MARISCO
Human-centred and
ecosystem-based

MARISCO: Adaptive Management of Vulnerabilities and Risks at Conservation sites

Methodology guide

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Introduction

Resource management in the Anthropocene is crisis management. Climate crisis, biodiversity crisis, health crisis and humanitarian crises are mutually dependent and often have a joint impact on humans and nature. In view of this permanent crisis, it becomes clear that "*an extension of the present no longer has a future. Our globalised, ruthless world based on the organisation of inequality no longer works, as it consumes more and more irreplaceable resources and yet does not provide food, water, education, health or peace for most of the world's people* (Ibisch & Sommer 2021)*".*

To overcome the crisis, new approaches are needed "*that break with the old thinking that caused this crisis".* The proposal is to strive for ecosystem-based sustainable development (Ibisch 2018). Ecohumanism represents an approach to thinking that advocates "*grounding our thinking and actions: Starting from nature and moving towards human beings"* (Ibisch and Sommer 2021). Ecohumanism "*links the acceptance of planetary boundaries with the goal of a just world - and places humans and their strengths at the centre of the debate about ecology and our future. Ultimately, it is based on two simple principles:*

1. the acceptance of the ecological boundaries and our role as a component of this ecosystem.

and

2. the universal human right to a good life for all people today and in future generations. "(Ibisch & Sommer 2021)

The MARISCO method tries to implement these principles within the framework of strategic planning processes: People-focused and ecosystem-based.

The aforementioned "grounding" of our society has also occurred in other scientific disciplines. In the 1990s, UNESCO developed and disseminated the concept of ecohydrology as part of its International Hydrology and Man and Biosphere programmes to place physical science in a socio-ecological context (Bridgewater et al. 2018, Zalewski et al. 1997). This reorientation was necessary because the status of many water bodies and groundwater bodies has deteriorated extremely, and groundwater recharge has also been restricted in part due to land use. Overexploitation, increasing demand, pollution, poor management, lack of infrastructure and climate change, which is accompanied by extreme heat and drought events, among other things, considerably exacerbate the problem situation and endanger the availability of freshwater worldwide.

Ecohydrology uses an understanding of the relationships between hydrological and ecological processes at different scales to improve water security, enhance biodiversity and create further opportunities for sustainable development by reducing ecological threats and achieving greater harmony within watersheds.

The basis for this is a better understanding of the interactions between water and ecosystems, which are inextricably linked to the cycles and flows of nutrients and energy. Precipitation that falls on the land surface in terrestrial ecosystems is converted into either "green water" or "blue water". Green water is the part that is stored in the soil and potentially available for uptake by plants, while blue water either drains into streams and rivers or percolates into an aquifer below the root zone. Green water enters the atmosphere mainly through evaporation from the soil, while blue water flows through the surface or pore space of an aquifer.

Globally, the flow of green water accounts for about two-thirds of the global flow of all water and is equivalent to the flow of all the Earth's rivers into the oceans (Sposito 2017). The green water flow leading to transpiration is a complex process because the soil environment close to the roots, the rhizosphere, is the habitat for the soil microbiome, an extraordinarily diverse collection of microbial organisms that influence water uptake through their symbiotic relationship with plant roots.

Green water is the basis for the functioning of terrestrial ecosystems. It is the most important source of water to produce food, feed, fibre, wood and bioenergy. To understand how freshwater scarcity limits the production of these vital commodities, it is therefore essential to explain and include the use of green water (and its limits).

In order to implement effective water and ecosystem management, it is therefore important to understand and take into account the complex interactions between the hydrosphere and the biosphere. Complex interactions, feedback effects and non-linear change cause uncertainty and indeterminacy. Decisions with potentially large consequences must be made without sufficient knowledge being available. Goal-oriented, but open-ended and flexible adaptive management is the order of the day.

Methodology background

The **MARISCO method**[1] was initially developed to systematically assess the vulnerability of ecosystems and terrestrial or aquatic landscapes subject to human influence. This is the basis for developing adaptive management strategies aimed at reducing human impacts and securing or restoring the best possible functioning conditions in ecosystems. The methodology enables participants to analyse human-induced threats and impacts from an integrated, ecological perspective. The end product of the holistic analysis is the development of a complex conceptual model based on the participants' perceptions, assumptions and knowledge. The conceptual model represents both whole ecosystem health and vulnerability and ecosystem-dependent human well-being.

MARISCO is a visualised systematic process designed for collecting, organising and documenting both knowledge and non-knowledge related to biodiversity, threats and drivers of change, as well as conservation management (to date) for a given area. It reflects the perceptions, assumptions and knowledge of the people participating in the exercise. The distinctly participatory method uses an orderly, step-by-step approach to strategic planning.

The methodology has been developed for over 10 years at the Centre for Econics and Ecosystem Management at the Eberswalde University of Applied Sciences based on adaptive management methods.

Initially, this was mainly done in the context of and in cooperation with partners in development cooperation - especially for and with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

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[1] Ibisch & Hobson 2014, https://www.marisco.training/resources/manual/

One focus at the beginning was on protected areas. Eventually, MARISCO was made generally usable for projects and ecosystem-based and participatory diagnostics for the holistic management of landscapes. The methodology is also used in other contexts and is adapted for each. It enables the systematic development and implementation of sustainable scenario-based and adaptive-proactive solution strategies.

Application of these guidelines

The guide is intended as an accompanying document for the use of the MARISCO software. It provides the introductory texts, explanations of terms and examples of the individual steps in their chronological order. You can easily access the required information without having to open new windows in the software or move back and forth between individual steps. The guide is also suitable as a companion document during the revision of the situation analysis in step 18, as well as the (non)knowledge management of step 30.

The guide is neither a manual for conducting MARISCO workshops nor an introduction to the theoretical background of the MARISCO method. For this information, please consult the MARISCO manual (Ibisch & Hobson 2014) and the materials and information provided on the MARISCO homepage (www.marisco.training).

Notes

It is necessary to introduce some terms. They are an indispensable part of the method and an expression of its systematic. This is done in the knowledge that the reader will already be familiar with some similar facts under other terms. For example, the common "cause of danger" is named "stress driver" here. All experiences from the applications of MARISCO show that this specific conceptual system is quickly accepted and learned. Another peculiarity of MARISCO are the semi-quantitative assessments in four classes (low - moderate - high - very high). To ensure a transparent planning process, each individual decision is visualised. Ratings are made visible by corresponding colours (dark green - light green - yellow - red). The four-level evaluation method represents a compromise between differentiated evaluation on the one hand and intuitive or experiential knowledge on the other. Such knowledge is used where no reliable data is available for decisions.

Ideally, you document all the information you have gathered on the elements of the systemic situation model in the specific comment fields. This helps you to remember why you made certain decisions and allows other team members to follow your conclusions. In this way, you can reduce the risk of other team members repeating past mistakes in the future.

1. Methodology

The methodology comprises seven phases with 30 steps:

- Phase I: Motivation and geographical scope,
- Phase II: Human well-being and social systems,
- Phase III: Ecosystem functionality,
- Phase IV: Stresses and risks,
- Phase V: Strategies,
- Phase VI: Plausibility and effectiveness,
- Phase VII: Operational planning and implementation.

Figure 1: MARISCO cycle with seven phases

Diagnostic ecosystem analysis

Most of our ecosystems and the landscapes they form have been used and shaped by humans for a long time. The result is complex overlays of natural conditions with sequences of human-induced changes in changing spatial extents. The diagnostic analysis of ecosystems and their condition creates a common basis for understanding large-scale landscape ecological conditions. For example, it helps to identify the course of important natural boundaries. Furthermore, it gives a first impression of the problems for regional biodiversity. It is important to flexibly vary the section under consideration.

Ecosystem diagnosis can be based on satellite and aerial imagery, maps, and existing literature on historical and current land use. If the circumstances require it, looking at Google Earth satellite images can also produce valuable insights. In particular, site visits are indispensable for good ecosystem diagnosis. If possible, both approaches should be combined and carried out before starting the actual work.

