



TransformAr

Accelerating and upscaling transformational adaptation
in Europe: demonstration of water-related innovation
packages

Tools on the avoided damages and benefits per demo

Deliverable 3.4



This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101036683.

Deliverable Number and Name	D3.4 - Tools on the avoided damages and benefits per demo
Work Package	WP3 – Envisioning transformative pathways for the demonstrators
Dissemination Level	Public
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Date Due	July 2023
Date Submitted	July 2023
File Name	TransformAr_WP3_D3.4_Tools_on_the_avoided_damages_and_benefits_per_demo_final.docx
Status	Version 3
Reviewed by (if applicable)	J. Cool, A. Trabuco, A. Bjornavold, R. Nagy
Suggested citation	S. Karozis, I. Zarikos, A. Sfetsos (2023) Tools on the avoided damages and benefits per demo. TransformAR Deliverable 3.4, H2020 grant no. 101036683

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This document has been prepared in the framework of the European project TransformAR. This project has received funding from the European Union’s Horizon 2020 innovation action programme under grant agreement no. 101036683.

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TransformAR

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ABBREVIATIONS

Abbreviations	Description
TADF	TransformAr Avoided Damaged Framework
TADA	TransformAr Avoided Damaged Application
DSS	Decision Support System
WP	Work Package
CEI	Choice Experiment for Investors
URB	Urban runoff system
CAF	Crowdsourcing Citizen app
ICW	Integrated Constructed Wetlands
ICWM	Integrated Constructed Wetlands Monitoring
GB	Green Bonds
NBS	Nature-Based Solution
AF	Local Adaptation Fund
NUDG	Nudging
MRM	Mussel-Raft Monitoring
INTERM	Intertidal monitoring
RI	Resilience Index
INSUR	Insurance scheme
SCS	Smart Climate Stations
CAE	Citizen App Engagement
AWAR	Awareness-raising modules
CIH	Climate Innovation Hub
SG	Smart Grid and gates
COAST	Coastal contract
DSI	Demand analysis for social Services/Infrastructures
DB	Database
CEI	Choice experiment



EXECUTIVE SUMMARY

The current deliverable is type “Other” and this document is functioning as a summary presentation of two main elements of Task 3.3 - Analysis of avoided damages and other direct benefits of pathways at demonstrator scale:

1. The TransformAr Avoided Damages Framework (TADF)
2. The TransformAr Avoided Damages web-based Application (TADA)

The TADF includes and integrates the steps that demonstrators followed in order to decide the climate hazards of interest, the solutions that address them and a way to quantify the effectiveness via the calculation of KPIs before and after the implementation of the solution. On the other hand, TADA is a web-based application that functions as a presentation of tools and solutions used for the TransformAr project, and at the same time as potential replicator to find the most relevant solution based on a multicriteria selection.

D3.4 serves as an information baseline to communicate on the project impacts, support policy making, and serve as a basis for Task 3.4. Moreover, the experience and knowledge gained from the demonstrators, will be used to produce a guideline of good practices, to disseminate results and render them usable and useful in other cases (D3.5).

1.0 Introduction

In the current deliverable, the TransformAR Avoided Damages Framework (TADF) and the TransformAR Avoided Damages web-based application (TADA) are presented for evaluating and assessing effectiveness or avoided damages of the adaptation pathways produced in Task 3.2 per demonstrator.

The term *Avoided Damages* could have different interpretations depending on the context. However, in general terms, it refers to taking measures or actions to prevent or minimize damage from occurring hazards. In the existing literature there is absence of an “Avoided damages” approach. The general approach is the cost-benefit analysis of adaptation efforts, based mainly on the economic impact (losses), by the various hazards. The majority of the approaches applied to date are focused on the post-disaster analysis and adaptation of disasters, without prevention planning and analysis of the potential associated economic and environmental hazards. An attempt, similar to the approach of TADF, of a pre-disaster framework is published by UNESCO¹. In addition, Valverde, M. J., et al., 2022² proposed an avoided damages due to floods that are directly correlated to climate change and it is aiming to bridge the gap between pre- and post-hazards assessment. More precise, a series of suggested steps, from defining the cost of inaction to monetise the adaptation costs, are presented, alongside the cases of Austria and France. As it is stated, the data of aforementioned cases cannot extrapolated to European level.

In the context of the TransformAR project and the *Task 3.3 - Analysis of avoided damages and other direct benefits of pathways at demonstrator scale*, Avoided Damages are the quantification of potential effectiveness of solutions implemented at demonstrator level to cope with climate change risks. The solutions have been proposed by the demonstrators of the TransformAR project during the compilation of the proposal and have been discussed and agreed upon with stakeholders during the demonstrators’ workshops (Task 3.2). The adaptation pathways defined in Task 3.2 were derived to be elaborated in the context of Avoided Damages and utilizing the tools and data compiled in WP2 to estimate the effectiveness of the solutions. Towards the latter, the TADF was compiled and applied to the demonstrators.

