifying and integrated crowdsourced data into existing models			programs
	Enablers	a) Existing technology b) potential cost savings from reduced flood damage	Cost savings from accurate predictions	Growing market demand for STEM games (potential for high return on investment)	Potential long-term economic growth due to informed and engaged citizenry	Investment in STEAM education can lead to a highly skilled workforce and economic growth.
	Barriers	Concerns about privacy		Varying acceptance levels among different cultural and socio-economic groups	Diverse societal views on the role of education	a) Same as C.4 b) Potential disparities in access to STEAM resource across different socio-economic groups & countries c) Difference in the education systems and their direction between the countries
Social Factors	Enablers	Younger generations are used to taking photos and uploading them. They are also more "alert" and "sensitive" towards environmental issues	a) Same as C.1 & C.2 b) Potential high interest in contributing to community safety and disaster preparedness	Increasing parental and educational focus on interactive and engaging learning tools	Increased community cohesion and empowerment in younger generations	Same as C.4
	Barriers	Challenges in data accuracy	Data quality and managing large volumes of multimedia content	Continuous updates required due to rapid technological development		Same as C.4
Technological factors	Enablers	Technology already in use	Widespread availability of smartphones	Advances in technology and research	Digital platforms and tools to	a) Same as C.4 b) Same as C.5

Factors	Barriers / Enablers	C.1 & C.2	C.3	C.4	C.5	C.6
			and internet connectivity	enabling more interactive and engaging educational tools	facilitate interactive learning and engagement	
Legal Factors	Barriers	Compliance with data privacy laws and cross-border legal issues regarding data sharing		Compliance with safety standards and educational regulations		Same as C.4
	Enablers					
Environmental factors	Barriers			Environmental impact of manufacturing and disposing new toys/games (plastic, electronic components etc)		Same as C.4
	Enablers	Increased frequency of flood events shows the need for monitoring				
Factors	Barriers / Enablers	C.7	C.8			
Political Factors	Barriers	Political changes and differing priorities across countries and regions affect funding and long-term commitment	a) Different political status and strategies in the Black Sea countries b) The lack of a clear agenda focusing on sustainability in the Black Sea and the political will for the agenda to be followed by all c) Dependency on “stronger” states (economically, strategically etc) not allowing independency in decision making			
	Enablers	Alignment with national and international water management policies				
Economic factors	Barriers	Initial investment and ongoing operational costs could be high, depending on the Lab size and coverage	a) Differences in the general economic status of the Black Sea countries and dependencies on “stronger” states b) High initial costs for the establishment of the open databbase			
	Enablers	Potential for economic growth through local development and job creation related to environmental management	Profits created by the collection of data			
Social Factors	Barriers	a) Time consuming b) varying levels of community engagement and	Good practices are different for each region/country due to Socio-economic differences and cultural backgrounds			

Factors	Barriers / Enablers	C.1 & C.2	C.3	C.4	C.5	C.6
		resistance to change among local populations				
	Enablers	Rising “sense of community” and “belonging” especially in younger generation	Same as C.7			
	Barriers	Integration of new technologies with existing systems & technical expertise at the local level				
Technological factors	Enablers	New technologies and technological advancements	New technologies and technological advancements facilitate and ease the establishment of this open platform			
	Barriers	a)Regulatory requirements about privacy protection b) compliance with national and international laws	Same as C.7			
Legal Factors	Enablers	Supportive legal frameworks for community involvement				
	Barriers					
Environmental factors	Enablers	Climate crisis and its consequences engage local communities for taking action				

Table 83: CS6 regional level - CS6 regional level: PESTLE analysis: Innovations code names for theme D international cooperation

LEGEND: Identified Innovations	
Sector D: International Cooperation	
D.1	Develop a transparent and well-defined catalogue of validators and transfers of data - with a common channel
D.2	Methodology on how to create a unified adaptation strategy and response on common strategies
D.3	Interregional Intercalibration Exercises between scientific groups
D.4	Establishment of an online coordination tool for listing regional research project coordination

Table 84: CS6 regional level - Identification of barriers and enablers for innovation related to International Cooperation

Factors	Barriers / Enablers	D.1, D8	, D.6, D.7
Political Factors	Barriers	sustainability in the Black Sea and the political will for the agenda to be followed by all c) Dependency on “stronger” states (economically, strategically etc) not allowing independency in decision making	

Factors	Barriers / Enablers	D.1, D8	, D.6, D.7
	Enablers	a) Existing International Organisations focusing on the cooperation of research institutes and organisations. b) international alliances can be utilised to foster a closer cooperation between the Black Sea countries allowing them to jointly work together	
Economic factors	Barriers	a) Initial investment cost b) Differences in the general economic status of the Black Sea countries and dependencies on “stronger” states	
	Enablers	The long-term profits created	a) The long-term profits created b) Enhanced cross-border research activity supports additional funding through public-private sector cooperation
Social Factors	Barriers		Cultural differences may create obstacles in communication
	Enablers		
Technological factors	Barriers		The technological background may differ across participating countries
	Enablers	a) The rising of new technologies pushes the need for immediate jointly organised actions b) New technologies help in cross-country cooperation and communication	New technologies allow simultaneous work and cooperation across regions/countries
Legal Factors	Barriers	Differences in regulations between countries	a) Differences in regulations between countries b) Contracts must be signed beforehand to ensure horizontal share of data
	Enablers		
Environmental factors	Barriers		Pollution (air, water etc) may be risen due to these activities (e.g. travelling between countries)
	Enablers		The ever-growing environmental issues can be used as challenges in these activities

CS7

Table 85:CS7 - Identification of barriers and enablers for innovation related to Citizen/civil society.

Factors	Barriers / Enablers	Innovation 1 Web portal	Innovation 2 App	Innovation 3 Concepts for citizen engagement	Innovation 8 Economic models	Innovation 14 Education
Political Factors	Barriers	N/A	N/A	Citizen involvement may be affected by individual political view on climate change.	Risk of political disagreements/ conflicting interests could invalidate models	No political focus on climate adaptation / Paris Agreement

	Enablers	N/A	N/A		Targeted economic models could strengthen corporation and help focus on common goals	
	Barriers	N/A	N/A	Motivation may be affected by the perceived economic risk to the individuals.	Economic costs to civil society; low willingness to pay	(High) costs of education
Economic factors	Enablers	Free access to the web portal	Free access to app (low-cost technology)		Mainstreaming cost-benefit analyses, economic tools could encourage investments and uptake of solutions; loan options to different target groups	Evolve educations and classes offered to ones further focused on sustainability-themes
	Barriers	Disengaged users. Relevant users may not be present on this platform		Disengaged users (e.g. "climate risk overloading", irrelevance)	Lack of "common issues need common solutions" mindset/culture	Education is not tailored to a broad group of citizens; success depends on the ability to received education
Social Factors	Enablers	Promoting portal's usefulness; encourage users to recommend the portal. Integration with high-interest case that rally the users	Promote the app's usefulness and new features; encourage users to recommend the app. Relevance to users	Engage civil society in different ways to reach broader target groups	Promoting culture-change through fair and convincing investment models	approaches
	Barriers	Less appealing to tech-challenged users/target groups		N/A	N/A	If digital tools play a large role then education could be less appealing to tech-challenged users/target groups
Technological factors	Enablers	Simplified functionality (web portal functions); promote physical meetings by mail		N/A	N/A	Digital tools could help reach a broader

					audience and make education relevant
Legal Factors	Barriers	GDPR			N/A
	Enablers	Regulation (integration of tool)		Existing regulation could promote some models	Regulation (climate education could be mandatory)
Environmental factors	Barriers	N/A	N/A	N/A	Lack of observed events, communication (negative willingness to pay)
	Enablers	Flood risk	Events, flood risk		Events, flood risk (positive willingness to pay)
					Events, flood risk (relevance, interest)

Table 86: CS7 - Identification of barriers and enablers for innovation related to Public Authority (Esbjerg Municipality, national government, etc.).

