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Make the Change

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Assessment and selection of the KPIs

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1	10/04/2024	Complete version of the KPI library presented to the whole consortium

2	27/06/2024	FInal version revised by the consortium and with the addition of a user guide.

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1 Introduction

This report is devoted to an initial mapping of a broad family of Key Performance Indicators (KPIs) aimed at assessing project impacts, and the efficacy of the actions implemented by the project in terms of reduction of climate-change impacts, capacity building, public acceptance, and additional benefits of the interventions. The document is based on the review of the research output of major initiatives and projects that tackled adaptation in the Po Valley region and on the critical revision by the whole Climax-Po consortium. The key content introduced and described by the report is the KPI Library which identifies and categorises a set of KPIs adopted by Climax-Po. After this brief introduction, section 2 discusses the methodology implemented to select and classify the indicators, section 3 describes the KPI library, section 4 provides guidance for the use of the library and section 5 summarises the key points for the uptake of the library if the monitoring activities.

2 Monitoring methodology

In consideration of the holistic approach adopted by CLIMAXPO, the reduction of climate-change impacts is foreseen by strengthening multi-sector and multidisciplinary scientific and technical knowledge on climate change by creating a Multilevel Governance Deal (MGD) able to reorganize the climate adaptation governance (WP2 and WP3). At the same time efficacy of the implementation of adaptation measures is assisted by actions for achieving awareness of stakeholders and local communities on climate change issues regarding water resources through co-design and experimental activities (WP4).

Specifically, here we propose a workflow for the selection of KPIs that are based on the tested methodology developed during OPERANDUM (OPEn-air laboRAtories for Nature baseD solutions to Manage Environmental risk, 2018-2022), a Horizon-2020 project funded by the European Commission to provide new evidence concerning the feasibility of addressing hydrometeorological hazards effectively through the development and analysis of Nature-Based Solutions (NBS). In this initial phase of CLIMAXPO, we have discussed with the consortium the opportunity of selecting KPIs from a library of 303 indicators developed in OPERANDUM and 12 new KPIs that we proposed for the project assessment. Concerning the latter, new additions will occur in the other phases of the project (Deliverable 9.6).

An important component of the workflow is the adoption of a comprehensive methodology developed in OPERANDUM and illustrated below. The workflow (see Figure 9.1) includes 1) the Integrated Environmental Performance Assessment, 2) the risk assessment, 3) the assessment of indirect benefits, 4) the cost-benefit assessment, and 5) the evaluation of public acceptance.

Component 1 represents the direct connection between the mitigation measures (e.g., NBS) and the addressed hazards. The action of the mitigation measures on the hazard characteristics goes through changes in actionable and impact variables. Actionable variables are bio-geophysical variables that mediate between the measures and hazards. Actionable variables are both 1) directly modified by the mitigation measures and 2) can affect the local mitigation-measure impact on the hazards which is quantified by the so-called impact variables. Impact variables are bio-geophysical variables that can be used to 1) describe the modified natural process, 2) quantify the impact of extreme hydro-meteorological events, and 3) estimate the effectiveness of mitigation measures through their modification by the actionable variables. In principle, actionable and impact variables may coincide. Since the modification of an impact variable implies that the mitigation measures can reduce the magnitude, duration, or frequency of occurrence of hazards, then the risks for society and ecosystems will be reduced as well leading to beneficial outcomes (Component 2). These outcomes translate into direct (market) benefits (e.g., reduction of damage to properties) that can be assessed from the hazard perspective without affecting both exposure and vulnerability. However, mitigation measures can also alter these two elements of the risk assessment by providing indirect benefits (i.e., monetary estimates of co-benefits such as recreation, biodiversity, and human health; Component 3). The estimate of costs and benefits leads to the evaluation of the mitigation measures cost-efficiency through cost-benefit analyses (Component 4). Lastly, the methodology includes the assessment of public acceptance (Component 5) by the direct engagement of stakeholders in the mitigation measures interventions and the identification of drivers and barriers that affect acceptance.

The practical use of the methodology requires the identification of Key Performance Indicators (KPIs). Table 1 shows a prospect of the KPIs selected within the OPERANDUM project to quantify the effectiveness of the mitigation measures and their action on the socio-ecological system. These indicators are classified into

5 thematic areas. The first 4 areas are the impact KPIs that estimate the impacts of mitigation measures. These areas are:

1) Performance of mitigation measures (suitable for Component 1), further divided into Actionable and Impact variables;
2) Risk (suitable for Component 2), subdivided into the vulnerability and exposure sub-categories;
3) Co-benefits (for Components 3 and 4), which covers a very broad set of ecosystem co-benefits, and socio-economic and well-being co-benefits;
4) Public acceptance (for Component 5), subdivided into knowledge, Acceptance, and Mainstreaming.

The 5th thematic area consists of the project KPIs that help to estimate the overall project achievements in 1) the development of effective technologies, 2) the engagement of stakeholders, and 3) the provision of scientific results and policies. Further information is reported in Table 1 such as the sub-categories defined for some categories, the number of indicators, and an example for each category.

The methodology for the construction of the CLIMAXPO KPI-Library Is outlined In Figure 9.2.

The starting point was the CLIMAXPO Grant Agreement which reports 22 transversal KPIs and 3 Specific KPIs. The transversal KPIs are indicators that estimate the development of the activities in the different Work Packages (from WP5 to WP8) and their potential for replication within and outside the Po River Basin.