1.1 Phase 1 Motivation and geographical scope

Figure 2: Phase I

Before you start the actual work, it can be helpful to write down what motivated you to start in the first place. You can use this later as an impetus to continue if your work ever fails to progress. Similarly, it is advisable to document what outcomes you want to achieve as part of this process. This provides you and your team with a starting point for discussion and can help avoid frustration at certain points. A shared vision can be a useful tool to motivate and unite a team. Keep the duration of your planning cycle in mind when formulating it, as it will influence how much you can achieve. The final step of this phase is to determine the geographical scope of your planning area, which sets the boundaries for your analysis.

Don't worry too much about possible mistakes, the different steps can always be revised later in the process.

Steps:

- 1. motivation, expectation and management vision,
- 2. identification and dimensioning of the required geographical scope.

Step 1: Motivation, expectation and management vision

Describe your motivation

It is rewarding and insightful for a number of reasons to be able to recall later what motivated you to start analysing in the first place.

Motivation

Motivation is what initiates, guides and sustains goal-directed behaviour. It causes us to act.

Example:

-The overall objective is to contribute to the conservation of local ecosystems and their biodiversity and to empower local people to manage natural resources in an equitable, participatory, and sustainable manner.

The aim of this application is to gain a better understanding of the status and dynamics of the complex socio-ecological systems of the study area and to develop an adaptive management plan for the planning area based on this knowledge.

Describe your expectation

What do you want to achieve with this application? What are the expectations of the other people involved? A good understanding of this can help you manage the expectations of the other people involved and avoid any frustration at the end.

Expectation

Expectations are your personal beliefs about the effect of an action on achieving a particular outcome.

Example:

-At the end of this application, I would like to have gained a better understanding of the state of the dynamics of the complex socio-ecological systems in the study area, as well as to have developed a detailed work plan for the adaptive management of the ecosystems of the study area.

Managing expectations

When you work in a team, it may become necessary to manage the different expectations. To do this, you should communicate in such a way that everyone involved has a clear understanding of what to expect - and when to expect it. Expectations can change over time, so it may be necessary to address them.

Design a management vision

A management vision helps to guide activities, management goals and objectives. It is important to formulate this vision before moving on to detailed situation analysis because the vision stimulates consensual strategic thinking and provides a basis for goal formulation. The vision should relate to the planning area within the geographical scope. However, it can also relate to the institution that is to be managed.

The vision should be general, visionary and brief.

Vision

A vision is a general statement of the desired state or end state you want to achieve.
A good vision statement should meet the following criteria:

-Relatively general
- Broadly defined to include all activities,
-Visionary
- Inspiring by outlining the desired change in the state of the goals one is working towards,
-Short
- Simple and concise so that everyone involved can remember it.

Example:
The Great Altay Transboundary Biosphere Reserve is a very well conserved natural area with a unique biological, landscape, ethnic and cultural diversity, which provides a wide range of ecosystem services important for both local communities and humanity at regional and global levels. It was created to conserve and explore its biotic and abiotic features in a transboundary context and to enhance both the material and spiritual well-being of local communities.

Step 2: Geographical scope

Define the geographical scope

Using the map, draw the current boundaries of the planning area and evaluate in the team the appropriateness of the existing area in the context of the ecosystems present there.

The following questions provide some guidance for this process:

- Is the existing area of the planning area large enough to allow the effective functioning of the relevant ecosystems?
- Does the adopted geographical scope take into account larger ecological units or landscape-level processes that (may) influence the biodiversity of the planning area?
- Are relevant hydrological features such as catchments, watersheds or groundwater bodies taken into account?
- Does the current size of the study area ensure or support the sustainable occurrence of viable populations of important species?
- Does the current size of the planning area include relevant stakeholders and/or communities in the vicinity of the protected area?

- Have existing protected areas, administrative boundaries or socio-economic conditions been adequately taken into account?

Geographical scope

- The geographical scope defines the planning area and includes all components of biodiversity identified as needing protection. When applying an ecosystem-based approach, it is important to identify whole systems where possible, representing not only the components of an ecosystem, but also the processes, structures and dynamics that constitute and control them.
- Note for the processing of protected areas: In many cases, the planning area already exists as a designated protected area or is soon to be designated. However, the decision to designate an area as a protected area is often based on socio-political factors or economic reasons and has little to do with the ecological needs of biodiversity. Consequently, the areas are usually too small to provide adequate protection. There are other issues related to human impacts in the surrounding landscape that can affect biodiversity on the ground, but may go unrecognised. Only a landscape perspective that places the planning area in a wider context can capture these kinds of problems.

Additional tools with which you can define the geographical scope

Information on habitat types, land use cover, administrative boundaries as well as subtleties and details of topography and hydrology should be taken into account when defining the planning area. Detailed information on your designated planning area can be found on this homepage https://geofolia.org, for example.

Aerial or satellite imagery (such as Google Earth imagery), alongside existing maps, is extremely useful for understanding a space. They provide realistic images with surface features that do not necessarily appear on maps. They also allow the terrain to be viewed at different scales and often how they have changed in the past.

Some thoughts at the beginning...

The aim of the application is not to reflect perfect knowledge. In the early stages of the application, a basic understanding is developed from collected and shared knowledge. This understanding will eventually be revised as the systemic situation model develops and at each stage of review. The processing team will recognise that the knowledge in the group is initially provisional and prepares the ground for further learning. Each element that is integrated into the systemic situation model represents a preliminary hypothesis. Each element can be validated, specified and improved or disproved and discarded in the course of the adaptive planning process.

How specific should the descriptions of the elements be?

In general, there are no absolute rules on how specific an element of the systemic situation model should be described. However, the recommendation is to formulate the elements as precisely and specifically as possible. For example, a generic stress driver titled "climate change" will be much less helpful in a situation analysis than the following more precisely described facet of climate change: "increased frequency of severe frosts in early spring after warm winters". It is important to specify the driver that causes stress. While the drivers of stresses are discussed, one may conclude that the stresses would be better reformulated. Again, it is important to be as specific and clear as possible for a meaningful analysis.

1.2 Phase 2 Human well-being and social systems

Figure 3: Phase II

Ecosystems are the basis for sustainable development in your planning area, including adaptation to environmental changes. Their functioning must also be ensured so that the local population can live in an environment of adequate quality. Humans are an integral part of the global ecosystem. In reality, complex situations of different social and ecological systems occur in areas of application and consideration, which influence each other - they are called social-ecological systems. Therefore, any specific strategies proposed to bring about change and transformation in the complex social-ecological systems of the planning area must also adequately take into account people's needs and attitudes. Otherwise, they are very likely to be ineffective. It is particularly important to reflect social conflicts and (presumed) reasons for certain habits and actions. In this context, it must always be remembered that people are part of the complex ecosystems on which they live and which they change. As a key element of these systems, the human subsystem therefore deserves particularly careful analysis.

Elective step

This is an optional step. You can decide whether or not you want to perform this step during the complex situation analysis. If you do not want to perform this step, you will be shown a generic list of elements. You can edit these generic elements if you wish.

Step 3: Human well-being

Identify the elements of human well-being

All your actions ultimately affect the people within the planning area and even beyond. A good understanding of the elements that make up the well-being of the people in your planning area is important. It will also make it easier for you - if necessary - to raise awareness among local people about how they benefit from functioning ecosystems in the form of ecosystem services. It will also help you to understand potential conflicts of interest and risks that may arise from different interests in the use of natural resources.

Human well-being includes immediately understandable elements such as access to clean water, nutritious and healthy food and good physical health. However, other important elements also relate to mental and emotional well-being and social relationships.

Human well-being

Human well-being encompasses all the key components that people need for a good life. The components of well-being as experienced and perceived by people are situational and may be strongly influenced by geography, culture and ecological conditions. Nevertheless, it must be assumed that people can universally agree on minimal components of well-being. Hunger, disease or material poverty, the lack of security or esteem, for example, lead to an impairment of human dignity and a fundamentally good life.