Factors	Barriers / Enablers	Innovation 1 Web portal	Innovation 3 Concepts for citizen engagement	Innovation 4 Storm surge barrier	Innovation 8 Economic models	Innovation 15 Multi-functional harbour facilities
Political Factors	Barriers	Possible competitive situation compared to existing platforms adopted by the local authority.	See Table 2	For phase 1: Pressure from enterprises who want the barrier moved to secure west of the barrier. For phase 2: Short term political decisions may weigh heavier than long term. Uncertainty on sea level rise on longer term.	See Table 2	Further in the process conflicting interests may develop
	Enablers	Strong focus on citizen involvement in general in Denmark.		Phase 1 is in place so far. Strategy for phase 1 and 2 has been submitted by city council.		Strong focus on a common vision and multifunctionality
Economic factors	Barriers	Lack of economic means to drive an effective web portal.		Phase 2: Lack of willingness to pay because of uncertainty		An economic feasible project may conflict with the initial common vision

				of sea level rise and no efficient economic incentives so far.		
	Enablers	Availability of sufficient budget is set aside to drive the portal		Development of a sufficient model for incentives to invest.		Communicate different possibilities during the planning process
	Barriers	Lack of user-engagement; interest on the side public authorities		Long term perspective may be hard to prioritize.		Agreeing on what multifunctionalities can be a challenge
	Enablers	Promotion, visibility		Phase 2 will improve visual access to the sea and strengthen mobility for cyclists and pedestrians as well as strengthen historical identity in the area.		Using means such as the web portal and app to strengthen this process
Social Factors						
	Barriers	See Table 2		Buildings have to be moved making space for the barrier. During the 20-30 years of building the phase 2 barrier significant terrain differences will be the situation.		A technical feasible project may conflict with the initial common vision
	Enablers	Internal training; easy-to-use user interface.		Technology in place.		Communicate different possibilities during the planning process
Technological factors						
	Barriers	GDPR and other regulations		N/A		N/A
	Enablers	Proper integration (e.g. upholding data-privacy		Legal factors in place.		N/A
Legal Factors						

		regulations)				
Environmental factors	Barriers	N/A				
	Enablers	N/A				
		N/A				
		N/A				
		N/A				

Table 87: CS7 - Identification of barriers and enablers for innovation related to Private sector (industry, enterprises and investors).

Factors	Barriers / Enablers	Innovation 1, 3 & 8 Web portal / Concepts for citizen engagement / Economic models	Innovation 5 Incentives / pathways towards private investments	Innovation 16 Tourist service Visitor centre	Innovation 17 Innovative building protection	Innovation 18 Off-grid solutions
Political Factors	Barriers	See Table 2	Lack of public requirements. "Business as usual" understanding.	N/A	N/A	Lack of political focus.
	Enablers		Focus on climate change and adaptation.	N/A	N/A	Political focus caused by safety situation in Europe in general.
Economic factors	Barriers		Move investments to other places. Negative willingness to pay	Lack of funding.	Optional public funding.	Lack of budget.
	Enablers		Ensure proper foundation for long term investments. Positive willingness to pay	Positive perception of business opportunities	Lack of public funding. Positive perception of business case	N/A
Social Factors	Barriers	See Table 2 and 3	Not sufficient information available. Lack of urgency of the problem (individual perception) Individuals do not perceive this as their responsibility	N/A	Not sufficient information available. Lack of urgency of the problem (individual perception).	N/A
	Enablers		Positive	N/A	Individual	N/A

			willingness to pay		perception of problem urgency	
Technological factors	Barriers		N/A	N/A	Suitable technologies are not available	N/A
	Enablers		N/A	N/A	Already existing technologies are found to be adequate	N/A
Legal Factors	Barriers		Lack of legal regulation.	N/A	Building codes may conflict with innovations	N/A
	Enablers		Potential barriers are removed. Incentives are supported by regulation.	N/A	Building codes and regulations promote innovations	N/A
Environmental factors	Barriers		No events observed	N/A	No events observed	N/A
	Enablers		Events, flood risk			N/A

Table 88: CS7 - Identification of barriers and enablers for innovation related to Utility sector (water, wastewater, electricity, district heating).

Factors	Barriers / Enablers	Innovation 6 Cascading risks	Innovation 7 Climate risk assessment	Innovation 9 Climate risk management	Innovation 10 Novel pumping system
Political Factors	Barriers	Political priorities change – climate risks are not prioritised by policymakers	Political priorities change – climate risks e.g. to utilities (electricity) are not prioritised by policymakers		N/A
	Enablers	Increased political focus			
Economic factors	Barriers	Lack of funding for developing an operational system	Lack of funding (short term and long term)	Optional budget limitations caused by legislative.	Broader need to start up innovation process.
	Enablers	Follow-up funding	Funding	Need to protect critical infra structure.	Funding
Social Factors	Barriers				
	Enablers				
Technological factors	Barriers	The technical possibilities for the model can be limited	Historically irrelevant data.	N/A	N/A
		Relevant	Suitable models are not		

		expertise and data are unavailable	available		
	Enablers	The model can be further developed when the technical methods are possible Relevant data and expertise is available	Development of suitable models and methods.	N/A	N/A
Legal Factors	Barriers	Needed data may not be publicly available		Optional budget limitations caused by legislative.	N/A
	Enablers	Gather consent to collect needed data		N/A	N/A
Environmental factors	Barriers	No real-life events are observed leading to lower prioritization			
	Enablers	Events, flood risk			

Table 89: CS7 - Identification of barriers and enablers for innovation related to Knowledge institutions.

Factors	Barriers / Enablers	Innovation 12 Storm surge models	Innovation 13 Decision-making tools & AI
Political Factors	Barriers	Lack of political focus affects research funding and interest.	Lack of political interest of using new models. Lack of political focus affects research funding.
	Enablers	Political focus provides a research incentive Improved political focus may affect funding.	
Economic factors	Barriers	Lack of funding.	
	Enablers		
Social Factors	Barriers	Lack of qualified and interested researchers	
	Enablers	Public visibility	
Technological factors	Barriers	Computing resources; required data is unavailable or insufficient; methods are not mature; research may take extended time	Computing resources; required data is unavailable or insufficient; methods are not mature; research may take extended time Lack of proper co-design and co-creation
	Enablers	Research infrastructure, data and methods are available, high quality and mature	
Legal Factors	Barriers	Data is legally restricted	GDPR
	Enablers	Cooperation, data management agreement can be signed	
Environmental factors	Barriers	No real-life events are observed leading to lower prioritization and interest	
	Enablers	Events, flood risk may provide new data and increase focus, funding	

Table 90: CS8 - Identification of barriers and enablers for innovation related to the Cross-Sector (Health, community, biodiversity, infrastructure, water and flooding)