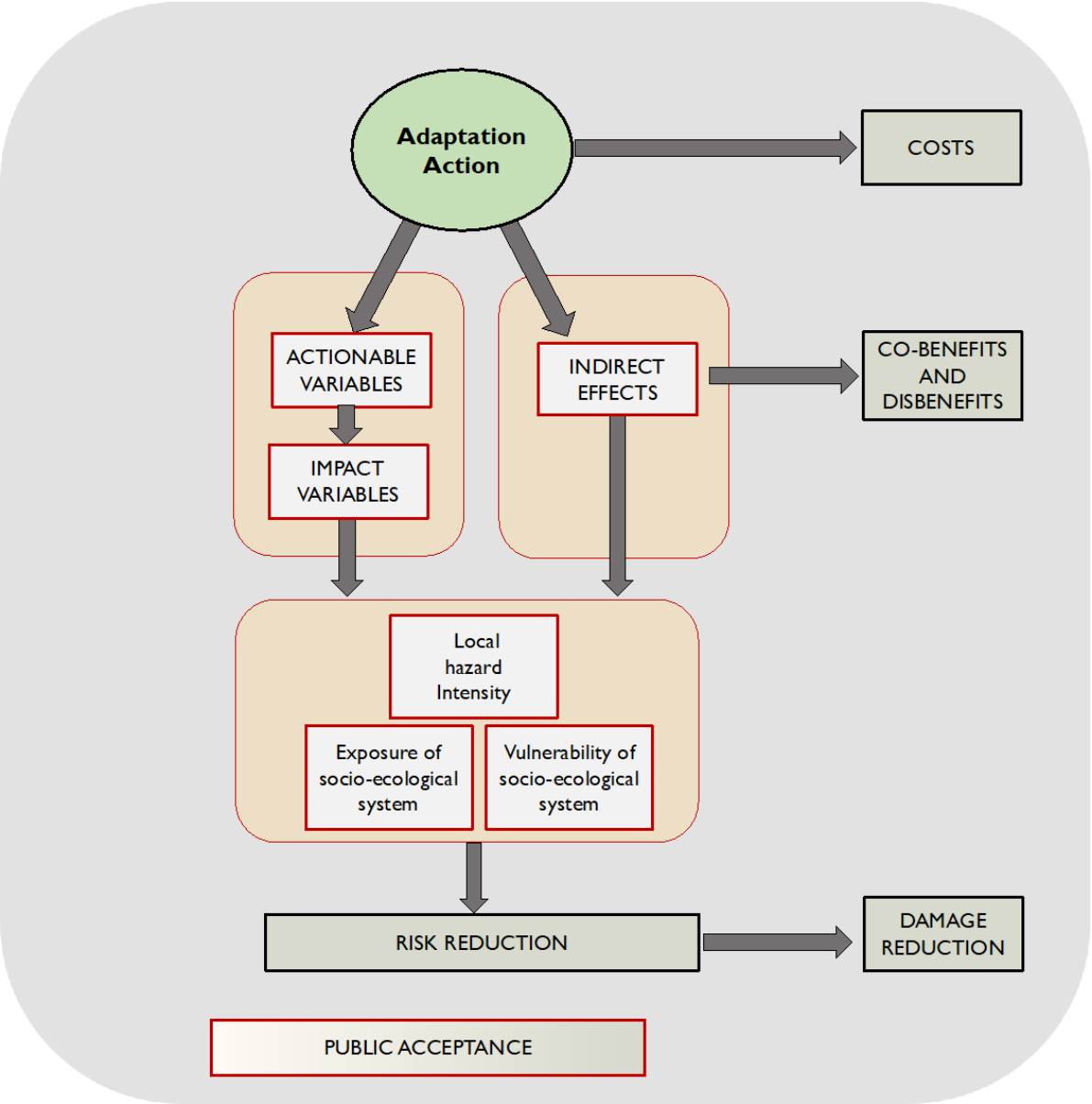

Figure 9.1: Schematic of the workflow adapted from OPERANDUM for the mitigation of climate risks. Numbers from one to five label the coloured shadings that identify the 5 steps of the methodology discussed in the body text. Red rectangles encompass thematic areas that are targeted by indicators. Green rectangles encompass categories of monetary costs and benefits.

The Specific KPIs are indicators that quantify the impacts of project actions and are related to water efficiency, water quality, vulnerability for strategic sectors, and population density exposed to floods. These KPIs were classified according to the thematic areas included in the methodology and integrated with a reduced version of the library selected during OPERANDUM (170 out of the Initial 315 KPIs). This selection was carried out by combining similar KPIs with each other.

Since the climate-change perspective of CLIMAXPO, the KPI library was further extended by including 39 indicators developed during the AdriaClim project (AdriaClim Deliverable 4.2.1).

Table 1: Summary of performance indicators, columns show from left to right: the thematic area of the indicators, categories and sub-categories, the number of indicators in each category, and an example indicator.

Area	Category	Sub-categories	# of indicators	Example
Performance of Mitigation Measures	Actionable variables	9 hazard-based sub-categories	29	NDVI
	Impact variables (Hazard)	9 hazard-based sub-categories	55	Flood depth (m)
Risk	Vulnerability	Ecosystem Susceptibility	33	Biodiversity Index
		Social Susceptibility	32	Poverty (% of population)
		Ecosystem Robustness	10	Percentage of wetlands restored (%)
		Coping Capacity	27	Early warning system/monitoring (% of population covered)

Risk		Adaptive Capacity	9	Existence of adaptation policies/strategies (yes/no)
	Exposure	Ecosystem Exposure	9	Proportion of area exposed to landslide (%)
	Exposure	Social System Exposure	15	Proportion of Residential area (ha)
Co-benefits	Environmental Co-Benefits	11 sub-categories	48	Carbon storage in vegetation
	Socio-economic and Well-being (Co-)benefits	5 sub-categories	19	Noise Attenuation Potential
Public acceptance	Knowledge	-	6	Knowledge of tools and techniques for ecosystem services evaluation
	Stakeholder Acceptance	-	6	Perceived effectiveness of mitigation measures
	Mainstreaming	-	5	Implementing and maintaining the

				mitigation measures
Project Impacts	Key Performance Indicators	-	12	Number of products showing a technology advancement (TRL)

AdriaClim was an Interreg Italy-Croatia project founded by the European Commission between 2020 and 2022. The goal of this project was the improvement of climate resilience in the Adriatic coastal and marine areas by increasing the capacity to update the existing climate adaptation plans and develop new ones and mitigation strategies based on reliable and high-resolution climate data. 30 AdriaClim KPIs were classified in a new thematic area named "Climate KPIs" whose goal is the estimate of climate trends and the impact of mitigation measures on those trends. Climate KPIs were subdivided into 3 categories according if these indicators are related to the "Temperature & Wind", "Water Cycle", or "Ocean" system.