Ecosystems provide many services that contribute directly to human well-being. Some of these ecosystem services can be replaced (temporarily and with the use of more or less resources) with technical solutions by the social systems, while others cannot be replaced in principle.

Examples:
-Food security; freedom and choice; health; good social relationships; personal security.

Step 4: Social services

Identify the social services

Humans are social beings. Therefore, it is not surprising that our well-being is strongly influenced by our social environment. Many social systems have been created by humans to achieve a better life. Social systems contribute to human well-being through social benefits. They describe a range of public services provided by government, private, for-profit and non-profit organisations. These services aim to create more effective organisations, build stronger communities and promote equality and opportunity.

Social services include e.g. education, food subsidies, health care, police, fire brigade, vocational training and subsidised housing, adoption, municipal administration, political research, lobbying and many more.

Social services

Social services describe a range of services provided by government, private, for-profit and non-profit organisations, but also by smaller and more informal social institutions such as families or a circle of friends. These services aim to create more effective organisations, build stronger communities and promote equality and opportunity, or simply provide support, affection and care. Basically, provisioning, regulating and cultural social services can be distinguished. Providing refers to supplying people with all the goods and services they need to live (or survive). The regulating services organise the coexistence of people and the functions of institutions. These include all legal and political functions. Cultural services provide people with educational opportunities and all forms of intellectual and spiritual stimulation.

Examples:

Social benefits include services such as education, food subsidies, health care, police, fire brigade, vocational training and subsidised housing, adoption, municipal administration, political research or lobbying.

Identify the links between the elements of the systemic situation model

In a complex system, most of the elements do not act in isolation, but are interrelated, which is what makes the system work in the first place. In this step, you can identify the connections between the different elements in the systems under consideration. The connections can be between elements of the same category or between neighbouring categories.

Sometimes feedback loops occur through these connections. This means that elements in a system are influenced by others that influence them themselves. This can lead to self-reinforcement of processes (positive feedback) or self-control (negative feedback).

Feedback and systemic connections between the elements of the systemic situation model

In reality, there are no linear cause-effect chains in complex, ecological and socio-economic systems. The unpredictability and non-linear change in complex systems are caused, among other things, by synergistic effects, escalation or positive and negative feedbacks. It may even be that target system stresses generated by anthropogenic stress drivers influence underlying factors and causes in the system, creating a feedback loop. Reduced ecosystem functionality and loss of ecosystem services may also influence stress drivers and underlying factors and causes.

People who are unable to meet their basic needs may be forced to make increasingly unsustainable use of natural resources.

Examples:

-The increased flammability of dry vegetation, which can contribute to the risk or threat of forest fires.

-A decline in grassland productivity could encourage nomadic pastoralists to move beyond their traditional grazing areas or return more frequently to the same areas, which in turn become overgrazed.

Set the strength of the relationships

Now you have the option to set the "Strength" of the relationship or effect according to the following options: "Very Weak", "Weak", "Strong", "Very Strong". You can also mark relationships as "Uncertain" if you are not sure if it exists at all.

Step 5: Social systems

Identify the social systems

The social services you identified in the previous step are produced by one or more social systems. Now it is time to describe these systems. Unless you want to focus specifically on a particular social system, it is advisable to focus on the larger complexes of social systems. Social systems can include institutions such as governments, civil society, and profit and non-profit organisations, or any groups of people interacting with each other.

If you want, you can add important subsystems such as specific groups, actors or stakeholders to one or more social systems. These can be actors relevant to the implementation of your work, such as farming or hunting associations, specific companies or important key actors known to play a relatively large role in the system.

Social systems

Humans are social beings; an important component of our human existence is sharing and caring for each other. Social systems are groups of people interacting with each other. Interaction gives rise to emergent properties of these human groups that would not exist without this interaction. Social interaction leads to the emergence of a larger whole that acts and is recognisable as such. This can happen on the basis of a group identity and symbolic effects, but also through the joint management of resources and through structured decisions and the implementation of joint management. Social systems can be very temporary and intuitive. But they can also exist in the long term and function on the basis of constitutional documents or formal statutes.

Examples:

-core family units,

-municipalities, cities, nations,

-groups and industries.

Step 6: Key social attributes

Identify the key social attributes

The ultimate goal of any sustainability management is to ensure the functioning of relevant systems. To be functional, social systems need certain components and conditions. These are the key social attributes. They include both tangible factors, such as access to resources, information and energy, and intangible factors, which relate to the interactions of various social components, such as cooperation, coordination and trust.

A detailed description of key social attributes increases your understanding of the current state of social systems and enables you to make better management decisions.

Key social attributes

Key social attributes are best described as integral elements and properties of social systems that maintain function and provide the necessary adaptation and resilience to cope with disruption. As with social systems, the organisation and definition of key social attributes are subject to strong cultural differences. They may even vary within members of the same group according to socio-economic status, ethnicity, religion or social function. A basic key social attribute of a social system is often the well-being of individuals. Since human groups and institutions exist as nested systems, often the functionality of subsystems can be a key social attribute.

Examples:

- *Material factors such as access to resources, information and energy,*
- *Intangible factors that relate to the interactions of various social components, such as cooperation, coordination and trust.*

Define indicators to measure the status of key social attributes

Efforts should be made to identify at least one indicator for each attribute; although in some cases more than one indicator would be required to represent more complex attributes. In this context, it is relevant to consider how intensive the management of the planning area may be. If time and resource constraints are an issue, more attention should be paid to representing the larger systems within the planning area. As always, the focus is on creating indicators that are measurable.

While it is usually quite easy to find indicators for the tangible key attributes, the intangible key attributes often require some creativity. Therefore, at the beginning it is important to find good indicators that are meaningful and also cost-effective. In more favourable cases, there may already be extensive data from which the processing team can derive suitable indicators. It is important not to get lost in the details of the process, as this part of the application can always be revised and improved.

The stress level of key social and environmental attributes is assessed against several criteria to enable thoughtful and rational prioritisation of system elements for structuring effective management strategies. Three main criteria were used for assessment:

- Strategic Relevance (SR)
- Manageability (M) and

- Knowledge (W)

In this context, criticality is understood as the importance of degraded key attributes/constraints to the state of vulnerability of a target (environmental or social) system. Degraded key attributes/stresses with high criticality values would ideally receive higher attention in the strategy development process.

Assessment of the functioning of the most important key social attributes

The first step is to determine the acceptable range of variation and a rating scale.

According to the principles of non-equilibrium ecology, all properties vary in a naturally functioning ecosystem. Such natural variations are recognised as part of the fluctuations and dynamics of an ecosystem and are considered to be within an "acceptable range of variation" if their condition is defined as very good or good. Scientists and managers are alerted to a potential threat if the condition does not fall into one of these two categories.

Guiding questions for determining the range of variation are:

- How much change in an indicator is acceptable for a system? How much change is too much?
- How much restoration is sufficient?

In order to determine the rating and thus the status of a key social attribute, an initial distinction can be made between very good/good and average/bad using best-fit data and information. Once a rough distinction has been made, it is somewhat easier to divide the categories into four levels: very good, good, moderate and poor. Although informed decision-making is important at this stage of the process, this should not preclude attempting to categorise when there is very little information on which to base decisions. MARISCO's focus is on continuing adaptive management planning and knowledge mapping even when circumstances are far from perfect - in this case, when there are noticeable gaps in knowledge availability.

With this approach, the process can move forward without stalling or getting lost in the goal of achieving a knowledge-perfect situation analysis.

Once the assessment status for each indicator of a key social attribute is determined, the next step is to determine the current and projected future status for each of the key attributes. The desired future state of the key social attribute is the state that is aimed for in the future - i.e. by the end of the planning horizon, when the management vision should have been achieved.