In addition, TADA works as a presentation of tools used by the demonstrators, their descriptions and the presentation of results of the solution using Key Performance Indicators (KPIs)³ via an online interface. Moreover, a multicriteria function is accommodating possible replicators to find information on the project impacts at demonstrator level, and the most relevant solutions for their region / hazard / type of solution. The good practices and guidelines for avoiding damages and other direct costs in regional governance scale will be derived from TADA and described in D3.5.

¹ <https://unesdoc.unesco.org/ark:/48223/pf0000384487>

² Valverde, M. J., et al., 2022, Costs of adaptation vs costs of inaction

³ Key Performance Indicators (KPIs) are measurable values that organizations use to assess the success or effectiveness of specific actions, processes, or strategies. KPIs help monitoring progress, identify areas for improvement, and evaluate the overall performance of an action.

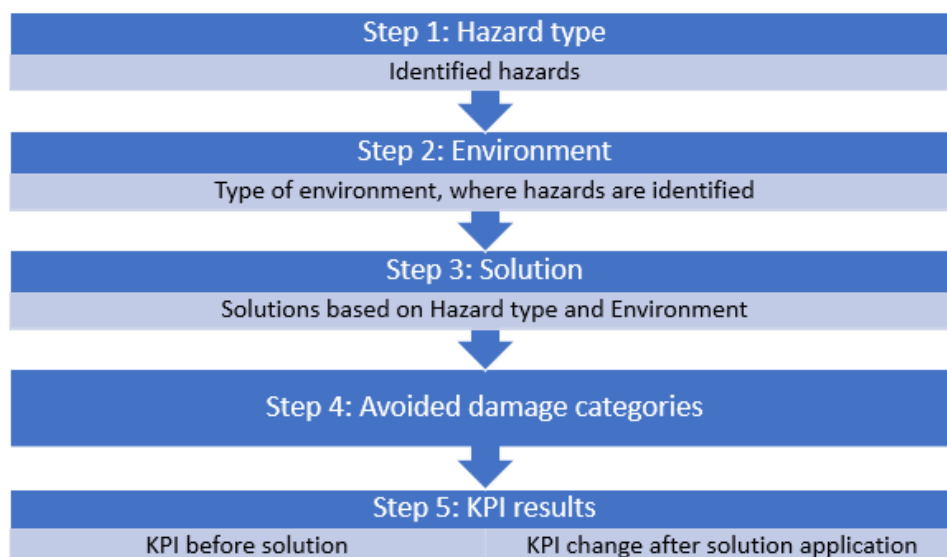
2.0 TransformAr Avoided Damage Framework

The TADF identifies what hazards are relevant, which tools and solutions are available to minimize damages, estimate damage values per hazard or/and avoided damage per solution and/or climate pathway, and what KPIs (per hazard and solution) shall be used for quantification. The framework is divided in five steps, shown in Figure 2.1: (1) is the characterizations of hazards in the study area; (2) the characterization of the environment type in the study area (coastal, rural, tropical, riparian zone); (3) available solutions can be selected based on the hazard and environment type’s characteristics; (4) the KPIs available for the evaluation/quantification of the solution are generated and (5) the effectiveness of the applied solutions via comparison of a baseline scenario (no adaptation solution implemented) against a scenario with implementation of the solution(s).

For each demonstrator, the 5 impact categories of TADF need to be evaluated, of which damages, quantified via KPI from existing practices, works, and tools:

- Physical
- Social
- Environmental
- Health
- Economic

Figure 2.1 Avoided damages framework.



These impact categories are linked to the adaptation pathways and hazards for each region individually. Based on information provided, the impact quantification can be extracted via tools and models from WP2 or by expected estimation from experts. The expert input can be a percentage estimation of the amount of change in the KPI used, based on their experience, knowledge, literature review or best practices. A comparison of quantified values with and without implementation of planned solution for a set of climate scenarios will provide the assessment of avoided damages. Given the multi-component (size, sector, type and number of solutions, and local characteristics) complexity



of the avoid damages assessment, both qualitative and quantitative assessment values will be taken into account. ANNEX B: KEY PERFORMANCE INDICATORS presents a series of KPIs that demonstrators and replicators can choose from.

TADF consists of the steps below:

1. Mapping of tools & quantification per solution for the 5 impact categories
2. Use data to estimate [step] damage function for the KPIs (utilizing WP2 tools and models, outcomes of Task 2.5 or/and expert opinion)
3. Utilize adaptation pathways (T3.2) to calculate damages per hazard or/and solution

In ANNEX A: Application per demo, the implementation of the framework per hazard and the data gathered from the demonstrators of the TransformAr are presented. In the next section, the TADA is described.