The integration of all indicators from the CLIMAXPO Grant Agreement, OPERANDUM, and AdriaClim constitutes a first draft of the KPI Library that includes 234 KPIs. Figure 9.3 shows the subdivision in both thematic areas and categories of KPIs included in this first draft. This library was then reviewed by the Po River District Basin Authority (ADBPO) by selecting 97 KPIs potentially related to the activities carried out in the CLIMAXPO project.

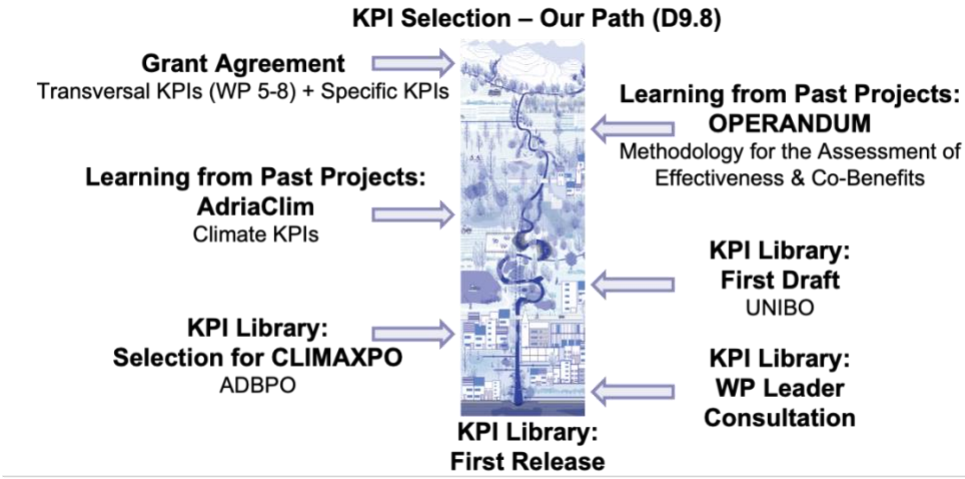

Figure 9.2: Schematic of the KPI-selection path followed for the development of the KPI Library (central figure from PHUSICOS, Deliverable D8.7). The path includes a first UNIBO draft obtained through the integration of the KPIs proposed in the CLIMAXPO Grant Agreement with the KPIs selected in past projects (i.e., OPERANDUM, Deliverable D6.8 and Grant Agreement; AdriaClim, Deliverable D4.2.1). To select the most suitable KPIs for the CLIMAXPO project, this draft was reviewed by ADBPO and WP Leaders until the first release of the KPI library.

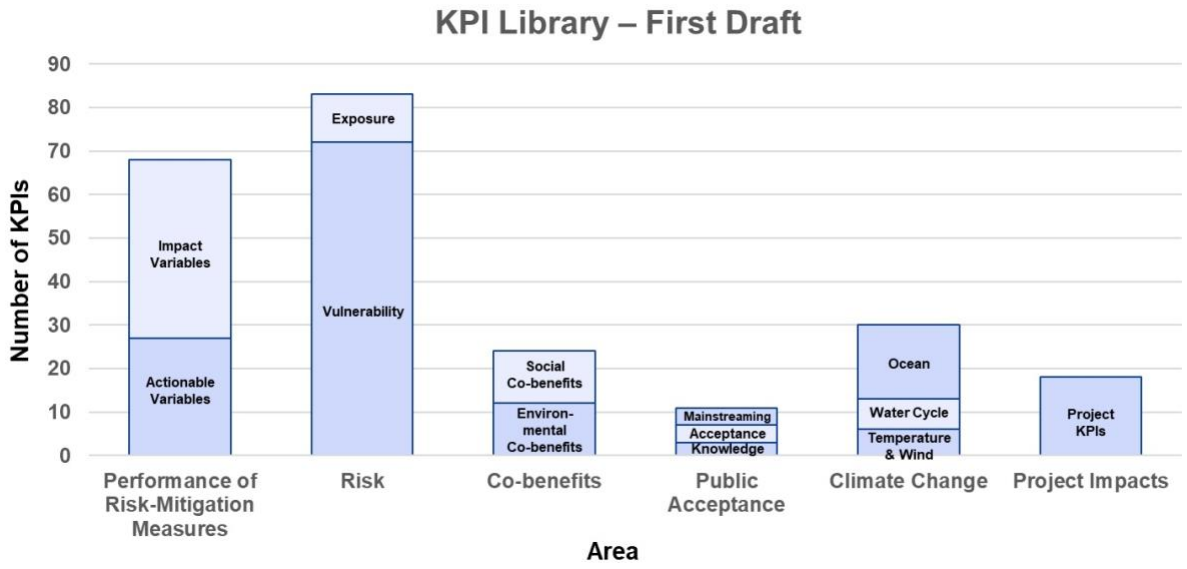

Figure 9.3: Bar charts of the 234 KPIs included in the KPI Library during the first-draft stage. KPIs are subdivided into both thematic areas and categories.