Table 1: Rating criteria for indicators of key social attributes

Evaluation criteria for indicators			
Very good = 4	**Good = 3**	**Mediocre = 2**	**Bad = 1**
The indicator is in a desirable state. Only minimal intervention - or no intervention at all - is required to maintain the	The indicator is within an acceptable range of variation. Some intervention may be required to maintain the	The indicator is outside the acceptable range of variation. The functionality of the target system could be at risk if the situation is	The indicator is far outside the acceptable range of variation. The functionality of the target system is seriously

Evaluation criteria for indicators			
Very good = 4	**Good = 3**	**Mediocre = 2**	**Bad = 1**
functionality of the target system.	functionality of the target system.	not changed. Interventions are required.	endangered. Recovery could be difficult.

Table 2: Example of key social attributes, indicators and indicator scores

Target system	Key attribute	Indicator	Indicator				Current state	Desired state
			Very good	**Good**	**Medium**	**Bad**		
State systems	Legi-timacy	Acceptance of the government by relevant interest groups	The legitimacy of the government is accepted by (almost) all relevant interest groups.	The legitimacy of the government is accepted by a large part of the relevant interest groups.	The legitimacy of the government is only supported by a small part of the relevant interest groups, but not rejected.	The legitimacy of the government is supported by only a few of the relevant interest groups and rejected by most.	Medium	Good
Civil-social systems	Available sweet water resources	Cubic metres (m^3/per capita)	> 1700	1700-1001	1000-500	< 500	Good	Very good

Step 7: Ecosystem services

Identify the ecosystem services

Identifying ecosystem services is essential for working with stakeholders and understanding their needs and perspectives. It is also important for communicating the benefits of protecting functional ecosystems to the public. The representation of ecosystem services reflects the potential of a given area for ecosystem-based sustainable development. When this step is completed, the ways in which people use or depend on the ecosystems of the planning area can be understood and visualised.

Ecosystem services

Ecosystem services are the benefits that people derive from ecosystems or their functions. These include provisioning services such as food and water, regulating services such as flood, drought, soil degradation and disease regulation, and cultural services such as recreation, spiritual, religious and other non-material benefits. Ecosystem services are based on emergent properties of ecosystems. A distinction is made between direct services provided by specific species - e.g. in connection with the production of plant or animal biomass - and indirect services that result from the (inter)interaction of system components (e.g. pollination, climate regulation).

Examples:

- *Cultivated land plants (including fungi, algae) grown for food purposes,*
- *Water cycle and water flow regulation (including flood protection and coastal protection),*
- *Wind energy.*

1.3 Phase 3 Ecosystem functionality

Figure 4: Phase III

Functioning ecosystems are the basis for sustainability. Therefore, a good understanding of ecosystems is fundamental to the development of any planning. When applying an ecosystem-based approach, it is important to identify, where possible, whole systems that represent not only the compositional elements of an ecosystem, but also the processes, structures and dynamics that govern them.

In most cases, this refers to ecosystems at the landscape level, which may also include smaller aquatic and terrestrial subsystems. A large spatial system may represent a particular landscape type - e.g. a forest landscape, a lake landscape (around a large lake including the surrounding mountains and [lower] catchments), a seascape, a coastal landscape, a groundwater landscape, and so on. This may well be the highest order ecosystem object to be conserved, and it is likely to extend beyond the boundaries of the established protected areas within the planning area.

Step 8: Ecosystems and components

Describe the ecosystems

> Identify a sufficiently large spatial unit that encompasses the most important ecological processes in the region and is encompassed by boundaries that are as natural as possible.

> List the smaller ecosystems that are included and are assumed to contribute significantly to the functionality of the larger system - e.g. rivers, lakes, forests, peatlands.

If you wish, you can add important components such as species, populations, functional groups or habitats to one or more ecosystems.

> Identify groups of species (guilds) or individual species that are of particular importance for ecosystem functionality. These can be: structure builders, such as dominant tree species; engineering species, such as beavers; or important keystone species known to play a relatively large role in the system. Typical species that should be listed include apex predators.

Ecosystems

Ecosystems work as "bioreactors" that capture radiant energy from the sun, use it and convert it into chemical energy or "eco-energy". The end result of this conversion process is the production of elaborate and complex molecules with biomass and function. These also have the ability to store residual energy and transfer it between systems if necessary. Energy drives all phenomena in nature. The eco-energy captured by ecosystems can be stored in long-lived organisms such as trees or in organic compounds in soils or fossil sediments. But it can also be used to maintain food webs, which include so-called producers, consumers and decomposers or destructors.

The living beings in ecosystems are in constant interaction and generate forces and emergent properties that do not correspond to the sum of the parts of a system. In other words, it is not possible to accurately characterise an ecosystem simply by describing it in terms of its living things. Rather, it is the interactions of these living things that make up an ecosystem. These interactions relate to the exchange of energy, matter and information.

Example:

Small lakes and ponds are subsystems within temperate wetland ecosystems that contain many representatives of the amphibian functional group, including the fire-bellied toad.

Additional tools you can use to identify ecosystems

Detailed information on the ecosystems of your selected planning area can be found on this homepage https://global-ecosystems.org/analyse.

Step 9: Key ecological attributes

Determine the key ecological attributes and functionality of the target ecosystems

The ultimate goal of ecosystem-based management is to ensure ecosystem functioning. To be functional, ecosystems need certain components and conditions. These are the key ecological attributes. They include abiotic factors, such as temperature regimes, precipitation patterns and soil conditions, and biotic factors, which refer to the presence and interaction of different biological components.

You can identify specific key ecological attributes for each ecosystem. Alternatively, you can insert generic key ecological attributes and then link them to one or more ecosystems. Identifying specific key ecological attributes for each ecosystem gives you a much more accurate understanding of the current state of the ecosystem. This allows for better diagnosis and you can make better management decisions if necessary.

Key ecological attributes

Key ecological attributes are best described as the integral elements and properties of ecological systems that maintain their functioning. This includes ensuring that systems have the necessary adaptive and resilient capacity to better cope with disturbance and environmental change. Key ecological attributes include both biological properties of the system itself and corresponding framework conditions that make their existence possible in the first place. These framework conditions mainly include energy supply, water, a certain climatic regime and the availability of nutrients.

The growth and maturation of living systems - processes associated with a greater capacity to work - are best characterised by biomass, networks and information. These thus represent very basic key ecological properties. Biomass is usually very much shaped by producers and can include living and dead components, both of which perform very important functions in the system (e.g. living trees and deadwood in forests). The information content comprises the diversity of solutions to exist in the ecosystem and to maintain it. The essential basis of information is genetic diversity. Only through a coherent network - the result of the interaction of the various ecosystem components - can energy, matter and information be exchanged and processed in the ecosystem.
In line with the concept of vulnerability, key ecological attributes are closely related to ecosystem sensitivity. Ecosystems with many "demanding" key ecological attributes are more sensitive to changes in exposure to stress drivers. This concerns, for example, narrow temperature preference ranges, large water requirements, highly specialised feeding habits. Key ecological attributes may also be associated with characteristics relevant to ecosystem adaptive capacity.

Define indicators to measure the status of the key ecological attributes

Efforts should be made to identify at least one indicator for each attribute (although in some cases more than one indicator would be needed to represent more complex attributes). In this context, it is relevant to consider how intensive the management of the planning area may be. When time and resources are scarce, more attention should be paid to representing the larger systems within the planning area. Of course, the focus is on selecting indicators that can actually be measured well.

Monitoring the condition of target properties can require a lot of resources - even if this does not necessarily directly contribute to more effective management measures. It is therefore important to find good indicators that are both meaningful and cost-effective. Often, there may already be extensive data sets from which the team can derive suitable indicators. It is important not to get lost in the details of the process. This part of the application can always be revised and improved.

Indicators

An indicator is a measurable quantity that relates to a specific information need, such as the status of an object, the change in a stressor, or progress towards a goal. Indicators can be quantitative measures or qualitative observations. Good indicators meet the following criteria:

Measurable: Can be recorded and analysed quantitatively or in discrete qualitative form.