It is noted, that in D3.5, that concerns the good practices and guidelines for avoiding damages and other direct costs in regional governance scale, will include an update of TADF based on the TADA data and TransformAr Demonstrators feedback during the implementation. The updated version will be based on the feedback from implementing in the demonstrators of TransformAr and incorporating the knowledge, tools and data from WP2.

3.0 TransformAr Avoided Damage Application

The TADF presented in the previous section is applied to the demonstrators and the data gathered were compiled and utilized to create TransformAr avoided damage application (TADA), a web-based application that functions as a presentation of tools used by the demonstrators, their descriptions and the presentation of results of the solution. TADA can also be used as a Decision Support System (DSS) to support the avoided damages framework for potential replicators, policy makers and communicate the project impacts.

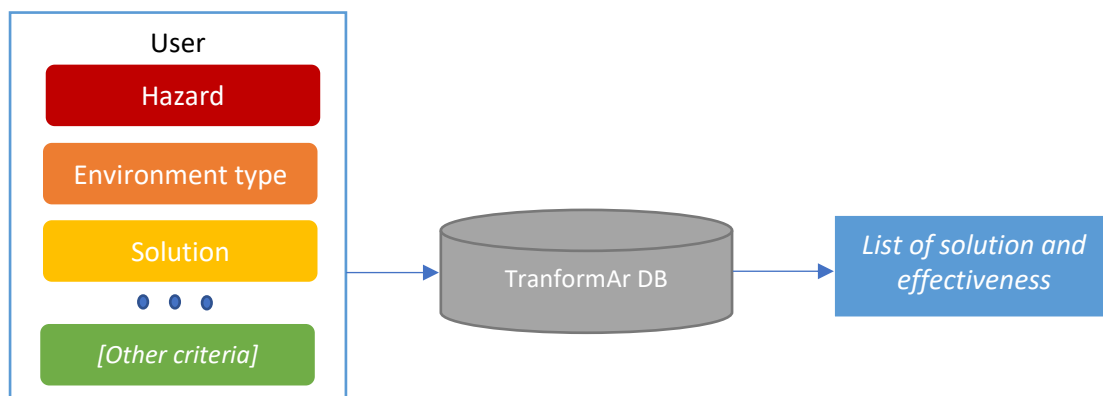
TADA is based on a multi-criteria method tailored to the needs and transformation pathways adopted by each demonstrator. The DSS tool takes into account the geographic location and specific climate conditions and risks of each demonstrator, the sectors affected by these risks, the actionable solutions adapted by them, and the KPI for each solution.

Figures 3.1, 3.2, 3.3 and 3.4 illustrate the workflow of TADA and the web-based interface for the TransformAr project. The interface has been developed in order to help users beyond TransformAr:

1. To learn what solutions and tools have been used to assess avoided damages in the project
2. To communicate the project impacts and effectiveness of solutions, and support policy making
3. To facilitate users with multi-criteria decisions of solution for their cases.

In the case of (3), TADA helps the user to follow a series of choices (decide what filters are relevant to their case) that present with the relevant and effective solutions already tested from TransformAr demonstrators. For each solution, the way it was assessed and information on how it can be further replicated (D3.5) will be available.

Figure 3.1 TADA workflow



TADA can be found at: https://mssg.ipta.demokritos.gr/transformar_tools_repo/

Figure 3.2 TADA main page.

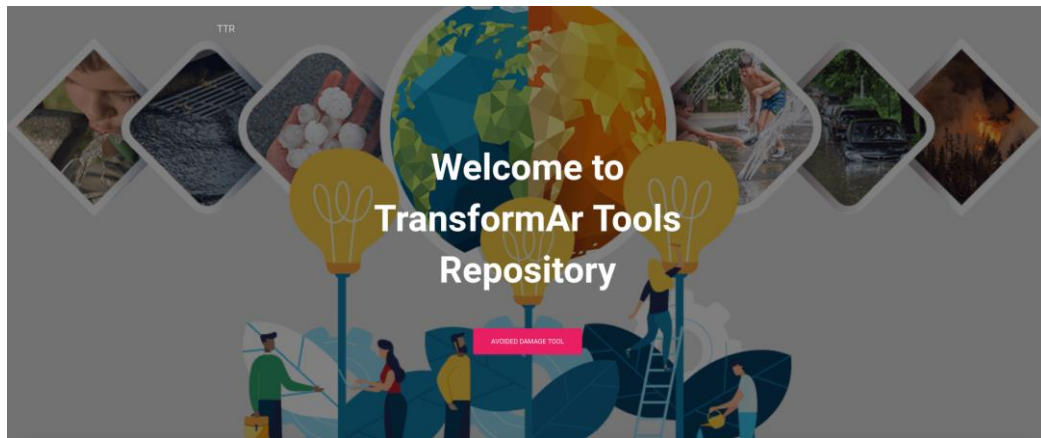



Figure 3.3 TADA multi-criteria interface.