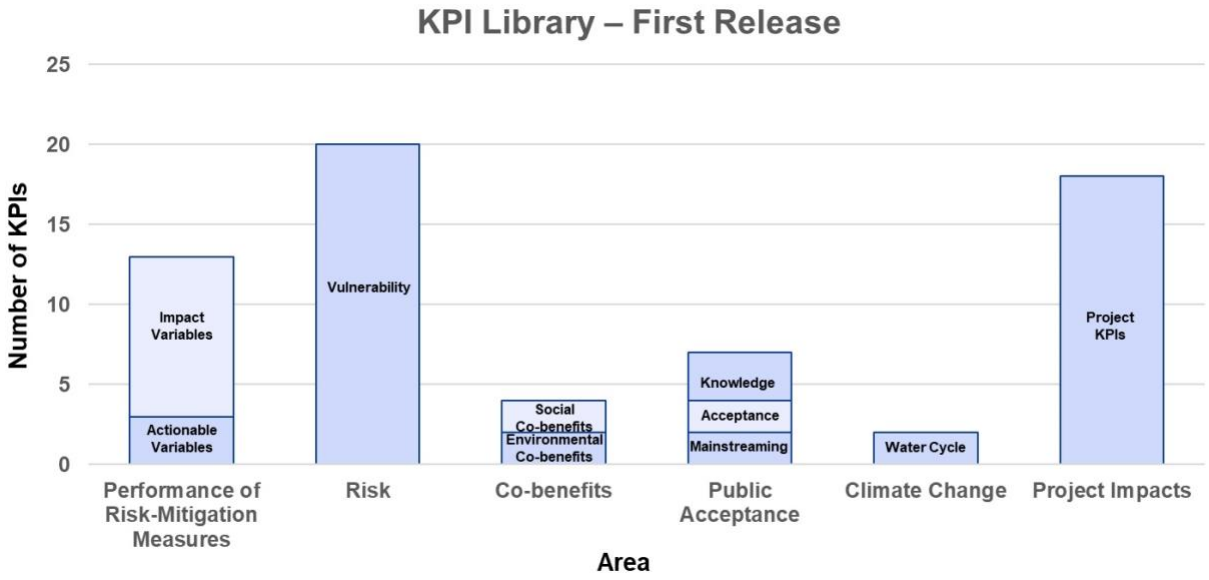

Figure 9.4: Bar charts of the 64 KPIs included in the KPI Library during the first-release stage (i.e., after ADBPO and WP-Leaders selection). KPIs are subdivided into both thematic areas and categories.

This selected version was further reviewed by WP Leaders which reduced the number of KPIs related to CLIMAXPO work packages up to 64 indicators. These 64 KPIs constitute the first-released version of the CLIMAXPO KPI library which subdivision in both thematic areas and categories is reported in Figure 9.4. The KPI library may be updated during the development of the project.

3 The CLIMAXPO KPI Library

The first-released KPI library consists of 66 Indicators related to project Impacts (18 indicators), the performance of mitigation measures (13), climate change (2), risks (20), co-benefits (4), and public acceptance (7). Table 2 shows the list of KPIs included in the library at the first release and the related unit of measurement, thematic area, category, sub-category, and work packages. The word "project" as relevant work packages states that an indicator may be relevant for all the work packages (i.e., WP5-8). The set of project impacts consists of 15 KPIs identified in the Grant Agreement (13 transversal KPIs and 2 specific KPIs), enriched by other 3 KPIs from the OPERANDUM project. These added KPIs are related to the development of scientific results during the project (number of peer-reviewed papers, actions that are validated and show a significant technology advancement). Since the activities that will be carried out in the project aim to improve water efficiency and quality In the Po-River basin, the selected KPIs concerning climate change and

performance of mitigation measures focus on hydrological indicators. The hazards addressed by these indicators are mainly 1) river and urban floods (2 actionable, 6 impact, and 2 climate-change variables) and 2) drought events (1 actionable and 1 impact variables). However, impact variables are also related to other hazards such as 3) salt-water intrusion (2 impact variables) and 4) coastal floods, coastal erosion, and storm surges (1 impact variables). This is because mitigation strategies can indirectly affect other hazards, even though these hazards are not the primary hazards for which the strategies were implemented. For Instance, strategies that limit water consumption in crop fields may be beneficial to reduce salt-water wedge events along the Po River. Furthermore, the strategies designed in CLIMAXPO can affect the risk by acting on the vulnerability component. The selected risk KPIs are related to 5 domains of the vulnerability of socio-ecological systems:

- Ecosystem susceptibility of the Po basin and the surrounding lands (4 KPIs);
- Social susceptibility of crop fields along the river (2 KPIs);
- Ecosystem robustness of the basin after the Implementation of mitigation strategies (4 KPIs);
- Coping Capacities developed through the implementation of both water-management and warning systems (4 KPIs);
- Adaptive Capacity developed through the implementation of strategies and policies (6 KPIs).

The reduction of ecosystem and social vulnerabilities may also translate into the provision of co-benefits that are classified as environmental (2 KPIs; e.g., potential soil erosion) and socio-economical & well-being (2 KPIs, e.g., the increase of natural resources) co-benefits.

Finally, the last thematic area takes into account the engagement of stakeholders in the project activities by investigating their perception (2 KPIs), acceptance of strategies (2 KPIs), and knowledge and awareness of risks, strategies, and interests (3 KPIs).

Table 2: List of the 64 KPIs included in the KPI Library on the date 25/07/2024.

KPI type	Indicator	Variable and unit	Area	Category	Sub-Category	Relevant WPs
Project KPI	Building a hydro-climatological database of the Great Lakes taking advantage of the highly-replicable ERA5 global database	Yes/No	Project Impacts			WP5
Project KPI	Set up and feeding of a water discharge database	Yes/No	Project Impacts			WP5
Project KPI	Set-up and feeding of an agricultural water uses database	Yes/No	Project Impacts			WP5
Project KPI	Selection of an open-source hydrological model platform for the assessment of water availability in various scenarios	Yes/No	Project Impacts			WP5
Project KPI	Selection of an open-source hydraulic model platform for the simulation of the real-time water storage	Yes/No	Project Impacts			WP5
Project KPI	Number of training events organized for technicians and practitioners within and outside the Pilot areas	Number of training events (No.)	Project Impacts			WP7