Factors	Barriers / Enablers	Water Is life	Climate Outreach Programme	Literacy SuDS/NBS	Community/School	Nature-based problem solving initiative	Flood Risk roof tax
Political Factors	Barriers	Regulatory Approvals: Obtaining the necessary permits and approvals for rewilding and water management projects can be time-consuming and complex. Policy Changes: Changes in local or national environmental policies could impact long-term planning and project stability.	Local Government Priorities: Shifting local political priorities may affect funding availability and support for climate literacy initiatives specific to Torbay. Regulatory Frameworks: Compliance with Torbay Council's environmental policies and regulations may add complexity to programme implementation.	Local Regulations: Adhering to Torbay's specific urban planning and environmental regulations for implementing sustainable drainage and nature-based solutions. Government Funding: Dependency on local government support and funding allocations for sustainable infrastructure projects in Torbay.	Regulatory Complexity: Torbay, like many UK regions, may have strict regulations governing land use and community projects. Obtaining necessary permits for urban agriculture and community-led initiatives could be time-consuming and complex. Policy Alignment: Ensuring that local policies support initiatives like urban agriculture and community resilience projects may require advocacy and alignment with broader regional goals.	Local Opposition: Resistance from local developers and property owners who perceive the roof tax as an additional financial burden in an area already facing economic challenges. Planning Permissions: Potential delays or complications in obtaining planning permissions due to new taxation policies impacting development feasibility.	
	Enablers	Government Support: Policies and initiatives at both local and national levels that promote environmental conservation and sustainable water management can provide a supportive environment. Funding Programs: Access to government grants and subsidies aimed at promoting green infrastructure and community-led projects.	Local Policy Support: Alignment with Torbay Council's climate action plans and strategies, which prioritise community engagement and environmental education. Advocacy: Building partnerships with local councillors and policymakers to advocate for funding and policy support for climate literacy initiatives in Torbay.	Supportive Policies: Alignment with Torbay's environmental policies promoting sustainable urban development and biodiversity conservation. Local Advocacy: Strong community and governmental advocacy for sustainable initiatives enhancing political will.	Local Government Support: Engaging with local councils and policymakers who prioritise sustainable development and community resilience can facilitate smoother regulatory processes. Funding Opportunities: Accessing grants and funding streams from local and national government bodies supporting community initiatives and environmental projects.	Local Government Support: Strong backing from Torbay Council and Devon County Council, aligning with regional flood risk reduction strategies and sustainable development goals. Policy Alignment: Integration of the roof tax with Torbay's existing flood risk management plans and environmental policies.	
Economic factors	Barriers	Funding Limitations: Limited financial	Limited Funding Sources: Challenges in securing sufficient	Budget Constraints: Limited budget allocation for	Financial Constraints: Torbay	Financial Impact on Developers: Concerns about increased costs	

		resources in Torbay, a region with pockets of deprivation, may constrain the scale of micro-funding initiatives. Economic Pressures: Economic challenges in Torbay, including unemployment and budget constraints, might limit investment in environmental projects.	funding from Torbay-specific grants and local sponsors for developing and distributing programme toolkits. Cost Considerations: High costs associated with venue rentals and materials for in-person workshops and community events in Torbay.	implementing and maintaining sustainable drainage systems and nature-based solutions in Torbay. Cost of Implementation: High initial costs of infrastructure development and ongoing maintenance.	communities may face financial challenges in funding infrastructure for urban agriculture and maintaining community-led initiatives. Cost of Implementation: Initial costs for setting up infrastructure and providing training in permaculture practices could be prohibitive for some community groups.	impacting housing affordability and potentially discouraging new developments in Torbay. Revenue Allocation: Ensuring effective allocation of tax revenues towards flood risk reduction projects that benefit the local community.
	Enablers	Local Economic Benefits: The project can generate local jobs and business opportunities, particularly in eco-tourism and green infrastructure, supporting Torbay's economy. Cost Savings: Demonstrating long-term savings from reduced flood damage and improved water management can attract investment from local stakeholders.	Local Funding Opportunities: Accessing Torbay-specific grants and funding streams dedicated to community-based environmental initiatives. Partnerships: Collaborating with Torbay businesses, organisations, and stakeholders to secure sponsorships and donations for programme implementation costs.	Cost-Benefit Analysis: Demonstrating long-term cost savings from reduced flood damage and improved environmental quality to attract local investments. Community Fundraising: Engaging local businesses and stakeholders in fundraising efforts to support sustainable projects.	Community Investment: Demonstrating economic benefits such as reduced food costs and improved health outcomes through local produce can attract investment from local businesses and stakeholders. Grant Funding: Leveraging grants and funding opportunities specifically targeting community-led projects and sustainable development in Torbay.	Long-term Cost Savings: Demonstrating economic benefits from reduced flood damage and improved infrastructure resilience, which can attract investors and developers committed to sustainable practices. Tourism and Development: Positioning Torbay as a sustainable and flood-resilient destination can attract environmentally conscious tourists and developers.
Social Factors	Barriers	Community Resistance: Some Torbay residents may resist changes due to a lack of understanding of the benefits of rewilding and natural water management solutions. Social Inequity: Ensuring that all communities, including disadvantaged	Community Diversity: Ensuring inclusivity and engagement across diverse communities in Torbay, including marginalised groups who may face barriers to participation. Behavioural Change: Overcoming local scepticism or indifference towards climate action and literacy among certain segments of the Torbay population.	Community Engagement: Ensuring active involvement and support from diverse Torbay communities, including addressing potential resistance or skepticism. Public Awareness: Educating Torbay residents about the benefits of sustainable drainage and nature-based solutions to foster community buy-in.	Community Engagement: Encouraging participation from diverse community groups in permaculture and urban agriculture initiatives may face challenges due to varying levels of interest and awareness. Inclusivity: Ensuring that are	Public Perception: Addressing concerns among residents about the fairness and impact of the roof tax on property values and community development. Community Engagement: Ensuring transparent communication and engagement with local communities to gain support for flood risk reduction initiatives.