☰ Avoided damages DSS



TransformAr - Tools on the avoided damages and benefits per demo

Hazard:

Environment type:

Solution:

Index	Impact	Category	KPI Name	KPI Definition	KPI Equa
156	Economy	Climate Hazards	Global Climate Risk Index	The Global Climate Risk Index shows the level of exposure and vulnerability to extreme weather events	Number
176	Health	Climate Hazards	Global Climate Risk Index	The Global Climate Risk Index shows the level of exposure and vulnerability to extreme weather events	Number
171	Environmental	Climate Hazards	Global Climate Risk Index	The Global Climate Risk Index shows the level of exposure and vulnerability to extreme weather events	Number
166	Social	Climate Hazards	Global Climate Risk Index	The Global Climate Risk Index shows the level of exposure and vulnerability to extreme weather events	Number
161	Physical / Infrastructure	Climate Hazards	Global Climate Risk Index	The Global Climate Risk Index shows the level of exposure and vulnerability to extreme weather events	Number
151	Economy	Economic Growth	GDP per capita	NaN	NaN
116	Social	Economic Growth	GDP Growth Contribution	Variation in total GDP Growth once the policy is implemented, compared to a no-policy scenario	Growth C
141	Economy	Economic Growth	Import value index	NaN	Import vi
136	Social	Economic Growth	Import value index	NaN	Import vi
131	Economy	Economic Growth	Unemployment Rate	Percentage of the labour force unemployed (working-age residents without work divided by total labour force)	% of unes
126	Social	Economic Growth	Unemployment Rate	Percentage of the labour force unemployed (working-age residents without work divided by total labour force)	% of unes
121	Economy	Economic Growth	GDP Growth Contribution	Variation in total GDP Growth once the policy is implemented, compared to a no-policy scenario	Growth C
146	Social	Economic Growth	GDP per capita	NaN	NaN
203	Social	Human needs satisfaction	Drinking water access	People using safely managed drinking water services (%)	% of popi
194	Physical / Infrastructure	Human needs satisfaction	Safe sanitation access	Percentage of population with access to improved sanitation facilities/ People using safely managed sanitation services	% of popi

*** This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101036683.

Figure 3.4 TADA, when specific filters can be applied.

Create a new demo x

Demonstrator: Hazard: Environment type:

Solution: Impact: Category:

KPI Name: KPI Definition:

KPI Equation/Formula: Source (if any):

The main application comprises of two parts. The multicriteria section on the left, where the user can choose the type of hazard, type of environment, and applied solution. In addition to that, the application allows the user to import new data to the database. Based on the multicriteria selection, the results are presented on the right-hand section on the app. The results comprise of:

- Impact category
- KPI category
- KPI name
- KPI definition
- KPI equation/source



4.0 Integration in TransformAr and beyond

The current deliverable serves as a summary presentation of two essential components of Task 3.3 - Analysis of avoided damages and other direct benefits of pathways at the demonstrator scale.

The TransformAr Avoided Damages Framework (TADF) is a framework encompasses the steps undertaken by demonstrators to identify climate hazards, select appropriate solutions, and quantify their effectiveness through Key Performance Indicators (KPIs) before and after implementation.

The TransformAr Avoided Damages web-based Application (TADA) *serves as both a showcase of tools and solutions utilized in the TransformAr project and a potential replicator, allowing users to find relevant solutions based on a multicriteria selection process.*

Under the TransformAr project, TADF and TADA will provide a comprehensive and replicable workflow to estimate the effectiveness of the solutions implemented during the project. At the same time, they will function as DB for all solutions and best practices of the TransformAr project, that will help potential replicators to choose and assess their solution beyond TransformAr.

ANNEX A: Application per demo

Annex A presents the available solutions and the linked KPIs for each impact category for each case study (shown in Section 2).

Municipality of Egaleo

Heatwaves

	Physical	Social	Environmental	Health	Economic
KPI per category		Imports of goods and services (% of GDP)		Global Climate Risk Index	GDP deflator
		GDP Growth Contribution		Fire Weather Index	Exports of goods and services (% of GDP)
	Increased integration of RES	Unemployment Rate	Reduced emissions	Air Quality Index	Imports of goods and services (% of GDP)
	Global Climate Risk Index	Increased integration of RES	Global Climate Risk Index	Health impacts of exposure to noise from transport	GDP Growth Contribution
	Fire Weather Index	Global Climate Risk Index	Fire Weather Index	Mortality Rate	Production-based CO2 intensity, energy-related CO2 per capita
	Safe sanitation access	Fire Weather Index	Air Quality Index	Life expectancy rates	Unemployment Rate
	Resilience Index	Mortality Rate	Air pollution	Quality of health services	Reduced emissions
	Risk exposure	Quality of health services	Resilience Index	Death rate	Increased integration of RES
	Access to energy	Death rate	Risk exposure	Air pollution	Global Climate Risk Index
		Safe sanitation access		Healthy life expectancy	Fire Weather Index