Project KPI	Number of trained people during the events	Number of trained people (No.)	Project Impacts			WP7
Project KPI	Number of accesses to websites and platforms providing the results developed also thank to the Task activities	Number of accesses to websites and platforms (No.)	Project Impacts			WP7
Project KPI	Number of accesses to the developed products by expert users for further post-processing (e.g., by API)	Number of accesses to the developed products (No.)	Project Impacts			WP7
Project KPI	Number of national and international initiatives within which the activities carried out in WP5-8 will be capitalized	Number of national and international initiatives (No.)	Project Impacts			WP5/WP6/WP7/WP8
Project KPI	Number of forecast models (based on open-source codes) developed or exploited in the different Tasks, also through relocatable platforms for an easier and faster implementation	Number of forecast models (No.)	Project Impacts			WP7
Project KPI	New governance proposals implemented in new policies or supporting existing ones	Number of governance proposals (No.)	Project Impacts			WP8
Project KPI	Leverage of complementary funds integrating CLIMAX PO solution	Euro (€)	Project Impacts			WP8
Project KPI	Number of municipal administrations involved in the process	Number of municipal administrations (No.)	Project Impacts			WP8

Project KPI	Ratio between the number of municipalities that will update the plan contemplating the LDN and the total number of involved municipalities that must update the plan	Percentage (%)	Project Impacts			WP8
Project KPI	Number of cases where the benefits and replicability of actions will be validated over the project lifetime	Number of cases (No.)	Project Impacts			Project
Project KPI	Number of products related to new actions showing a technology advancement (Technology Readiness Level, TRL)	Number of products (No.)	Project Impacts			Project/WP7
Project KPI	Number of peer-reviewed research papers and conference abstracts	Number of peer-reviewed research papers (No.)	Project Impacts			Project
Climate KPI	River discharge	Volume per second (m^3s^{-1})	Water Cycle			WP5
Climate KPI	Standardized Flow Index	Adimensional	Water Cycle			WP5
Impact KPI	Fractional vegetation cover on riverbanks	Percentage of vegetation cover (%)	Performance of Risk-Mitigation Measures	Actionable Variables	River & Urban Floods	WP6
Impact KPI	Capacity of reservoirs	Volume (m^3)	Performance of Risk-Mitigation Measures	Actionable Variables	River & Urban Floods	WP5
Impact KPI	Water consumption	Volume per year (m^3/yr)	Performance of Risk-Mitigation Measures	Actionable Variables	Drought	WP5/WP8
Impact KPI	Inundation depth	Meters (m)	Performance of Risk-Mitigation Measures	Impact Variables	River & Urban Floods	WP7
Impact KPI	Surface water Level	Meters (m)	Performance of Risk-Mitigation Measures	Impact Variables	River & Urban Floods	WP7

Impact KPI	River discharge	Volume per second (m^3s^{-1})	Performance of Risk-Mitigation Measures	Impact Variables	River & Urban Floods	WP7
Impact KPI	Flow velocity	Velocity (m/s)	Performance of Risk-Mitigation Measures	Impact Variables	River & Urban Floods	WP7
Impact KPI	Urban runoff	Volume per second (m^3s^{-1})	Performance of Risk-Mitigation Measures	Impact Variables	River & Urban Floods	WP7
Impact KPI	Population density exposed to floods hazard in the whole regions' territories of the District	Number of people per area (No./km^2)	Performance of Risk-Mitigation Measures	Impact Variables	River & Urban Floods	Project
Impact KPI	Damages to public and private goods caused by extreme events/storms	Euro (€)	Performance of Risk-Mitigation Measures	Impact Variables	Coastal Floods, Coastal Erosion & Storm Surges	Project
Impact KPI	Volume salt flux	Volume per second (m^3s^{-1})	Performance of Risk-Mitigation Measures	Impact Variables	Salt-Water Intrusion	WP7
Impact KPI	Salt wedge length	Kilometres (Km)	Performance of Risk-Mitigation Measures	Impact Variables	Salt-Water Intrusion	WP7
Impact KPI	Water use efficiency	Volume of consumed water per hectare (m^3/ha)	Performance of Risk-Mitigation Measures	Impact Variables	Drought	WP5
Impact KPI	Rate of change of SOC, in the arable layer (0-30 cm), within the pilot basin	Percentage (%)	Risk	Vulnerability	Ecosystem Susceptibility	WP8
Impact KPI	Rate of change of the Variation degree of waterproofing / degradation of the territory	Percentage (%)	Risk	Vulnerability	Ecosystem Susceptibility	WP8

Impact KPI	Water Quality, reduction in area or length of surface water bodies and groundwater bodies whose ecological status is affected (in the context of the Water Framework Directive)	Percentage (%)	Risk	Vulnerability	Ecosystem Susceptibility	Project
Impact KPI	Rates of surface water drainage	Volume per second (m^3/s)	Risk	Vulnerability	Ecosystem Susceptibility	Project
Impact KPI	Agricultural crop production	Production per year (ton/yr)	Risk	Vulnerability	Social Susceptibility	Project
Impact KPI	Crop diversification	Number of crop species (No.)	Risk	Vulnerability	Social Susceptibility	Project
Impact KPI	Morphological quality index (IQM)	Adimensional	Risk	Vulnerability	Ecosystem Robustness	WP6
Impact KPI	Linear meters of restored shore	Meters (m)	Risk	Vulnerability	Ecosystem Robustness	WP6
Impact KPI	Area returned to the river corridor	Hectares (ha)	Risk	Vulnerability	Ecosystem Robustness	WP6
Impact KPI	Ecosystem Functionality Index (EFI scores)	Adimensional	Risk	Vulnerability	Ecosystem Robustness	WP6
Impact KPI	Water Efficiency, Reduction in new water supplied, due to appropriate water saving measures (e.g. through increasing water reuse and/or avoiding water losses) in m^3 / year	Volume per year (m^3/yr)	Risk	Vulnerability	Coping Capacity	Project
Impact KPI	Early warning system/monitoring (% of population covered)	Percentage of covered population (%)	Risk	Vulnerability	Coping Capacity	Project