		areas in Torbay, benefit equally from the project can be challenging.			inclusive and address the needs of marginalised groups within Torbay communities.	
	Enablers	Community Engagement: Torbay has a strong sense of community, and engaging local groups and residents in co-designing solutions can increase project acceptance. Each ward within Torbay has a 'Community Builder' enhancing opportunities for wider community engagement. Awareness Campaigns: Effective communication and education about the benefits of natural and rewilding solutions can build support among Torbay residents.	Community Co-design: Involving Torbay residents in the design and delivery of the programme to ensure cultural relevance and accessibility. Local Awareness Campaigns: Tailoring outreach strategies to Torbay's unique social dynamics and community interests to foster local ownership and engagement.	School Involvement: Collaborating with Torbay schools to educate students, parents, and teachers about sustainable water management and biodiversity. Community Workshops: Hosting workshops and forums to gather input and co-design solutions with Torbay residents, enhancing project relevance and support.	Social Cohesion: Strengthening community bonds through shared activities like gardening and permaculture workshops can foster a sense of ownership and pride in local initiatives. Local Community Builders can provide an opportunity for wider community involvement. Capacity Building: Providing training and support to empower community members to take active roles in project design and implementation	Community Consultation: Actively involving residents and community groups in decision-making processes regarding flood risk management and sustainable development. Education and Awareness: Educating the public about the benefits of sustainable urban planning and flood resilience measures specific to Torbay's environment
Technological factors	Barriers	Technology Access: Limited access to advanced technology for monitoring and implementing water management solutions in Torbay can be a barrier.	Digital Divide: Addressing disparities in digital access and literacy within Torbay communities, which could limit the reach of online resources and toolkits. Technological Infrastructure: Dependence on reliable internet connectivity and digital tools for virtual workshops and online educational materials in Torbay.	Technological Integration: Adapting advanced technologies to Torbay's specific environmental conditions and infrastructure needs for effective implementation. Accessibility: Ensuring technological accessibility and affordability for all stakeholders involved in Torbay's sustainable projects.	Technological Access: Ensuring equitable access to technology and technical expertise for implementing modern permaculture techniques in urban settings. Infrastructure Requirements: Addressing the need for basic infrastructure such as water management systems and storage facilities for sustainable urban agriculture.	Technology Accessibility: Varying levels of technological readiness among developers and local authorities for implementing advanced flood risk assessment and mitigation technologies. Integration Challenges: Integrating new technologies into Torbay's existing urban planning and development frameworks.
	Enablers	Innovation and Research: Collaborating with local institutions like South Devon College and the University of Exeter	Mixed Delivery Methods: Offering alternative formats such as printed materials and in-person workshops alongside digital	Innovation Hub: Leveraging Torbay's technological innovation hubs and partnerships with local universities for tailored solutions.	Low-Tech Solutions: Adopting low-tech and sustainable solutions suitable for community-level	Technological Innovation: Partnering with local tech firms and research institutions to develop and apply innovative technologies tailored to Torbay's flood

		can bring technological support and innovative solutions. Training Programs: Providing training and capacity-building initiatives to Torbay residents can empower the community with necessary skills.	resources to accommodate diverse technological access in Torbay. Local Tech Partnerships: Collaborating with Torbay-based tech companies and community organizations to provide access to technology and digital platforms for learning.	Pilot Projects: Testing and refining technology-based solutions through small-scale pilot projects in Torbay communities.	implementation, reducing reliance on advanced technology. Skill Development: Providing training programs and workshops to build local capacity in permaculture practices and sustainable agriculture methods.	risk management needs. Capacity Building: Providing training and support to local stakeholders to effectively utilize new technologies in sustainable development and flood resilience projects.
Legal Factors	Barriers	Regulatory Compliance: Navigating the complex legal landscape of land use, water rights, and environmental protection in Torbay can be challenging. Liability Issues: Concerns about legal liabilities related to potential flooding or water quality issues from the project can be a barrier.	Local Legal Compliance: Navigating Torbay-specific regulations related to public events, data protection, and community engagement activities. Liability Concerns: Addressing potential legal liabilities associated with conducting educational workshops and activities in public spaces across Torbay.	Land Use Regulations: Navigating Torbay's complex land use regulations and permissions for implementing nature-based solutions within urban areas. Liability Management: Addressing potential legal liabilities related to infrastructure failures or environmental impacts in Torbay	Regulatory Compliance: Navigating complex legal frameworks related to land use, health and safety, and environmental protection regulations in Torbay. Liability Concerns: Addressing legal liabilities associated with community use of public and private land for urban agriculture and permaculture projects.	Legal Compliance: Navigating complex legal frameworks related to property taxation, planning regulations, and environmental assessments in Torbay. Enforcement Issues: Ensuring compliance with the roof tax regulations and addressing legal challenges from developers or affected stakeholders.
	Enablers	Supportive Legal Framework: Supportive local laws and regulations in Torbay that encourage sustainable water management and community-led initiatives. Partnerships: potential for collaborations with legal experts and organisations in Torbay to navigate regulatory challenges effectively.	Legal Guidance: Seeking advice from Torbay-based legal experts to ensure compliance with local laws and regulations governing community outreach and educational programmes Community Partnerships: Establishing partnerships with Torbay community organisations and stakeholders to collectively address legal considerations and ensure responsible programme implementation.	Local Legal Expertise: Accessing Torbay-specific legal expertise to ensure compliance with local regulations and mitigate project risks. Regulatory Support: Collaborating with Torbay authorities to streamline approval processes and support sustainable infrastructure initiatives.	Legal Guidance: Accessing legal expertise and guidance to ensure compliance with local regulations and mitigate risks associated with community-led initiatives. Collaborative Partnerships: Establishing partnerships with local authorities and landowners to develop legal agreements that support sustainable land use practices	Clear Regulatory Framework: Establishing clear and accessible guidelines for implementing and enforcing the roof tax within Torbay's legal context. Stakeholder Collaboration: Collaborating with legal experts, developers, and community stakeholders to address concerns and improve regulatory frameworks specific to Torbay.
Environ	Barriers	Climate Change: Increasing			Climate Change Impact: Adapting	Environmental Impact: Conducting thorough

mental factors		frequency of extreme weather events in Torbay due to climate change can complicate water management efforts. Environmental Degradation: Existing environmental issues in Torbay, such as coastal erosion and pollution, may require extensive restoration efforts before new projects can be effective.			to local climate change impacts such as extreme weather events and shifts in growing seasons. Biodiversity Conservation: Balancing urban agriculture activities with conservation efforts to protect local biodiversity in Torbay.	environmental assessments to minimise adverse effects of development and maximise flood risk reduction benefits in Torbay. Biodiversity Conservation: Mitigating potential impacts on Torbay's unique biodiversity and coastal ecosystems from urbanisation and flood management activities.
	Enablers	Natural Resources: Torbay's natural resources, including its coastline, rivers, and green spaces, provide a solid foundation for environmental projects. Biodiversity Enhancement: Enhancing local biodiversity can improve ecosystem services, which are crucial for the project's success.	Local Sustainability Initiatives: Engaging Torbay communities in local environmental stewardship projects that enhance resilience to climate impacts and protect biodiversity. Ecosystem Education: Highlighting Torbay's natural assets and ecosystem services to foster appreciation and support for local conservation efforts.		Nature-Based Solutions: Implementing nature-based solutions that enhance biodiversity and ecosystem services within urban environments. Climate Resilience: Building community resilience to climate change through sustainable agriculture practices and natural resource management.	Nature-based Solutions: Promoting green infrastructure and nature-based solutions that are tailored to Torbay's coastal and estuarine environment to enhance flood resilience and biodiversity. Sustainable Practices: Incorporating sustainable building designs and green development standards to minimise environmental footprint and strengthen Torbay's resilience to climate change impacts.