		Healthy life expectancy		Resilience Index	Health impacts of exposure to noise from transport
		Resilience Index		Risk exposure	Resilience Index
		Local risk perception			Risk exposure
		Risk exposure			Access to energy
		Risk perception			
Solution	Climate Innovation Hub	Climate Innovation Hub	Climate Innovation Hub	Climate Innovation Hub	Climate Innovation Hub
	Demand analysis for social services/infrastructures (DSI)	Demand analysis for social services/infrastructures (DSI)	Demand analysis for social services/infrastructures (DSI)	Demand analysis for social services/infrastructures (DSI)	Demand analysis for social services/infrastructures (DSI)
	Smart climate stations (SCS)	Smart climate stations (SCS)	Smart climate stations (SCS)	Smart climate stations (SCS)	Smart climate stations (SCS)
	Citizen app (CAE)	Citizen app (CAE)	Citizen app (CAE)	Citizen app (CAE)	Citizen app (CAE)
Percentage affected due to CC [%]					

Guadeloupe Archipelago

Drought

	Physical	Social	Environmental	Health	Economic
KPI per category		GDP Growth Contribution			
		Unemployment Rate			
	Global Climate Risk Index	Import value index		Global Climate Risk Index	GDP Growth Contribution
	Water stress level	GDP per capita	Global Climate Risk Index	Water stress level	Unemployment Rate
	Safe sanitation access	Global Climate Risk Index		Drinking water access	Import value index
	Drinking water access	Water stress level			GDP per capita
		Safe sanitation access			Global Climate Risk Index
		Drinking water access			
			Risk perception		
Solution	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)
	Nudging (NUDG)	Nudging (NUDG)		Nudging (NUDG)	
Percentage affected due to CC [%]					

Coastal erosion

	Physical	Social	Environmental	Health	Economic
KPI per category	Global Climate Risk Index	GDP Growth Contribution Unemployment Rate Import value index GDP per capita Global Climate Risk Index Risk perception	Global Climate Risk Index	Global Climate Risk Index	GDP Growth Contribution Unemployment Rate Import value index GDP per capita Global Climate Risk Index
Solution	Adaptation Fund (AF)	Adaptation Fund (AF) Nudging (NUDG)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)
Percentage affected due to CC [%]					

Flood

	Physical	Social	Environmental	Health	Economic
KPI per category	Global Climate Risk Index Water stress level Safe sanitation	GDP Growth Contribution Unemployment Rate	Global Climate Risk Index Resilience Index	Global Climate Risk Index Water stress level	GDP Growth Contribution Unemployment Rate Import value index

	access	Import value index		Death rate	GDP per capita
	Drinking water access	GDP per capita		Drinking water access	Global Climate Risk Index
	Resilience Index	Global Climate Risk Index		Resilience Index	Resilience Index
		Water stress level			
		Death rate			
		Safe sanitation access			
		Drinking water access			
		Resilience Index			
		Risk perception			
Solution	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)
	Nudging (NUDG)	Nudging (NUDG)		Nudging (NUDG)	
Percentage affected due to CC [%]					

Hurricane

	Physical	Social	Environmental	Health	Economic
KPI per category	Global Climate Risk Index	Imports of goods and services (% of GDP)	Global Climate Risk Index	Global Climate Risk Index	Exports of goods and services (% of GDP)

	Safe sanitation access	GDP Growth Contribution	Resilience Index	Death rate	Imports of goods and services (% of GDP)			
	Drinking water access	Unemployment Rate		Drinking water access	GDP Growth Contribution			
	Resilience Index	Import value index		Resilience Index	Resilience Index	Unemployment Rate		
		GDP per capita				Import value index		
		Global Climate Risk Index				GDP per capita		
		Death rate				Global Climate Risk Index		
		Safe sanitation access				Resilience Index		
		Drinking water access				Risk perception		
		Adaptation Fund (AF)				Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)
		Nudging (NUDG)						
Percentage affected due to CC [%]								

Rising temperatures

	Physical	Social	Environmental	Health	Economic
KPI per category		GDP Growth Contribution			
		Unemployment Rate			GDP Growth Contribution
	Global Climate Risk Index	Import value index		Global Climate Risk Index	Unemployment Rate
	Water stress level	GDP per capita	Global Climate Risk Index		Import value index
		Global Climate Risk Index			GDP per capita
		Water stress level			Global Climate Risk Index
			Risk perception		
Solution	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)	Adaptation Fund (AF)
	Nudging (NUDG)	Nudging (NUDG)		Nudging (NUDG)	
Percentage affected due to CC [%]					