Impact KPI	Participation in decision making / implementation from interdisciplinary sectors	Adimensional	Risk	Vulnerability	Coping Capacity	Project/WP2/WP4
Impact KPI	Irrigation technology and pumps	Adimensional	Risk	Vulnerability	Coping Capacity	WP8
Impact KPI	Extension of agricultural canal network (km) interested by at least one of the points (i to v), normalised upon the total network (kmMOD/kmTOT)	Kilometers of canals out of the total (km_{MOD}/km_{TOT})	Risk	Vulnerability	Adaptive Capacity	Project
Impact KPI	Area suitable for the application of smart storage and extended rotation, expressed as potentially implementable area (PIA ha)	Hectares of potentially implemnetable area (ha_{PIA})	Risk	Vulnerability	Adaptive Capacity	WP8
Impact KPI	Existence of adaptation policies/strategies	Yes/No	Risk	Vulnerability	Adaptive Capacity	Project
Impact KPI	Existence of integrated development plans: conservation, protection; adaptation; land use planning; controls by authorities	Yes/No	Risk	Vulnerability	Adaptive Capacity	Project
Impact KPI	Social capital	Percentage of population (%)	Risk	Vulnerability	Adaptive Capacity	Project/WP9
Impact KPI	Managed sharing and allocation of water	Yes/No	Risk	Vulnerability	Adaptive Capacity	Project/WP5
Impact KPI	Potential soil erosion	Soil Erodibility Factor (ton ha yr)	Co-Benefits	Environmental Co-Benefits		WP8

Impact KPI	LDN indicator (15.3.1)	Percentage (%)	Co-Benefits	Environmental Co-Benefits		WP8
Impact KPI	Percentage of green space	Percentage (%)	Co-Benefits	Socio-economic and Well-being (Co-)benefits		Project
Impact KPI	Impact on natural resources	Percentage (%)	Co-Benefits	Socio-economic and Well-being (Co-)benefits		WP9
Impact KPI	Willingness/commitment of relevant stakeholders to engage in this project and future one	Adimensional	Public Acceptance	Mainstreaming		Project/WP4
Impact KPI	Implementing and maintaining funding/investment actions	Adimensional	Public Acceptance	Mainstreaming		Project/WP2/WP11
Impact KPI	Perceived effectiveness of the actions	Adimensional	Public Acceptance	Acceptance		Project/WP9
Impact KPI	Perception of co-benefit	Adimensional	Public Acceptance	Acceptance		Project/WP9
Impact KPI	Knowledge/awareness about adaptation measures and their implementation	Adimensional	Public Acceptance	Knowledge		Project
Impact KPI	Knowledge/awareness about how to evaluate the ecological system and hydro-meteo risks in a specific area	Adimensional	Public Acceptance	Knowledge		Project
Impact KPI	Knowledge of other stakeholders (interests, motivations, and roles)	Adimensional	Public Acceptance	Knowledge		Project/WP4

4 User guide and examples

The proposed KPI library allows moving from the theoretical methodology (Figure 9.1) to the risk assessment in monitoring or modeling case studies. The selection of KPIs is not straightforward because each case study is a unique mosaic of climate, environmental, social, and economic conditions. However, the wide variety of categories in the KPI library helps to describe the complexity of each analyzed context. This section reports an example from the Open-Air Laboratory Austria (OAL-Austria, OPERANDUM project) that serves as a guideline for future application of the methodology described in the previous section.

OAL-Austria Is located in the lower Watten Valley (Tyrol, Austria) on the Vögerlsberg slope affected by a deep-seated landslide driven by groundwater recharge, especially during prolonged moist periods and snow melt. The monitoring experiment implemented by OPERANDUM consists of a nature-based sealing of leaky streams along the slope by bio-degradable materials (i.e., bentonite). However, the enhancement of slope stability by optimized forest management was also tested through a modeling experiment.

Table 3 reports the selected KPIs for both the monitoring and modeling experiments.

The first step for the application of the methodology requires the selection of both actionable and impact variables that describe the effect of the NBS on hazardous events (Figure 9.5). Since the two experiments are based on different approaches, the selected variables are different. The actionable variable for the sealing of leaky streams was the streambed permeability because this NBS acts as a waterproof layer that prevents Infiltration Into the soil. Soil moisture probes above and below the layer were combined with both periodic terrestrial layer scanning surveys and electrical resistivity tomography measurements. These filed campaigns have allowed the assessment of the impact variables, I.e., soil moisture, and slope deformations and movements. On the other hand, optimized slope management aims to enhance the water balance by changing the vegetation features such as the plant species composition, stand structure, and Leaf Area Index (LAI). A process-oriented hydrological model was set up for analyzing the trends in both evapotranspiration and soil moisture.

The second step of the methodology is the risk assessment (Figure 9.6). This assessment requires the integration of the impact variables (i.e., KPIs for the hazard component) with KPIs that describe the exposure and vulnerability components.

By addressing the hazard, both solutions can reduce risks for the exposed elements located below the slope such as roads, properties, buildings, water supply networks, and other critical physical infrastructure. The extent of these elements constitutes the exposure component. These elements and the local population are vulnerable to landslides for several reasons. For instance, a selected vulnerability indicator was the deformation of elements at risk because several buildings and infrastructure already showed damage before the experiments due to previous ground motions. Other factors that can increase the vulnerability of the study area are the demographic composition and the slow implementation of policies and strategies. Table 3: Selected KPIs for the OAL-Austria experiments during the OPERANDUM project. Column shows from left to right: the thematic area of the indicators, categories, the selected KPIs to assess the sealing of leaky streams and the optimized forest management, and a reference to a detailed documentation of the selection and analysis.