Table 91: CS8 - Identification of barriers and enablers for innovation related to Cross-sector (Infrastructure, water and flooding)

Factors	Barriers / Enablers	Smart water butts as early warning system (SDS/Our Rainwater)
Political factors	Barriers	Regulatory Compliance: Ensuring compliance with local regulations and standards for implementing sensor technology in public buildings (schools, government buildings) can be challenging. Government Support: The availability of government funding and support for innovative flood warning systems may vary, affecting the project's scalability.
	Enablers	Government Initiatives: Supportive policies promoting sustainable water management and flood resilience could encourage adoption of smart water butt technologies. Collaboration: Partnerships with local authorities and government bodies can streamline regulatory approvals and funding opportunities.
Economic factors	Barriers	Cost: Initial investment in retrofitting smart sensors onto existing infrastructure (water butts) in schools and government buildings may be high. Budget Constraints: Limited budgets for maintenance and upgrades could hinder the sustainability of the

		technology.
	Enablers	Cost Savings: Demonstrating potential savings in flood damage mitigation through early warning systems can justify initial costs. Investment Opportunities: Attracting private investment or sponsorship for pilot projects can offset financial barriers.
Social Factors	Barriers	Public Awareness: Limited awareness among the public, especially in schools and government buildings, about the benefits and functionality of smart water butts for flood warnings. Acceptance: Resistance or scepticism from stakeholders regarding new technology implementation in public infrastructure.
	Enablers	Education and Engagement: Public awareness campaigns and educational programmes can promote understanding and acceptance of smart water butt technology. Community Participation: Involving local communities in the pilot projects can increase acceptance and support.
Technological factors	Barriers	Technological Infrastructure: Adequate infrastructure for data transmission and integration with existing flood warning systems may be lacking. Compatibility Issues: Ensuring compatibility of smart sensors with diverse existing water butt models and building infrastructures.
	Enablers	Advancements in IoT: Rapid advancements in Internet of Things (IoT) technology can facilitate the integration of smart sensors into water management systems. Collaborative Research: Partnerships with technology providers and research institutions can address technological challenges and enhance system reliability.
Legal Factors	Barriers	Data Privacy: Compliance with data protection regulations (e.g., GDPR) when collecting and using data from smart sensors. Liability: Clarifying liability issues in case of system failures or inaccuracies in flood warnings.
	Enablers	Legal Framework: Establishing clear guidelines and agreements regarding data ownership, usage rights, and liability can mitigate legal risks. Expert Consultation: Seeking legal advice and consultation from experts in data protection and liability can ensure compliance and risk management.
Environmental factors	Barriers	Environmental Impact: Assessing and mitigating any potential environmental impacts associated with the deployment and operation of smart water butt sensors. Resource Consumption: Managing resource consumption (e.g., energy, materials) throughout the lifecycle of the technology.
	Enablers	Sustainability: Designing smart water butt systems with minimal environmental footprint and promoting water conservation practices. Ecosystem Resilience: Enhancing flood resilience through improved water management practices can benefit local ecosystems and biodiversity.

Table 92: CS8 - Identification of barriers and enablers for innovation related to Cross-sector (Infrastructure, community)

Factors	Barriers / Enablers	Sustainable business model for innovations/ implementation	Public good/levy for communities	Emergency responder resource priority allocation model	Dashboard
Political factors	Barriers			Government Regulations: Torbay operates under UK regulations that govern emergency response protocols, which may require careful alignment of the new resource allocation model. Local Authority Coordination: Coordinating with Torbay Council and other local authorities to ensure the prioritisation model fits within their emergency management frameworks.	Regulatory Compliance: Adhering to data protection regulations (like GDPR in the UK) can limit how data on flooding incidents can be collected, stored, and shared. Government Support: Dependency on government funding or support for maintaining and updating the website hub/dashboard may fluctuate based on political priorities.

	Enablers			Local Government Support: Torbay Council's endorsement and cooperation in piloting the model can facilitate smoother implementation and integration into existing emergency services. Policy Alignment: Ensuring the model aligns with Torbay's specific emergency response policies and strategies to enhance effectiveness during flood events.	Government Initiatives: Supportive policies and initiatives promoting transparency and public access to flood data can facilitate easier implementation. Collaboration: Partnerships with local authorities and government agencies can streamline data sharing and regulatory compliance.
Economic factors	Barriers			Budget Constraints: Torbay faces financial limitations for upgrading emergency response systems, necessitating cost-effective solutions. Resource Allocation Costs: Initial investment in technology and training for emergency responders to adapt to the new prioritisation system.	Costs: Developing and maintaining a sophisticated website hub/dashboard with real-time data updates can be expensive, especially if it requires continuous technological upgrades. Budget Constraints: Public sector budget cuts or fluctuations in funding can affect the website's operational capabilities.
	Enablers			Efficiency Savings: Demonstrating potential cost savings through improved resource allocation efficiency during flood responses can justify the initial investment. Regional Funding Opportunities: Accessing regional funding programs aimed at enhancing flood resilience and emergency response capabilities in Torbay.	Cost Savings: Demonstrating cost savings for utilities and emergency services through improved flood response and reduced damage can justify ongoing investment. Public-Private Partnerships: Collaborating with private sector entities for funding or technical expertise can alleviate financial burdens.
Social Factors	Barriers			Community Expectations: Ensuring the new model meets the expectations of Torbay residents who are accustomed to current emergency response practices. Public Perception: Addressing concerns about fairness and equity in resource allocation across different neighbourhoods within Torbay.	Community Engagement: Ensuring that the website is user-friendly and accessible to all demographics in Torbay, including those with limited digital literacy, could pose challenges. Access to flood risk data could cause alarm and misconceptions within the community. Public Trust: Building and maintaining trust among the public regarding the accuracy and reliability of the flood data displayed on the website.
	Enablers			Community Engagement: Engaging Torbay residents through public consultations and community forums to	Education and Training: Providing training sessions and resources to educate the community on how to

				gather feedback and build support for the prioritisation model. Public Education: Educating the public about the benefits of the model in improving overall emergency response effectiveness and reducing flood impacts.	use the website effectively can enhance engagement, usability and accurate interpretation of the data. Feedback Mechanisms: Incorporating feedback mechanisms to address community concerns and improve user experience over time.
Technological factors	Barriers			Technological Infrastructure: Ensuring Torbay has robust technological infrastructure for real-time monitoring and communication during emergency situations. Integration Challenges: Integrating the new prioritisation model with Torbay's existing emergency management systems and IT infrastructure.	Data Integration: Ensuring compatibility and seamless integration of data from various sources (e.g., weather stations, sensors, local authorities) into the website Technological Infrastructure: Dependence on reliable internet connectivity and robust IT infrastructure to maintain real-time updates and accessibility.
	Enablers			Technological Advancements: Leveraging advancements in digital technology and data analytics to optimise resource allocation decisions specific to Torbay's geographic and demographic characteristics. Partnerships with Tech Providers: Collaborating with technology providers specialising in emergency management solutions tailored to coastal and flood-prone regions like Torbay.	Technological Advancements: Leveraging advancements in data analytics and visualisation technologies to provide intuitive and insightful flood incident displays. Partnerships with Tech Providers: Collaborating with technology providers for expertise in data management and cybersecurity can enhance the website's capabilities.
Legal Factors	Barriers			Legal Compliance: Adhering to UK and EU data protection regulations when handling sensitive information in emergency situations. Liability Considerations: Addressing legal liabilities associated with resource allocation decisions made by the prioritization model in Torbay.	Data Privacy: Ensuring compliance with data protection laws and regulations when collecting and sharing sensitive information related to flooding incidents. Liability Concerns: Clarifying liability issues related to the accuracy of flood data and the website's role in emergency response coordination.
	Enablers			Legal Framework: Ensuring the model is developed within a legal framework that supports innovative approaches to emergency management in Torbay. Legal Expertise: Consulting	Legal Framework: Establishing clear legal agreements and protocols with data providers and stakeholders to mitigate legal risks and ensure data integrity.

				with legal experts familiar with Torbay's regulatory environment to navigate potential legal challenges and ensure compliance.	Legal Expertise: Engaging legal professionals to navigate complex regulatory landscapes and mitigate potential legal challenges proactively.
Environmental factors	Barriers			Environmental Impact: Mitigating any potential environmental impacts of emergency response activities in Torbay, particularly in environmentally sensitive areas.	Climate Change Impacts: Increasing frequency and severity of floods due to climate change may necessitate continuous updates and adaptations to the website's functionalities. Environmental Impact Assessments: Considering environmental impacts and mitigation measures during the development and operation phases of the website.
	Enablers			Sustainable Practices: Incorporating sustainable practices into emergency response strategies to minimize environmental impact and enhance community resilience in Torbay.	Resilient Infrastructure: Incorporating climate-resilient design principles into the website's infrastructure to withstand environmental pressures and ensure continuity of service. Sustainability Practices: Promoting sustainable practices in data management and website operations to minimise environmental footprint.