Galicia

Aquaculture

	Physical	Social	Environmental	Health	Economic
KPI per category	Global Climate Risk Index	Global Climate Risk Index	Reduced emissions	Global Climate Risk Index	Reduced emissions
	Resilience Index	Resilience Index Local risk perception	Global Climate Risk Index Resilience Index	Resilience Index	Global Climate Risk Index Resilience Index
	Risk exposure	Risk exposure	Risk exposure	Risk exposure	Risk exposure
Solution	Resilience Index (RI)	Resilience Index (RI)	Resilience Index (RI)	Resilience Index (RI)	Resilience Index (RI)
	Intertidal monitoring (INTERM)	Intertidal monitoring (INTERM)	Intertidal monitoring (INTERM)	Intertidal monitoring (INTERM)	Intertidal monitoring (INTERM)
	Mussel raft monitoring (MRM)	Mussel raft monitoring (MRM)	Mussel raft monitoring (MRM)	Mussel raft monitoring (MRM)	Mussel raft monitoring (MRM)
Percentage affected due to CC [%]					

Oristano

Flooding

	Physical	Social	Environmental	Health	Economic
KPI per category		GDP Growth Contribution	Reduced emissions		Exports of goods and services (% of GDP)
	Global Climate Risk Index	Global Climate Risk Index	Global Climate Risk Index	Global Climate Risk Index	GDP Growth Contribution
	Water stress level	Water stress level	Sea surface temperature anomalies	Water stress level	Reduced emissions
	Resilience Index	Resilience Index	Resilience Index	Resilience Index	Global Climate Risk Index
	Risk exposure	Risk exposure	Risk exposure	Risk exposure	Resilience Index
			Risk perception	Risk exposure	
Solution	CAF	CAF	CAF	CAF	CAF
Percentage affected due to CC [%]					

Lappeenranta

Flooding

	Physical	Social	Environmental	Health	Economic
KPI per category	Human needs satisfaction Behavioral Change Climate Hazards	Economic Growth Human needs satisfaction Behavioral Change	Behavioral Change Climate Hazards	Human needs satisfaction Behavioral Change Climate Hazards	Inflation Economic Growth Behavioral Change Climate Hazards
Solution	URB SWMM CAF	CEI SWMM URB CAF	URB SWMM CAF	URB SWMM CAF	CEI SWMM URB CAF
Percentage affected due to CC [%]					

Extreme weather events

	Physical	Social	Environmental	Health	Economic
KPI per category	Vulnerability and Resilience	Vulnerability and Resilience Behavioral Change	Vulnerability and Resilience	Vulnerability and Resilience	Vulnerability and Resilience
Solution	CAF	CAF	CAF	CAF	CAF
Percentage affected due to CC [%]					

Increased rainfall

	Physical	Social	Environmental	Health	Economic
KPI per category	Climate Hazards	Climate Hazards	Climate Hazards	Climate Hazards	Climate Hazards
Solution	URB	URB	URB	URB	URB
	SWMM	SWMM	SWMM	SWMM	SWMM
Percentage affected due to CC [%]					

Deterioration of water quality

	Physical	Social	Environmental	Health	Economic
KPI per category	Behavioral Change	Behavioral Change	Behavioral Change	Behavioral Change	Behavioral Change
Solution	CAF	CAF	CAF	CAF	CAF
					SWMM
Percentage affected due to CC [%]					

Water quality

	Physical	Social	Environmental	Health	Economic
KPI per category	Human needs satisfaction	Human needs satisfaction		Human needs satisfaction	Inflation
Solution	URB	URB		URB	
	SWMM	SWMM		SWMM	CEI
Percentage affected due to CC [%]					

West Country Region

Drought

	Physical	Social	Environmental	Health	Economic
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KPI per category	Resource efficiency (Water)	Resource efficiency (Water)	Trade	Resource efficiency (Water)	Trade
	Behavioral Change	Behavioral Change	Carbon Footprint	Behavioral Change	Carbon Footprint
Solution	ICW	ICW	Resource efficiency (Water)	ICW	Resource efficiency (Water)
	NBS	NBS	Behavioral Change	NBS	Behavioral Change
				GB	GB
Percentage affected due to CC [%]					

Flooding

	Physical	Social	Environmental	Health	Economic
KPI per category	Resource efficiency (Water)	Trade	Trade	Resource efficiency (Water)	Trade
	Behavioral Change	Resource efficiency (Water)	Carbon Footprint	Behavioral Change	Carbon Footprint
Solution	ICW	Behavioral	Resource efficiency (Water)	ICW	Resource efficiency (Water)
	NBS		Behavioral Change	NBS	Behavioral Change
		ICW	ICW	GB	GB
		NBS	NBS		
		GB	GB		



Percentage affected due to CC [%]					
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Biodiversity loss

	Physical	Social	Environmental	Health	Economic
KPI per category	Vulnerability and resilience	Vulnerability and resilience Behavioral Change	Vulnerability and resilience Behavioral Change		Vulnerability and resilience Behavioral Change
Solution	ICW NBS	ICW NBS ICWM	ICW NBS ICWM		ICW NBS ICWM
Percentage affected due to CC [%]					

ANNEX B: KEY PERFORMANCE INDICATORS

Annex B presents each KPI used in this framework to quantify the effectiveness of a single or the combination of multiple solutions.