Area	Category	Sealing of Leaky Streams (monitoring experiment)	Optimized Forest Management (modeling experiment)	Main Reference
Performance of Mitigation Measures	Actionable variables	Streambed permeability	Plant species composition and stand structure; Leaf Area Index (LAI)	D4.3, D6.8
	Impact variables (Hazard)	Soil moisture; Slope movement/ deformation	Evapotranspiration; Soil moisture	
	Vulnerability	Deformation of elements at risk (buildings and infrastructure) (cm/annum); Dependency ratio (%) includes young (<15 years), elderly (>65 years), and disabled people;		

Risk		Government expenditure on environmental protection (% expenditure); Existence of adaptation policies/ strategies		D6.2, D6.3
	Exposure	Proportion of critical physical infrastructure (%); Proportion of length of road exposed in a hazard-prone area (%); Proportion of properties/ buildings in a hazard-prone area (%); Proportion of area/ length of water supply network in a hazard-prone area (% of area or length)		
Co-benefits	Environmental Co-Benefits	Biodiversity	Biodiversity; Carbon Storage	D5.3
	Socio-economic and Well-being (Co-)benefits	Property values		
Public acceptance	Knowledge	Knowledge of other stakeholders (interests, motivations, and roles); Knowledge/awareness about how to evaluate the ecological system and hydro-meteo risks in a specific area; Knowledge/awareness about mitigation measures and their implementation		D8.3
	Stakeholder Acceptance	Sense of personal responsibility/commitment		
	Mainstreaming	Willingness/commitment of relevant stakeholders to engage in this project and future one		

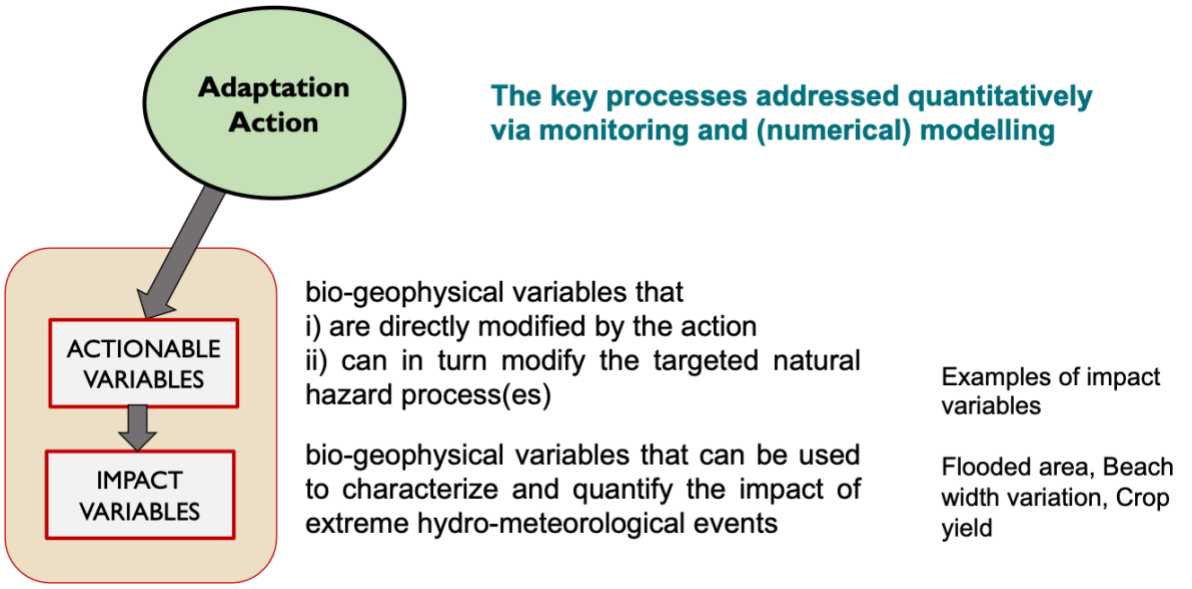

Figure 9.5: User guide for the selection of the suitable actionable and impact variables to apply the methodology reported in Figure 9.1.

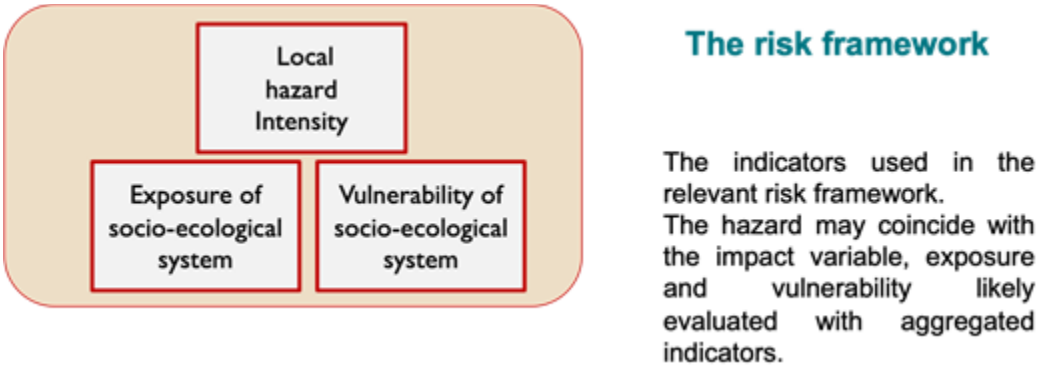

Figure 9.6: User guide for the selection of the suitable risk KPIs to apply the methodology reported in Figure 9.1.