Table 93: CS8 - Identification of barriers and enablers for innovation related to Cross-sector (Infrastructure, water and flooding, community).

Factors	Barriers / Enablers	Community water officer	Culture and Creativity networks	Citizen Science and observation	Climate 'Fear to Hope' Workshops
Political factors	Barriers	Local Government Priorities: Flooding may compete with other local priorities such as tourism and infrastructure development, affecting resource allocation and political support. Interagency Coordination: Coordination between different levels of government (local, county, regional) and agencies involved in flood management can sometimes be challenging.			
	Enablers	Local Authority Support: Torbay Council's commitment to environmental sustainability and community safety can provide a conducive environment for implementing flood communication initiatives. Partnerships: Collaboration with Devon County Council and regional environmental agencies can strengthen advocacy efforts for flood resilience projects.			
Economic factors	Barriers	Budget Constraints: Limited funding for flood mitigation and communication initiatives amidst competing demands for local budgets.			

		Tourism Dependency: Economic reliance on tourism revenues may divert attention and resources away from flood management investments			
	Enablers	Grant Opportunities: Accessing funding from national grants and EU initiatives (if applicable) aimed at flood resilience and community engagement. Public-Private Partnerships: Engaging local businesses and stakeholders in supporting flood communication and mitigation efforts through corporate social responsibility initiatives.			
Social Factors	Barriers	Community Engagement: Diverse demographic and socio-economic backgrounds in Torbay may require tailored approaches to engage all residents effectively in flood preparedness. Perception of Risk: Some residents may underestimate flood risks due to historical infrequency of major flooding events.			
	Enablers	Community Resilience Programs: Building on existing community resilience networks (e.g. Community Builders) and neighbourhood associations to disseminate flood information and training. Education Campaigns: Conducting targeted education campaigns in schools, community centers, and local events to raise awareness about local flood risks and preparedness measures.			
Technological factors	Barriers	Digital Divide: Ensuring that flood communication tools and technologies are accessible to all residents, including those in rural or less connected areas of Torbay. Data Integration: Coordinating and integrating data from various sources (meteorological, environmental monitoring) for effective flood forecasting and communication.			
	Enablers	Smart City Initiatives: Leveraging Torbay's Smart City initiatives to deploy innovative technologies for flood monitoring and early warning systems. Training and Support: Providing ongoing training and technical support for flood wardens on the use of communication technologies and data interpretation.			
Legal Factors	Barriers	Regulatory Compliance: Adhering to stringent environmental regulations and planning permissions when implementing flood mitigation measures and infrastructure improvements. Liability Concerns: Addressing legal liabilities related to public safety and property damage during flood events.			
	Enablers	Legal Expertise: Collaborating with legal advisors and local authorities to navigate regulatory requirements and ensure compliance in flood communication strategies. Insurance Partnerships: Partnering with insurance providers to promote flood risk reduction measures and incentivize community resilience initiatives.			
Environmental factors	Barriers	Coastal Vulnerability: Managing flood risks in Torbay's coastal areas prone to erosion and sea-level rise due to climate change. Biodiversity Conservation: Balancing flood management strategies with protection of local ecosystems and wildlife habitats.			
	Enablers	Natural Flood Management: Implementing nature-			

		based solutions such as wetland restoration and green infrastructure to enhance flood resilience while promoting biodiversity. Climate Adaptation Strategies: Integrating climate adaptation into flood management plans to address long-term environmental impacts and enhance community resilience.			
--	--	--	--	--	--

Table 94: CS8 - Identification of barriers and enablers for innovation related to Community

Factors	Barriers / Enablers	Climate Change Curriculum support package	Connection Programme	Building	Filling the void initiative
Political factors	Barriers	Government Priorities: Shifting priorities in education policies may affect the emphasis placed on climate change education within the curriculum. Local Government Priorities: Torbay Council's priorities may not currently emphasise climate change education, potentially impacting support and funding for such initiatives. Policy Alignment: Ensuring alignment with Torbay's local educational policies and strategies to integrate climate change into the curriculum may require advocacy and collaboration.	Local Government Priorities: Shifting priorities in Torbay's local government may affect funding availability and support for community cohesion initiatives. Policy Alignment: Ensuring alignment with Torbay's specific policies and regulations related to community engagement and conflict resolution.		Local Government Priorities: Shifting priorities in local government agendas may affect support and funding for community-led initiatives like "Filling the Void." Regulatory Compliance: Navigating local regulations and policies related to community engagement and information dissemination can be complex and time-consuming
	Enablers	Environmental Commitment: Torbay has shown commitment to sustainability and environmental conservation, which can create a favourable environment for climate change education initiatives. Political Support: Endorsement from local council members and representatives can facilitate access to funding and resources. Government Priorities: DfE Sustainability and climate change education strategy outline aspirations to incorporate Climate Education into the curriculum through varied existing national curriculum courses. This is planned to be enhanced through the new Natural History GCSE.	Local Council Support: Active endorsement and funding from Torbay Council for initiatives aimed at improving community relations and social cohesion. Community Leadership: Collaboration with local councillors and community leaders to advocate for and support the programme.		Local Council Support: Endorsement and financial backing from Torbay Council can provide crucial support and legitimacy to the initiative. Policy Alignment: Aligning with Torbay's strategic plans for community resilience and engagement can facilitate smoother implementation and resource allocation.
Economic factors	Barriers	Budget Constraints: Like many local authorities, Torbay may face financial constraints that limit investments in new educational initiatives.	Funding Challenges: Limited resources and competition for funding among various local projects and initiatives in Torbay.		Funding Challenges: Limited availability of funds for collaborative projects and leadership learning sets could