Category	KPI Name	KPI Definition	KPI Units Formula	Indicative source (if any)
Inflation	GDP deflator	The GDP price deflator shows how much a change in GDP relies on changes in the price level.	Percentage Directly from data	https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH#
Trade	Exports of goods and services (% of GDP)	Transactions in goods and services (sales, barter, and gifts) from residents to non-residents.	Percentage Directly from data	https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH#
Trade	Imports of goods and services (% of GDP)	Transactions in goods and services (sales, barter, and gifts) from residents to non-residents.	Percentage Directly from data	https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH#
Economic Growth	GDP Growth Contribution	Variation in total GDP Growth once the policy is implemented, compared to a no-policy scenario	Dimensionless Growth GDP (with policy) / Growth GDP (no-policy)	Based on previous indicators and applying effectiveness logic

CO2 Productivity	Production-based CO2 intensity, energy-related CO2 per capita	Production-based CO2 intensity is calculated as CO2 emissions per capita (tonnes/person). Included a	Tonnes Directly from data	https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH#
Energy productivity	Renewable energy supply, % total energy supply	Renewable energy supply is calculated as a share of renewable sources in TES (expressed as percentage).	Percentage Directly from data	https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH#
Economic Growth	Unemployment Rate	Percentage of the labour force unemployed (working-age residents without work divided by total labour force)	% of unemployment Directly from data	
Economic Growth	Import value index		Import value index Directly from data	https://data.worldbank.org/indicator/TM.UVI.MRCH.XD.WD
Economic Growth	GDP per capita		Local currency Directly from data	http://wdi.worldbank.org/table/WV.1
Carbon Footprint	Reduced emissions	Variation of annual total carbon dioxide equivalent emissions from energy production, transportation and industry.	Total annual emissions (%) Directly from data	https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Energy transition	Increased integration of RES	Variation of the share of capacity from renewable energy sources	Total RES capacity (%) Directly from data	
Land use	Deforestation rate	The total forest surface area that is cut down each year	Ha/year of forest loss Directly from data	Schokker, J., Kamilaris, A., & Karatsiolis, S. (2021). A Review on Key Performance Indicators for Climate Change. <i>Advances and New Trends in Environmental Informatics: A Bogeyman or Saviour for the UN Sustainability Goals?</i> , 273-292.
Climate Hazards	Global Climate Risk Index	The Global Climate Risk Index shows the level of exposure and vulnerability to extreme weather events	Number of deaths – Weight: 1/6, Number of deaths per 100,000 inhabitants – Weight: 1/3, Sum of losses in purchasing power parity (PPP) – Weight: 1/6, Losses per unit of Gross Domestic Product (GDP) – Weight: 1/3 Directly from data	Schokker, J., Kamilaris, A., & Karatsiolis, S. (2021). A Review on Key Performance Indicators for Climate Change. <i>Advances and New Trends in Environmental Informatics: A Bogeyman or Saviour for the UN Sustainability Goals?</i> , 273-292.
Climate Hazards	Fire Weather Index	Assess fire risk based on meteorological conditions	Based on 24-hour accumulated precipitation and daily values of air temperature, relative humidity,	https://www.eea.europa.eu/ims#c0=10&c12-operator=or&b_start=0


			and wind speed Directly from data	
Climate Hazards		Monitors trends in average sea surface temperature anomalies	T °C Directly from data	https://www.eea.europa.eu/ims#c0=10&c12-operator=or&b_start=0
Resource efficiency (Water)	Water stress level	The ability to meet a region's demand for water	Low-high ability to meet a region's demand for water Directly from data	Schokker, J., Kamilaris, A., & Karatsiolis, S. (2021). A Review on Key Performance Indicators for Climate Change. Advances and New Trends in Environmental Informatics: A Bogeyman or Saviour for the UN Sustainability Goals?, 273-292.
Pollution	Air Quality Index	Ranking of cities/countries based on annual average PM2.5 concentration ($\mu\text{g}/\text{m}^3$)	Annual average of PM2.5 concentration ($\mu\text{g}/\text{m}^3$) Directly from data	Schokker, J., Kamilaris, A., & Karatsiolis, S. (2021). A Review on Key Performance Indicators for Climate Change. Advances and New Trends in Environmental Informatics: A Bogeyman or Saviour for the UN Sustainability Goals?, 273-292.
Pollution	Health impacts of exposure to noise from transport	Chronic exposure to environmental noise significantly affects physical and mental health and well-being	Range and magnitude of chronic high annoyance and high sleep disturbance due to noise from transport Directly from data	https://www.eea.europa.eu/ims#c0=10&c12-operator=or&b_start=2