Unambiguous: Are presented or described in such a way that their meaning is the same for all people.

Sensitive: Changes proportionally in response to actual changes in the condition or object being measured.

Examples:

-The pH value can be used to measure the water quality of a river ecosystem.

-The wood biomass in t/ha can be used for a forest ecosystem.

Set the acceptable range of variation and a rating scale

All attributes vary in a naturally functioning ecosystem. Such natural variations are recognised as part of the fluctuations and dynamics of an ecosystem and are considered to be within an "acceptable range of variation" if the condition is defined as very good or good overall. Once you have defined the ranges, an alarm function can be set to report a potential threat if measurements below the defined threshold are entered. Guiding questions for identifying the range of variation are:

> How much change in an indicator is acceptable for a target ecosystem? How much change is too much?

> "How much" restoration of a '*better* state' is sufficient?

In order to determine the rating and thus the status of an ecological attribute, an initial distinction between very good/good versus average/poor can be made using appropriate data. Once a rough distinction has been made, it is then somewhat easier to further divide the categories into the four levels of very good, good, moderate and poor.

Determine the current and desired future state

Once the assessment status for each key ecological attribute indicator is determined, the next step is to provide some information on the current and desired future status for each of the attributes. The desired future status of the key ecological attribute is the status that is desired for the future - i.e. by the end of your planning horizon, when you should at least have achieved your management vision.

The stress level of key social and environmental attributes is assessed against several criteria to enable a considered and rational prioritisation of system elements for structuring effective management strategies. Three main criteria were used for assessment:

- Strategic Relevance (SR)
- Manageability (M) and
- Knowledge (W)

In this context, criticality is understood as the importance of degraded key attributes/constraints to the state of vulnerability of a target (environmental or social) system. Degraded key attributes/stresses with high criticality values would ideally receive higher attention in the strategy development process.

Assessment of the functionality of the most important ecological key attributes

The first step is to determine the acceptable range of variation and a rating scale.

According to the principles of non-equilibrium ecology, all properties vary in a naturally functioning ecosystem. Such natural variations are recognised as part of the fluctuations and dynamics of an ecosystem and are considered to be within an "acceptable range of variation" if their condition is defined as very good or good. Scientists and managers are alerted to a potential threat if the condition does not fall into one of these two categories.

Guiding questions for determining the range of variation are:

- How much change in an indicator is acceptable for a system? How much change is too much?
- How much restoration is sufficient?

In order to determine the classification and thus the status of a key ecological attribute, an initial distinction between very good/good and moderate/poor can be made using best-fit data and information. Once a rough distinction has been made, it is somewhat easier to divide the categories into four levels: very good, good, moderate and poor. Although informed decision-making is important at this stage of the process, this should not preclude attempting to categorise when there is very little information on which to base decisions. MARISCO's focus is on continuing adaptive management planning and knowledge mapping even when circumstances are far from perfect - in this case, when there are noticeable gaps in knowledge availability.

With this approach, the process can move forward without stalling or getting lost in the goal of achieving a knowledge-perfect situation analysis.

Once the assessment status for each indicator of a key ecological attribute is determined, the next step is to determine the current and projected future status for each of the key attributes. The desired future status of the key ecological attribute is the status that is aimed for in the future - i.e. by the end of the planning horizon, when the management vision is supposed to have been achieved.

Table 3: Rating criteria for indicators of key ecological attributes

Rating criteria for indicators			
Very good = 4	**Good = 3**	**Mediocre = 2**	**Bad = 1**
The indicator is in a desirable state. Only minimal intervention - or no intervention at all - is required to maintain the functionality of the target system.	The indicator is within an acceptable range of variation. Some intervention may be required to maintain the functionality of the target system.	The indicator is outside the acceptable range of variation. The functionality of the target system could be at risk if the situation is not changed. Interventions are required.	The indicator is far outside the acceptable range of variation. The functionality of the target system is seriously endangered. Recovery could be difficult.

Table 4: Example of key ecological attributes, indicators and indicator scores

Target system	Key attribute	Indicator	Indicator				Current state	Desired state
			Very good	Good	Medium	Bad		
Forest eco-system	Wood biomass	Standing and lying deadwood	Significant density of standing and lying, large, dead trunks throughout the forest	Standing and lying dead logs found in most parts of the forest	Only a few standing and lying dead trunks here and there; hardly any dead branches on the forest floor.	Hardly any or no dead trunks or branches in the forest	Bad	Good
River ecosystem	Water quality	pH	7.8-7.9	7.0-7.7	5.5--6.9	< 5.5	Good	Very good

1.4 Phase 4 Stresses and risks

Figure 5: Phase IV

Once the target objects are defined and before further action is taken to formulate the strategy, it is important to create as good as possible a detailed understanding of the circumstances and conditions that characterise the character and state of the socio-ecological systems of the planning area. The systemic situation analysis should adequately reflect the complexity of the socio-ecological system. This means that an effort is made to represent the manifold effects and interactions, at least to some extent. In particular, this also involves the human impacts in the ecosystem, which have often led to a very strong change in the system.

The end result of the MARISCO situation analysis is a visual representation of a systemic situation model. This model aims to include as many of the elements involved in the cause-effect dynamics of the complex socio-ecological system as possible. On another level, the model also tries to capture what is known about the system. It also tries to uncover the existing knowledge gaps and other forms of "non-knowledge" associated with the indeterminacy of the complex system to be managed. Knowledge management and consciously working with the various forms of non-knowledge, which include unresolvable uncertainty, is an essential component of the adaptive management approach. Working with knowledge and evidence is very important, but even more significant is the recognition of how provisional and incomplete knowledge about complex systems usually is.

Step 10: Ecological stress analysis

Carry out an ecological stress analysis

A detailed stress analysis of ecosystems is important for understanding how ecosystems and their components are affected by the negative impacts of direct and indirect human activities. It is the starting point for identifying and understanding stress drivers and for formulating hypotheses about cause-effect chains' that will eventually be triggered by policy implementation. The number of stresses provides further insight into the vulnerability of an ecosystem, as highly stressed ecosystems are generally expected to have higher vulnerability.

There are two ways to conduct an ecological stress analysis. You can either assess the stress level of each key ecological attribute that you have created specifically for the ecosystems and their components, or you can formulate generic stresses that can then be linked to the key ecological attributes. The first option provides a detailed understanding of the state of each ecosystem and its components, but takes a little more time. Of course, in water bodies or forests, for example, there are clearly differentiated key attributes in each case. In human-dominated agro-ecosystems or settlement ecosystems, there are again completely different attributes and thus also stresses. The second option of formulating generic attributes will be faster, but remains much more superficial.

You can always come back and revise and deepen this step if necessary. In the end, spending more time at this point means a deeper understanding and, especially in interdisciplinary and transdisciplinary planning groups, definitely important gains in knowledge.

Ecological stresses

Ecological stresses describe the symptoms and manifestations of the deterioration of key ecological attributes. They manifest themselves as loss of biomass, information and network, among other things. The implication of stress is that under certain conditions, ecological attributes begin to degrade, which then affects the resilience and adaptive capacity of biodiversity elements such as species or ecosystems. Systems take on different states, they degrade or even collapse. Stress describes a specific state, reaction or symptoms of a system or one of its components to anthropogenic pressures - the so-called stress drivers. These unfavourable states in relation to individual components or attributes can in turn trigger further stresses or also interact cumulatively with other stresses. The cumulative effect of several stresses can lead to an escalating degradation of an ecosystem.

Example:

Changes in the pH of seawater in the oceans, for example, alter the water's buffering capacity and its ability to regulate temperature fluctuations. Physical changes of this kind affect the ability of calcareous organisms to form an exoskeleton or, in the case of corals, to feed autotrophically (leading to coral bleaching).