		Economic Challenges: Economic pressures on local businesses and households may reduce available funding for educational programs.	Community Investment: Economic downturns impacting local businesses and their ability to sponsor or support community programmes financially.	restrict the scale and impact of the initiative. Economic Volatility: Economic downturns may reduce corporate sponsorship and individual donations crucial for sustaining the initiative.
	Enablers	Grant Funding: Accessing regional and national grants for environmental education can supplement local budgets.	Partnership Opportunities: Forming partnerships with Torbay-based businesses, foundations, and philanthropic organisations to secure funding and resources. Cost-Effective Strategies: Demonstrating cost-effectiveness and efficiency in programme planning and implementation to maximise available resources.	Partnership Opportunities: Forge partnerships with local businesses, tourism boards, and philanthropic organisations in Torbay to secure diversified funding sources. Cost-Effective Strategies: Demonstrating cost-efficiency and clear benefits from leadership learning sets can attract sustained financial support and participation.
Social Factors	Barriers	Community Engagement: Varying levels of awareness and engagement with climate change issues among Torbay residents may affect the reception and effectiveness of the curriculum package. Cultural Sensitivity: Ensuring that the curriculum package is culturally relevant to Torbay's diverse population is crucial for acceptance and impact.	Diverse Community: Torbay's diverse population with varying cultural backgrounds and socio-economic statuses may present challenges in fostering unified community engagement. Historical Divisions: Addressing historical tensions or divisions within Torbay that affect community trust and collaboration.	Community Engagement: Overcoming scepticism or apathy within Torbay's diverse communities towards collaborative initiatives and leadership training. Social Media Impact: Managing misinformation and public perception on social media platforms, which can influence community support.
	Enablers	Community Groups: Collaborating with local environmental groups, schools, and community centres can enhance community engagement and support for climate change education. Public Awareness Campaigns: Increasing public awareness through local media and community events can foster a culture of environmental stewardship.	Community Engagement: Actively involving diverse community groups, including ethnic minorities, youth, elderly, and marginalised populations, in programme development and activities. Cultural Sensitivity: Implementing culturally sensitive approaches and activities that resonate with Torbay's diverse communities.	Tailored Outreach: Implement targeted communication strategies that resonate with Torbay's community demographics and cultural sensitivities. Digital Literacy Programs: Promote digital literacy and critical thinking skills to help community members navigate and counteract misinformation online

Technological factors	Barriers	Digital Infrastructure: Varied access to digital resources and technology among schools in Torbay may affect the delivery of digital components of the curriculum package. Training Needs: Educators may require training on digital tools and methodologies for effective implementation.	Digital Divide: Disparities in access to technology and digital literacy skills among different demographic groups in Torbay. Cybersecurity Concerns: Ensuring data protection and cybersecurity measures are robust when utilising digital platforms for programme activities.	Digital Divide: Addressing disparities in access to digital tools and internet connectivity among Torbay residents, which could hinder virtual participation in leadership learning sets. Data Security: Ensuring robust data protection measures during online engagements and information sharing sessions.
	Enablers	Digital Inclusion Initiatives: Expanding digital access and infrastructure in schools through local government and community initiatives can support effective digital delivery. Professional Development: Providing INSET days focused on technological skills and environmental education methodologies supports educators in integrating climate change topics.	Digital Inclusion: Providing training and support for community members to enhance digital literacy skills and facilitate their participation in online engagement activities. Accessible Platforms: Using user-friendly digital platforms that accommodate diverse technological capabilities and accessibility needs.	Digital Inclusion Initiatives: Provide equitable access to technology and internet connectivity to enhance participation in virtual learning sets across Torbay. Technology Integration: Utilise technology effectively to facilitate interactive and informative sessions, improving engagement and knowledge-sharing.
Legal Factors	Barriers	Regulatory Compliance: Ensuring compliance with Torbay's educational regulations and policies when introducing new curriculum content is essential. Data Protection: Safeguarding student data and privacy when using digital platforms for education requires adherence to local and national data protection laws.	Legal Compliance: Adhering to local laws and regulations governing community programmes, data privacy, and liability issues in Torbay. Risk Management: Mitigating legal risks associated with conflict resolution activities and participant interactions.	Compliance Issues: Adhering to Torbay's specific data protection laws and regulations when collecting and disseminating information during community engagement activities. Liability Concerns: Addressing potential legal liabilities associated with information shared or actions proposed during collaborative sessions.
	Enablers	Policy Support: Supportive local educational policies that encourage curriculum innovation and environmental education facilitate smooth integration. Collaboration with Authorities: Working closely with Torbay Council and educational authorities ensures	Legal Guidance: Accessing legal advice and support from Torbay-based legal professionals familiar with local regulations and community law. Ethical Standards: Establishing clear ethical guidelines for respectful dialogue, confidentiality, and conflict	Legal Guidance: Collaborate with local legal experts to ensure compliance with Torbay's data protection regulations and mitigate liability risks effectively. Transparency Standards: Maintain

		alignment with legal and regulatory requirements.	resolution within the programme framework.	transparent communication channels to foster trust among Torbay residents and stakeholders involved in the initiative.
Environmental factors	Enablers	Local Environmental Challenges: Addressing specific environmental issues in Torbay, such as coastal erosion and biodiversity loss, may require tailored educational content. Resource Availability: Ensuring availability of local environmental resources for hands-on learning and outdoor activities can be challenging.	Environmental Impact: Considering the environmental implications of programme activities, especially if they involve physical events or resource-intensive projects in Torbay.	Environmental Impact: Considering and mitigating the ecological footprint of community initiatives and leadership learning sets in Torbay's coastal areas.
	Barriers	Natural Assets: Leveraging Torbay's natural assets, such as its coastline and parks, for outdoor and experiential learning enhances engagement with climate change topics. Local Sustainability Initiatives: Integrating local sustainability projects and partnerships into the curriculum supports practical learning and community involvement.	Sustainability Practices: Promoting sustainable practices in programme logistics and operations, such as reducing waste and minimising carbon footprint.	Sustainable Practices: Incorporate sustainable practices into the initiative's operations and leadership training sessions to promote environmental stewardship in Torbay.

	Enablers			
--	----------	--	--	--

Table 95: CS8 - Identification of barriers and enablers for innovation related to Biodiversity

Factors	Barriers / Enablers	Pop up shop/ green café / workshop. Drought resistant alternative plants workshop
Political factors	Barriers	Local Planning Permissions: Navigating Torbay Council's specific planning permissions for setting up pop-up shops and holding public events. Policy Limitations: Existing local policies may prioritise traditional horticulture over the introduction of new, drought-resistant plant species.
	Enablers	Council Support: Torbay Council's potential support for environmental sustainability initiatives aligns with the region's goals for green and blue infrastructure. Environmental Grants: Availability of local government grants for biodiversity projects and educational initiatives in Torbay.
Economic factors	Barriers	Funding Limitations: Limited funding and sponsorship opportunities in the Torbay area might constrain the project's scale. Economic Uncertainty: Economic challenges in Torbay, such as those arising from seasonal tourism, might impact discretionary spending on gardening.
	Enablers	Tourism Boost: Attracting tourists interested in sustainable gardening and biodiversity could provide an economic boost to the local area. Local Partnerships: Collaborations with Torbay-based garden centres, local businesses, and community groups can enhance funding and resource availability.
Social Factors	Barriers	Public Scepticism: Local residents in Torbay might be sceptical of adopting new gardening practices over traditional methods. Engagement Challenges: Ensuring widespread community engagement across diverse socio-economic groups in Torbay.
	Enablers	Community Spirit: Strong community networks in Torbay (including Community Builders) can facilitate engagement and participation in workshops and events. Educational Institutions: Partnering with local schools and colleges to promote educational outreach on drought-resistant gardening.
Technological factors	Barriers	Limited Access: Potential lack of access to advanced gardening technologies and resources in some parts of Torbay. Skill Shortages: Gaps in technological expertise among local gardeners and volunteers.
	Enablers	Local Innovation Hubs: Leveraging local innovation hubs and tech communities to support the project's technological needs. Digital Outreach: Utilising Torbay's active social media presence and local online platforms to promote events and share educational content.