Health & Safety	Mortality Rate	The mortality rate is calculated by dividing the number of total deaths by the population size for a defined population or geographical area over a specified period.	Tot deaths/population Directly from data	
Health	Life expectancy rates	An indicator that can help measure a person's health in a community	Life expectancy rates Directly from data	Zare Mehrjerdi, Y., Alemzadeh, R. & Hajimoradi, A. Dynamic analysis of health-related factors with its impacts on economic growth. SN Appl. Sci. 2, 1440 (2020). https://doi.org/10.1007/s42452-020-03203-1
Health	Quality of health services	Level of progress in the field of medical equipment and improvement in therapeutic methods		Zare Mehrjerdi, Y., Alemzadeh, R. & Hajimoradi, A. Dynamic analysis of health-related factors with its impacts on economic growth. SN Appl. Sci. 2, 1440 (2020). https://doi.org/10.1007/s42452-020-03203-3
Health	Death rate	It is a measure that affects the population	Death rate Directly from data	Zare Mehrjerdi, Y., Alemzadeh, R. & Hajimoradi, A. Dynamic analysis of health-related factors with its impacts on economic growth. SN Appl. Sci. 2, 1440 (2020). https://doi.org/10.1007/s42452-020-03203-4
Health	Air pollution	Health impacts of air pollution: air pollutants and greenhouse gases	Years of life lost or Premature death in [Number] or [rate] Directly from data	Eurostat
Human needs satisfaction	Safe sanitation access	Percentage of population with access to improved sanitation facilities/ People using	% of population Directly from data	World Bank, 2020

		safely managed sanitation services		
Human needs satisfaction	Drinking water access	People using safely managed drinking water services) (%)	% of population Directly from data	World Bank, 2020
Human needs satisfaction	Healthy life expectancy	The indicator Healthy Life Years (HLY) at birth measures the number of years that a person at birth is still expected to live in a healthy condition. HLY is a health expectancy indicator which combines information on mortality and morbidity. The data required are the age-specific prevalence (proportions) of the population in healthy and unhealthy conditions and age-specific mortality information. A healthy condition is defined by the absence of	age-specific prevalence (proportions) of the population in healthy and unhealthy conditions and age-specific mortality information Directly from data	IHME GBD (2019); Eurostat (2020): https://vizhub.healthdata.org/gbd-results/ https://ec.europa.eu/eurostat/databrowser/view/tps00150/default/table?lang=en

		limitations in functioning/disability.		
Human needs satisfaction	Sufficient nourishment	Percentage of population meeting dietary energy requirements (%) calculated as reverse of prevalence of undernourishment (rescaled onto scale from 0%-100%)	Ratio Directly from data	WB WDI 2020; Eurostat SDG
Vulnerability and Resilience	Resilience Index	Data on safety and risk collected in the World Risk Poll from over 125,000 people in 121 countries. The Resilience Index is an average of 4 domains: Individual,	Survey Directly from data	World Risk Poll

		Household, Community, Society.		
Behavioral Change	Local risk perception	Perception of risk that one's local area will be affected by climate change	Survey Directly from data	
Behavioral Change	Risk exposure	A person's actual exposure to environmental hazards, such as noise or pollution.		
Behavioral Change	Risk perception	perceptions about threats through climate change and environmental catastrophes and how likely they are or will be prevented	Survey Directly from data	European Social Survey 2016; International Social Survey Programme: Environment IV - 2020; Attitudes of Europeans towards Biodiversity. Special Eurobarometer 481, 2018
Vulnerability and Resilience	Access to energy	Access to electricity, urban Access to electricity, rural	% of population Directly from data	https://databank.worldbank.org/source/world-development-indicators



Climate change impacts are here and now. The impacts on people, prosperity and planet are already pervasive but unevenly distributed, as stated in the new EU Blueprint strategy (European Commission-EC, 2019). To reduce climate-related risks, the EC and the IPCC agree that transformational adaptation is essential. The TransformAr project aims to develop and demonstrate products and services to launch and accelerate large-scale and disruptive adaptive process for transformational adaptation in vulnerable regions and communities across Europe.

The 6 TransformAr lighthouse demonstrators face a common challenge: water-related risks and impacts of climate change. Based on existing successful initiatives, the project will develop, test and demonstrate solutions and pathways, integrated in Innovation Packages, in 6 territories.

Transformational pathways, including an integrated risk assessment approach are co-developed by means of 9 Transformational Adaptive Blocks. A set of 22 tested actionable adaptive solutions are tested and demonstrated, ranging from nature-based solutions, innovative technologies, financing, insurance and governance models, awareness and behavioral change solutions.



TransformAr



This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101036683.