Ecological stress analysis

For each stress, determine the perceived criticality by estimating the spatial extent, severity and degree of irreversibility or permanence. In the context of disaster risk reduction, criticality is a relative measure of the importance of an infrastructure in terms of the consequences that a disruption or loss of function has on the security of supply of essential goods and services to society. In the context of MARISCO analysis, criticality is seen as a relative measure of the significance of the problem in terms of the consequences that a disruption or functional failure of systems under consideration may entail. A particularly critical stress is of outstanding importance because it may determine the sustainable existence of a system.

There is no objective or absolute measure of criticality, not even with the highest degree of scientific support. Rather, it is a matter of making expertly supported assessments to arrive at the best possible judgement about the state and dynamics of a target system. This phase of the analysis can be carried out by a core planning team, with the results later validated by other experts in Step 19 during the revision. If you are short of time, you can also roughly assess the current criticality (initially) using summary criteria.

The use of key attributes to assess the status of target systems is strongly recommended. However, if it is not possible to assess them thoroughly due to time constraints, a higher-level assessment of the system should be made. For this purpose, the assessment criteria of the key attributes should be used directly for the target system.

Analysis of the current criticality

Ideally, with sufficient time and resources, a full assessment of the current criticality of each key ecological attribute should be carried out based on spatial extent, severity and irreversibility/permanence of the corresponding element. However, where this is not possible, you can carry out a summary or simplified assessment.

Table 5: Rating categories for current criticality

Rating categories for current criticality			
Current criticality: Spatial extent (extent of spatial distribution)			
Local occurrence = 1	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
The degraded key attribute is probably not widespread in its spatial extent or only widespread in a small area (1-10 %).	The degraded key attribute is probably widespread in its spatial extent in a rather limited area (11-30 %).	The degraded key attribute is likely to be widespread in its spatial extent over a large part of the area (31-70%).	The degraded key attribute is likely to be widespread in its spatial extent across all or most of its area (71-100%).
Current criticality: severity (extent of impact)			
Light = 1	**Moderate = 2**	**Heavy = 3**	**Extreme = 4**
Within the spatial extent, the degraded key attribute causes no	Within the spatial extent, the degraded key attribute could lead to a	Within the spatial extent, the degraded key attribute is likely to lead	Within the spatial extent, the degraded key attribute will most likely lead to a serious

Rating categories for current criticality			
reduction in the overall functionality of the system.	small reduction in the overall functionality of the system over the next 10 years.	to a reduction in the overall functionality of the system within the next 10 years.	reduction in the overall functionality of the system or even its loss within the next 10 years.
Current criticality: irreversibility (probability of permanence)			
Short-term disappearance probable = 1	**Probable medium-term and reversible = 2**	**Probably long-term and difficult to reverse = 3**	**Probably more permanent and irreversible = 4**
It is likely that the degraded key attribute will disappear spontaneously (without management) in the short term (1 to 5 years), with possibly only slightly reversible consequences for the system.	It is likely that the degraded key attribute will not disappear in the medium term (6 to 20 years) (without management), but this does not imply long-term and irreversible consequences for the system.	It is likely that the degraded key attribute will persist (without management) for the long term (21 to 100 years), which will also have long-term consequences for the system that are difficult to reverse.	It is very likely that the degraded key attribute will persist in the long term (probably even longer than a century), which also entails long-term consequences for the system that may be irreversible for decades.

To calculate the **total current criticality,** the three sub-criteria *spatial extent, severity* and *irreversibility* must be combined. First, the combination of *spatial extent* and *severity is* calculated as *extent.* Then the combination of *extent* and *irreversibility/permanence is* calculated, resulting in the total current criticality.

Table 6: Matrix for calculating the extent (combination of extent and severity)

Extent				
Spatial expansion (to the right)	**Local occurrence = 1**	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
Severity (bottom)				
Light = 1	1	2	2	3
Moderate = 2	2	2	3	3
Heavy = 3	2	3	3	4
Extreme = 4	3	3	4	4

Table 7: Matrix for calculating the total current criticality (combination of extent and irreversibility)

Total current criticality				
Extent (to the right)	**Low = 1**	**Medium = 2**	**High = 3**	**Very high = 4**
Irreversibility (below)				
Short-term disappearance probable = 1	1	2	2	3

Total current criticality				
Probable medium-term and reversible = 2	2	2	3	3
Probably long-term and difficult to reverse = 3	2	3	3	4
Probably more permanent and irreversible = 4	3	3	4	4

Table 8: Explanation of the total current criticality

Total current criticality			
Slightly critical = 1	**Moderately critical = 2**	**Critical = 3**	**Very critical = 4**
The degraded key attribute does not play a very important role in determining the overall vulnerability of the target system within the geographical area of analysis.	The degraded key attribute plays a moderately important role in determining the overall vulnerability of the target system within the geographical area of analysis.	The degraded key attribute plays an important role in determining the overall vulnerability of the target system within the geographical area of analysis. It/he is an important driver of negative change in the analysed system.	The degraded key attribute plays an extremely important role in determining the overall vulnerability of the target system within the geographical area of analysis. It/he is an important and persistent driver of negative change in the analysed system.

Analysis of past criticality

To determine past criticality, compare the current situation of each important ecological attribute with the (assumed) situation 20 years ago.

Table 9: Rating categories for former criticality

Past criticality (about 20 years ago)			
Lower than current = 1	**Corresponds to the current = 2**	**Higher than current = 3**	**Much higher than current = 4**
The past criticality (20 years ago) of the degraded key attribute is lower than the current criticality.	The past criticality (20 years ago) of the degraded key attribute more or less corresponds to the current one.	The past criticality (20 years ago) of the degraded key attribute is higher than the current criticality.	The past criticality (20 years ago) of the degraded key attribute was much higher than the current one.

Analysis of the change trend

An important aspect is the dynamic behaviour or the current trend of change.

Guiding questions for determining the current trend of change are:

> How is the stress level of key ecological attributes changing right now?

> Is the stress level currently increasing or decreasing? Slowly and gradually or even exponentially?

Table 10: Rating categories for the trend of change

Current trend of change in criticality (change in criticality)			
Decreasing = 1	**Stable = 2**	**Gradually increasing = 3**	**Rapidly increasing = 4**
Currently, the criticality of the degraded key attribute tends to decrease.	Currently, the criticality of the degraded key attribute seems to be quite stable. No change can be seen.	Currently, the criticality of the degraded key attribute is tending to increase, but rather gradually and apparently quite predictably.	Currently, the criticality of the degraded key attribute tends to increase rapidly and at an accelerated rate (exponentially).

Analysis of future criticality

To determine future criticality, compare the current situation of each key ecological attribute with the situation in 20 years' time based on current knowledge. Any change within the key ecological attributes that is not only relevant today but is expected to become more important in the future deserves more attention than a key ecological attribute with decreasing relevance. It is of course the case that it is mostly impossible to reliably predict or project future criticality. But the current assumption that an element will still gain in criticality should be incorporated in the sense of the precautionary principle and as part of the risk assessment. In the course of adaptive management, it must later become apparent whether the assessment needs to be validated or changed.

Table 11: Rating categories for future criticality

Future criticality (in about 20 years)			
Lower than current = 1	**Corresponds to the current = 2**	**Higher than current = 3**	**Much higher than current = 4**
Future criticality (20 years from now) is expected to be lower than current criticality.	It is assumed that the future criticality (in 20 years) is the same as the current one.	Future criticality (20 years from now) is expected to be higher than current criticality.	The future criticality (20 years from now) is expected to be much higher than the current one.

Knowledge analysis

Using the categories given below, classify the level of knowledge that exists within the team about the stress level of the main ecological attributes. The "knowledge" includes all possible dimensions that can be known about an element, such as its importance in the cause-effect network, its behaviour, its dynamics, etc. It does not include an assessment of the knowledge of other institutions operating in the environment and outside the influence of the team.