Legal Factors	Barriers	Regulatory Compliance: Ensuring compliance with Torbay-specific health, safety, and environmental regulations for public events and retail operations. Liability Concerns: Managing potential legal liabilities related to new plant introductions and their impact on local ecosystems.
	Enablers	Legal Assistance: Access to local legal experts who can assist with navigating regulatory requirements and compliance. Supportive Regulations: Local regulations promoting environmental sustainability and biodiversity can facilitate project implementation.
Environmental factors	Barriers	Climate Variability: Unpredictable weather patterns in Torbay, influenced by its coastal location, can affect plant growth and project outcomes. Existing Environmental Issues: Addressing existing environmental challenges in Torbay, such as soil quality and coastal erosion, which may impact gardening efforts. Introduction Risks: Risks associated with introducing non-native drought-resistant plants to Torbay's unique ecosystems. Habitat Sensitivity: Ensuring that new plant species do not negatively impact sensitive coastal and inland habitats in Torbay.
	Enablers	Biodiverse Ecosystem: Torbay's varied ecosystems provide a conducive environment for promoting and testing drought-resistant plants. Environmental Awareness: Growing environmental consciousness among Torbay residents can support the adoption of sustainable gardening practices. Local Biodiversity Projects: Alignment with ongoing biodiversity projects in Torbay, such as those led by the Torbay Coast and Countryside Trust, can enhance project credibility and support. Natural Resilience: Promoting drought-resistant plants can help build resilience in Torbay's ecosystems, contributing to broader conservation goal

CS9

Table 96: CS9 - Identification of barriers and enablers for innovation related to theme 1: sustainable agriculture

Factors	Barriers / Enablers	Innovation 1 DIGITAL TECHNOLOGIES	Innovation 2 CIRCULAR ECONOMY	Innovation 3 NEW MACHINES / TOOLS	Innovation 6 CONSERVATION AGRICULTURE
Political Factors	Barriers		Governmental policies e.g. (hampering implementation of regulation)		Implementation of UE directives into national laws
	Enablers	Governmental policies (e.g. favouring precision agriculture)		European Green Deal, IMO emissions regulation	
Economic factors	Barriers		Readiness to implement innovative circular strategies	Limited smallholder's spending capacities	Credit access
	Enablers	Policies favouring the implementation of digital solutions		High interest rates for capital investments	

Social Factors	Barriers	Resistance to change from farmers of low education level			Resistance to change due to cultural factors
	Enablers	Positive attitude towards smart, digital solutions	Increasing feasibility for closed circular solutions	Raised attitude towards sustainability	'Millennials' more attentive to sustainability and environmental pollution
Technological factors	Barriers	Low average know-how level		Unreliable Decision Support System (DSS) for rainfed crops in arid areas. Unreliable seasonal weather forecast for cropping system models.	
	Enablers	Data availability, Access to innovation	Decoupling from non-renewable energy	Disruptive technologies and processes (e.g. satellite-driven machinery)	Low cost technology availability
Legal Factors	Barriers			Restriction of usages during extreme events (e.g. heat waves)	
	Enablers	Farmers incentives favouring sustainable practices (e.g. precision agriculture)	Supporting regulation for implementing amendments and fertilizers	Farmers incentives favouring sustainable practices (e.g. low emission machines and tools)	Farmers incentives favouring sustainable practices, Soil protection regulation
Environmental factors	Barriers		Use of smelly products from waste processing (e.g. compost) with negative impact on communities	Highly impacting new machinery (e.g. seed drills and threshers) affecting soil structure	
	Enablers	Direct impact on sustainability			Long-term soil fertility conservation and restoration

Table 97: CS9 - Identification of barriers and enablers for innovation related to theme 2: local food chain

Factors	Barriers / Enablers	Innovation 1 BLOCK CHAIN	Innovation 2 FOOD CHAIN	Innovation 3 CERTIFICATION
Political Factors	Barriers		Lack of local supporting regulation	Long implementation time of UE Directives into national regulations
	Enablers		European Green Deal	
Economic factors	Barriers		Consumer purchasing power	High product certification fees for small local producers
	Enablers	Policies favouring the implementation of digital solutions	Consumer attitude towards local agri-food products	Favourable consumer attitude towards UE branding
Social Factors	Barriers	Resistance to implementation innovation	Disagreements between agri-food chain actors	
	Enablers	Positive attitude towards smart, digital solutions	Attention for circular solutions	Consumers more attentive to buy traditional agri-food products
Technological factors	Barriers	Resistance to innovations		
	Enablers	Internet of Things, Access to innovation		Enhanced access to social communication

Legal Factors	Barriers		Interference with Political factors (e.g. custom duties for commodities)	
	Enablers	Regulations favouring digital innovation	Regulations encouraging legal supply agreements between chain actors	
Environmental factors	Barriers			
	Enablers		Low GHG emissions due to reduced dependence on long-distance imports	Enhanced information about production sustainability

Table 98: CS9- Identification of barriers and enablers for innovation related to theme 3: water and energy

Factors	Barriers / Enablers	Innovation 1 ENERGY COMMUNITIES	Innovation 2 EXTRACTING GROUNDWATER TECHNOLOGIES	Innovation 3 REDUCED SALINIZATION TECHNOLOGIES
Political Factors	Barriers	Changing Governments, Effective implementation of regulation	Water Framework Directives	Water Framework Directives
	Enablers	European Green Deal, Paris Agreement		European Green Deal, From Farm to Fork Strategy
Economic factors	Barriers	Inertial attitude to implement innovative solutions	High extraction costs for deep groundwater	Low Commodity prices not outweighing increased production costs
	Enablers	Innovation potential for capital goods	Consumer spending behaviour for local products	Innovation potential for digital solutions
Social Factors	Barriers	Resistance to change	Competition for different water usages (e.g. civil, industrial)	Competition for different water usages (e.g. civil, industrial)
	Enablers	Increasing feasibility for closed circular solutions		Increasing awareness for resource depletion
Technological factors	Barriers			Limited access to innovation
	Enablers	Low cost technology availability	Low cost technology innovation	

Legal Factors	Barriers	Energy efficiency requirements	Restriction of usage during heat waves and water scarcity due to drought	Energy efficiency requirements for consumer goods
	Enablers	Supporting regulation for fighting climate change		Supporting regulation for fighting climate change
Environmental factors	Barriers		Long-term low groundwater level affecting water quality (e.g. (Salinization))	Long-term salinization risks for agricultural soils
	Enablers	Positive attitude towards Environment-friendly solutions		

Systems Innovation Approach (SIA) addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system? as a whole? and on the variety of actors. The Climate Innovation Window (CIW) is the EU reference innovations marketplace for climate adaptation technologies. ARSINOE shapes the pathways to resilience by bringing together SIA and CIW, to build an ecosystem for climate change adaptation solutions. Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing CIW technologies, or technologies by new providers (or a combination) to form an innovation package. This package may be designed for implementation to a specific region, but its building blocks are transferable and re-usable; they can be re-adapted and updated. In this way, the user (region) gets an innovation package consisting of validated technologies (expanding the market for CIW); new technologies implemented in the specific local innovation package get the opportunity to be validated and become CIW members, while the society (citizens, stakeholders) benefits as a whole. ARSINOE applies a three-tier, approach: (a) using SIA it integrates multi-faceted technological, digital, business, governance and environmental aspects with social innovation for the development of adaptation pathways to climate change for specific regions; (b) it links with CIW to form innovation packages by matching innovators with end-users/regions; (c) it fosters the ecosystem sustainability and growth with cross-



This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101037424.