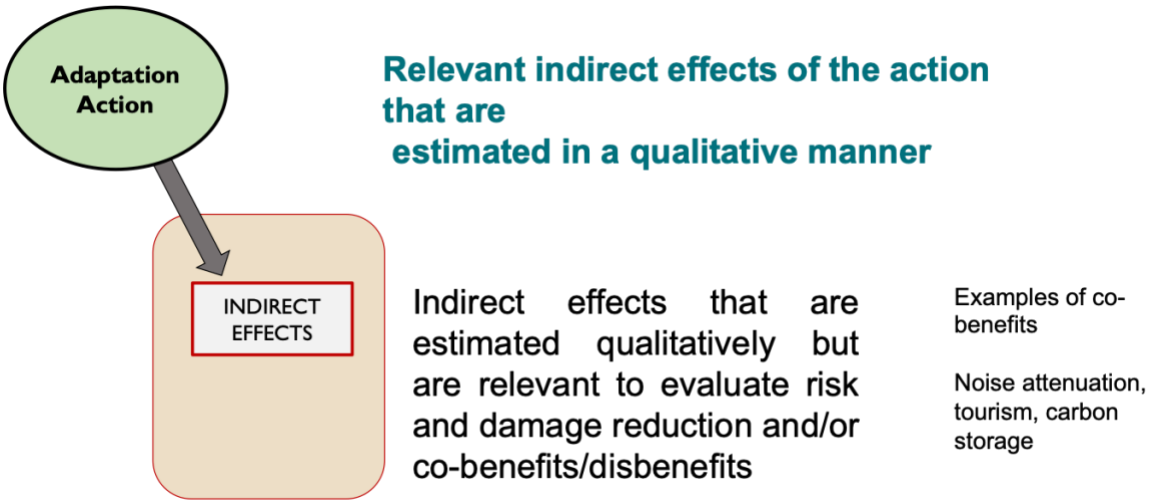

Figure 9.7: User guide for the selection of the suitable indirect-effect KPIs to apply the methodology reported in Figure 9.1.

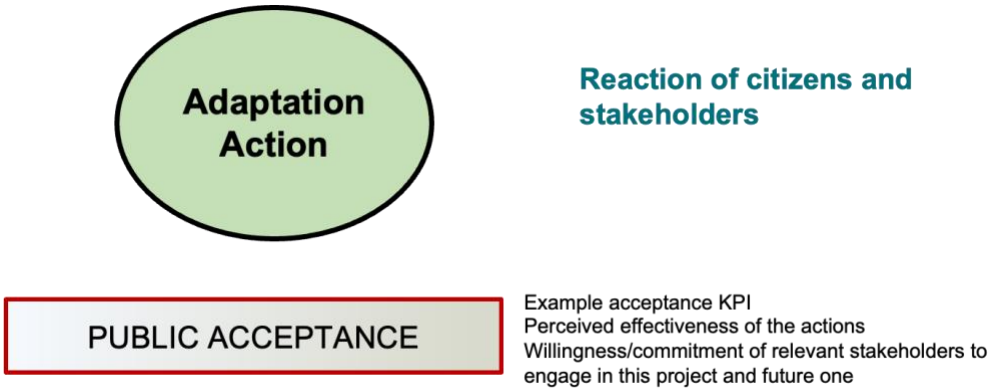

Figure 9.8: User guide for the selection of the suitable public-acceptance KPIs to apply the methodology reported in Figure 9.1.

The third step of the methodology is the assessment of both socio-economic and environmental indirect benefits (Figure 9.7). The higher the safety of buildings and infrastructure is, the higher the property values will be. The reduced chance of landslides can also help in preserving and enhancing the biodiversity that lives on the slope. Furthermore, optimized forest management can increase the uptake of carbon dioxide, while sealing streams with biodegradable materials cannot pollute the hydrological system as done by traditional engineering solutions such as polyethylene pipes, half shells, and sheets.

The fourth step of the methodology is the assessment of public acceptance (Figure 9.8). Several stakeholder meetings were organized to discuss their interests, motivations, and roles, and to make their awareness grow about the hydro-meteorological risks and the possible strategies to address these risks. This effort to engage stakeholders has increased the personal sense of responsibility and commitment. The people in the study area have expressed their willingness to be engaged in future projects such as the upscaling and replication of the experiments in the surrounding slopes.

These steps need to be followed by taking into account both the climate and project KPIs that help to estimate the impact of mitigation measures on climate trends and the overall impacts of all the experiments carried out during the project, respectively.

5 Conclusions

The CLIMAXPO project aims to enhance the adaptation to climate change of the Po River Basin by promoting sustainable management of water resources. The adoption in this area of the national climate-change adaptation strategy requires the definition and implementation of measures suitable for its peculiar features in terms of local climate and socio-economic and environmental conditions. To estimate and maximize the impacts of these measures, the current deliverable delves into the adoption of a monitoring methodology for the mitigation of climate risks and the selection of Key Performance Indicators (KPIs) that enable the application of the methodology In the CLIMAXPO project. The starting point for the monitoring methodology is the one developed during the OPERANDUM project. An adapted version of this methodology allowed a methodological exercise in WP9 that led to the definition of a KPI library. This library integrates contributions from the CLIMAXPO Grant Agreement with previous projects (i.e., OPERANDUM and AdriaClim) and can be used as an interactive tool to update indicators relevant to the project. The library includes project KPIs, impact KPIs, and climate KPIs. The project KPIs are essential to estimate the project achievements in terms of stakeholder engagement and production of both effective technologies and scientific results. The impact KPIs are indicators that assess the local impacts of mitigation measures and are classified into categories that comprise the Interaction between the mitigation measures and the features of hazardous events, the provision of co-benefits, the reduction of risks, and the public acceptance. The climate KPIs allow the assessment of the impacts on hydrological trends over climate scales. The first-release version of the KPI library Includes 64 Indicators (I.e., 18 project, 44 impact, and 2 climate KPIs), carefully selected through consultation with ADBPO and WP Leaders. To promote the transition of monitoring activities into an operational stage (periodic reports), this deliverable reports an example of the application of the KPI library that serves as a guideline for the future measures implemented in the CLIMAXPO project. The transition will be supported by regular WP9 meetings, the two project boards (exploitation and dissemination), and updated releases of the KPI library in case of need. The library is reported in an Excel file which acts as a tool available to the entire consortium for the continuous consultation and updating of the indicators adopted in the monitoring methodology. The updates of the library will be discussed during the periodic report on the status of the CLIMAXPO project (Deliverable 9.6). A further step in this report consists of the classification of each KPI as 1) strategic if the KPI will be strategic for

the formulation of guidelines resulting from the project and 2) implemented if the KPI will be estimated during activities carried out in the project.

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