Table 12: Rating categories for knowledge

Knowledge			
Well known = 1	**Somewhat known = 2**	**Not known, but theoretically possible to find out = 3**	**Not known = 4**
The knowledge of the degraded key attribute is very high; the planning team has a precise idea of the characteristics, meaning and dynamics of the element.	Knowledge of the degraded key attribute is adequate; the planning team has a fairly good idea of the characteristics, meaning and dynamics of the element. Some knowledge gaps might have been identified.	Knowledge about the degraded key attribute is low; the planning team does not have a good idea of the characteristics, meaning and dynamics of the element. Better knowledge may be available, but the team does not currently have it.	It is impossible to gain good knowledge about the degraded key attribute; the planning team can only formulate assumptions about the characteristics, meaning and dynamics of the element. Further research would not provide better knowledge. This lack of knowledge is related to the fact that the element is influenced in complex ways by other uncertain elements or that it represents future risks.

Manageability analysis

Manageability describes the extent to which the people or institutions responsible for management can realistically influence a problem or process. Assess the manageability of each key ecological attribute using the categories below. It is important to focus on the area of concern and not drift into discussions of manageability beyond the practical scope of the team (e.g. "Is climate change itself manageable?"). In other words, avoid more general and broad questions that relate to a global context.

Table 13: Rating categories for manageability

Manageability			
Very manageable = 1	**Somewhat manageable = 2**	**Insufficiently manageable = 3**	**Not manageable = 4**
The degraded key attribute can be easily and directly managed through strategies and project activities; usually these relate mainly to local elements.	The degraded key attribute can probably be directly managed to some extent through strategies and project activities, especially if more resources are made available than before.	The degraded key attribute is most likely not directly manageable. Instead, it can be influenced in a meta-systemic and indirect way.	The degraded key attribute is not manageable at all; it is highly unlikely that the local administration would change it directly or indirectly.

Strategic relevance summarises the result of the assessments of *overall current criticality*, *current trend of criticality change* and *future criticality:*

Strategic relevance for stress analysis of key attributes: $SR = K_A + K_T + K_Z$ (Strategic relevance = total current criticality + current trend of criticality change + future criticality)

Identify the environmental stresses

In the previous step, the key ecological attributes for the ecosystems and their components were identified. In an ideal world, all states of these key ecological attributes would be within their acceptable range of variation. Unfortunately, in reality this is often not the case, as direct and indirect impacts of human activities cause changes within the key ecological attributes that ultimately lead to their degradation. Identifying these changes is the first step in a thorough diagnosis of ecological stress, which is eventually addressed through the implementation of strategies.

To begin this exercise, review the key ecological attributes. Those that are degraded or could be degraded within the timeframe of your planning horizon can be classified as stresses. When a full functional analysis has been carried out, it should be somewhat clearer from the status given to the attributes which of these are likely to turn into stresses. Once this exercise has been completed, reflect on the status of the ecosystems and their components. This may lead to the identification of other stresses that may have been neglected when determining the key ecological attributes.

In general, the following guiding questions help to identify stresses:

> What kind of negative changes in key ecological attributes can be observed?

> What are the signs of "disorder" and "disease"?

> Are there critical changes in the state of the leading ecological factors, such as climate, soils or water?

> Is there a loss of biomass, information or networks within the system?

> Is there a loss of networking/connectedness with other systems?

The use of key attributes to assess the status of target systems is strongly recommended. However, if it is not possible to assess them thoroughly due to time constraints, a higher-level assessment of the system should be made. For this purpose, the rating criteria of the key attributes should be used directly for the target system.

Step 11: Ecological stress drivers

Identify the environmental stress drivers

Ecological stress is caused by corresponding drivers. In the case of the MARISCO analysis, the focus is on direct and indirect human activities that have a negative impact on one or more key ecological attributes.

Guiding questions for the identification of ecological stress drivers are:

> Which human activities have a negative impact on the viability of the various ecosystems or their components?

> What other processes degrade the functionality of key ecological properties by causing stress?

Ecological stress drivers

Ecological stress drivers are all pressures that can directly or indirectly affect the natural structure and dynamics of an ecosystem. They represent processes of change that negatively affect target systems by causing stress and increasing their vulnerability. Ultimately, they cause a change of state associated with degradation (which means the loss of guiding factors, biomass, information or networks). There are both obvious and subtle examples of stress drivers. Usually the indirect or imperceptible effects are the most difficult to observe or identify, yet they can cause the greatest disruption to the ecosystem. One example is the complex dynamics of human-induced climate change.
In principle, 'natural', non-human stress drivers can also be relevant and be included. This is especially true if natural and anthropogenic stress drivers together cause a poor condition of the systems under consideration and management must potentially also include mitigating or avoiding the effects of natural stress drivers (e.g. loss of coastal ecosystems as a result of natural land subsidence, indirectly human-induced sea-level rise and sand mining).

Examples:

-Extractive activities such as logging or hunting,

-consequences of changes in the physical or chemical conditions of the environment such as increased water runoff, soil erosion and water pollution.

Step 12: Underlying factors and causes

Identify the underlying factors and causes

Underlying factors and causes are human actions or activities that directly or indirectly lead to the emergence of a stressor.

Guiding questions for this process are:

> What are the reasons for the occurrence of a stress driver or an underlying factor?

> Which relevant actors and stakeholders are involved in the creation of a stressor? What are their reasons for doing so?

> Are there factors from the list that positively influence another underlying factor and causer or stress driver?

Underlying factors and causes

Underlying factors and causes are best described as a human action or activity that directly or indirectly leads to the occurrence of a stress driver. The stress driver then leads to one or more stresses in one or more components of an ecosystem. Often the underlying factors and causes work synergistically, but they can also produce opposing effects. Many of these underlying factors and causes pose risks because they can occur unpredictably in the future or change and contribute to impacts on target systems.

Examples:

The overuse of fossil fuels as a cause of increased CO2 levels in the atmosphere, which is an underlying factor in global climate change.

Structuring the systemic situation model - grouping

Look for underlying factors and causes that can be grouped according to the given thematic areas. For example, within the factors related to the use of natural resources, you can sub-group "agriculture", "forestry" and "mining".

The headings of these groups make it easier for the viewer to navigate the systemic situation model. Later, you can zoom out of the systemic situation model, hide the details and show only the first or second order elements. By this abstraction or reduction, the model does not reduce the complexity of the system, but it improves the clarity for the viewer who wants to understand it. No information is lost and the viewer can always zoom in again if more detailed information is needed.

Step 13: Social stress analysis

Carry out a social stress analysis

Once the team has identified key social attributes for the social systems, they may decide to conduct a social stress analysis, similar to the ecological stress analysis described in step 10.

To begin this exercise, first go through the key social attributes. Those that are degraded or could be degraded within the time frame of the planning horizon can be classified as stresses. When a full functional analysis has been carried out, it should be somewhat clearer from the status given to the attributes which are in such poor condition that stress is present. Once this step has been completed, one should reflect on the status of the social systems and their components. This may lead to the identification of other stresses that may have been neglected in determining the most important social attributes.

In general, the following guiding questions help to identify stress:

> What kind of negative changes in key social attributes can be observed?

> What are the signs of "disturbance" and "illness" of the social system?

> Is there a loss of quantity of components, information or networks within the system?

> Is there a loss of connectedness within the system or with other systems?

Social stress

Social stress describes the symptoms and manifestations of negative change in key social attributes. As in the ecosystem, they basically present themselves as a loss of a minimum level of mass, information and network and are often related to the deterioration of framework conditions and resources. The effect of stress is that under certain conditions, key social attributes begin to degrade. This in turn ultimately affects the resilience and adaptability of social systems and their components. Over time, this can cause the systems to lose significant functionality or even collapse. Stress describes a specific state, reaction or symptoms of a system or one of its components to anthropogenic pressures - the so-called stress drivers. If they persist, the effects lead to shifts or changes in the system.

In some cases, one stress can cause or promote another stress. In many cases, symptoms arise from the cumulative effect of multiple stresses in parts of the systems or in the systems themselves. These can then lead to escalating degradation of a social system.

Examples:
-(Violent) conflicts,
-loss of knowledge and traditions,
Lack of communication.

The use of key attributes to assess the status of target systems is strongly recommended. However, if it is not possible to assess them thoroughly due to time constraints, a higher-level assessment of the system should be made. For this purpose, the rating criteria of the key attributes should be used directly for the target system.

Analysis of the current criticality

Ideally, with sufficient time and resources, a full assessment of the current criticality of each key social attribute should be carried out based on the spatial extent, severity and irreversibility/permanence of the relevant element. However, where this is not possible, you can carry out a summary or simplified assessment.

Table 14: Rating categories for current criticality

Rating categories for current criticality			
Current criticality: Spatial extent (extent of spatial distribution)			
Local occurrence = 1	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
The degraded key attribute is probably not widespread in its spatial extent or only widespread in a small area (1-10 %).	The degraded key attribute is probably widespread in its spatial extent in a rather limited area (11-30 %).	The degraded key attribute is likely to be widespread in its spatial extent over a large part of the area (31-70%).	The degraded key attribute is likely to be widespread in its spatial extent across all or most of its area (71-100%).
Current criticality: severity (extent of impact)			
Light = 1	**Moderate = 2**	**Heavy = 3**	**Extreme = 4**
Within the spatial extent, the degraded key attribute causes no reduction in the overall functionality of the system.	Within the spatial extent, the degraded key attribute could lead to a small reduction in the overall functionality of the system over the next 10 years.	Within the spatial extent, the degraded key attribute is likely to lead to a reduction in the overall functionality of the system within the next 10 years.	Within the spatial extent, the degraded key attribute will most likely lead to a serious reduction in the overall functionality of the system or even its loss within the next 10 years.
Current criticality: irreversibility (probability of permanence)			

Rating categories for current criticality			
Short-term disappearance probable = 1	**Probable medium-term and reversible = 2**	**Probably long-term and difficult to reverse = 3**	**Probably more permanent and irreversible = 4**
It is likely that the degraded key attribute will disappear spontaneously (without management) in the short term (1 to 5 years), with possibly only slightly reversible consequences for the system.	It is likely that the degraded key attribute will not disappear in the medium term (6 to 20 years) (without management), but this does not imply long-term and irreversible consequences for the system.	It is likely that the degraded key attribute will persist (without management) for the long term (21 to 100 years), which will also have long-term consequences for the system that are difficult to reverse.	It is very likely that the degraded key attribute will persist in the long term (probably even longer than a century), which also entails long-term consequences for the system that may be irreversible for decades.

To calculate the **total current criticality,** the three sub-criteria *spatial extent, severity* and *irreversibility* must be combined. First, the combination of *spatial extent* and *severity is* calculated as *extent.* Then the combination of *extent* and *irreversibility/permanence is* calculated, resulting in the total current criticality.

Table 15: Matrix for calculating the extent (combination of extent and severity)

Extent				
Spatial expansion (to the right)	**Local occurrence = 1**	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
Severity (bottom)				
Light = 1	1	2	2	3
Moderate = 2	2	2	3	3
Heavy = 3	2	3	3	4
Extreme = 4	3	3	4	4

Table 16: Matrix for calculating the total current criticality (combination of extent and irreversibility)

Total current criticality				
Extent (to the right)	**Low = 1**	**Medium = 2**	**High = 3**	**Very high = 4**
Irreversibility (below)				
Short-term disappearance probable = 1	1	2	2	3
Probable medium-term and reversible = 2	2	2	3	3
Probably long-term and difficult to reverse = 3	2	3	3	4

Total current criticality				
Probably more permanent and irreversible = 4	3	3	4	4

Table 17: Explanation of the total current criticality

Total current criticality			
Slightly critical = 1	**Moderately critical = 2**	**Critical = 3**	**Very critical = 4**
The degraded key attribute does not play a very important role in determining the overall vulnerability of the target system within the geographical area of analysis.	The degraded key attribute plays a moderately important role in determining the overall vulnerability of the target system within the geographical area of analysis.	The degraded key attribute plays an important role in determining the overall vulnerability of the target system within the geographical area of analysis. It/he is an important driver of negative change in the analysed system.	The degraded key attribute plays an extremely important role in determining the overall vulnerability of the target system within the geographical area of analysis. It/he is an important and persistent driver of negative change in the analysed system.

Analysis of past criticality

To determine past criticality, compare the current situation of each important social attribute with the (assumed) situation 20 years ago.

Table 18: Rating categories for former criticality

Past criticality (about 20 years ago)			
Lower than current = 1	**Corresponds to the current = 2**	**Higher than current = 3**	**Much higher than current = 4**
The past criticality (20 years ago) of the degraded key attribute is lower than the current criticality.	The past criticality (20 years ago) of the degraded key attribute more or less corresponds to the current one.	The past criticality (20 years ago) of the degraded key attribute is higher than the current criticality.	The past criticality (20 years ago) of the degraded key attribute was much higher than the current one.

Analysis of the change trend

An important aspect is the dynamic behaviour or the current trend of change.

Guiding questions for determining the current trend of change are:

> How are the stress levels of key social attributes changing right now?

> Is the stress level currently increasing or decreasing? Slowly and gradually or even exponentially?

Table 19: Rating categories for the trend of change

Current trend of change in criticality (change in criticality)			
Decreasing = 1	**Stable = 2**	**Gradually increasing = 3**	**Rapidly increasing = 4**
Currently, the criticality of the degraded key attribute tends to decrease.	Currently, the criticality of the degraded key attribute seems to be quite stable. No change can be seen.	Currently, the criticality of the degraded key attribute is tending to increase, but rather gradually and apparently quite predictably.	Currently, the criticality of the degraded key attribute tends to increase rapidly and at an accelerated rate (exponentially).

Analysis of future criticality

To determine future criticality, compare the current situation of each key social attribute with the situation in 20 years' time based on current knowledge. Any change within the key social attributes that is not only relevant today but is also expected to become more important in the future deserves more attention than a key social attribute with decreasing relevance. It is of course the case that it is mostly impossible to reliably predict or project future criticality. But the current assumption that an element will still gain in criticality should be included in the sense of the precautionary principle and as part of the risk assessment. In the course of adaptive management, it must later become apparent whether the assessment needs to be validated or changed.

Table 20: Rating categories for future criticality

Future criticality (in about 20 years)			
Lower than current = 1	**Corresponds to the current = 2**	**Higher than current = 3**	**Much higher than current = 4**
Future criticality (20 years from now) is expected to be lower than current criticality.	It is assumed that the future criticality (in 20 years) is the same as the current one.	Future criticality (20 years from now) is expected to be higher than current criticality.	The future criticality (20 years from now) is expected to be much higher than the current one.

Knowledge analysis

Using the categories given below, classify the level of knowledge that exists within the team about the stress level of the main social attributes. The 'knowledge' includes all possible dimensions that can be known about an element, such as its importance in the cause-effect network, its behaviour, its dynamics, etc. It does not include an assessment of the knowledge of other institutions operating in the environment and outside the influence of the team.

Table 21: Rating categories for knowledge

Knowledge			
Well known = 1	**Somewhat known = 2**	**Not known, but theoretically possible to find out = 3**	**Not known = 4**
The knowledge of the degraded key attribute is very high; the planning team has a precise idea of the characteristics, meaning and dynamics of the element.	Knowledge of the degraded key attribute is adequate; the planning team has a fairly good idea of the characteristics, meaning and dynamics of the element. Some knowledge gaps might have been identified.	Knowledge about the degraded key attribute is low; the planning team does not have a good idea of the characteristics, meaning and dynamics of the element. Better knowledge may be available, but the team does not currently have it.	It is impossible to gain good knowledge about the degraded key attribute; the planning team can only formulate assumptions about the characteristics, meaning and dynamics of the element. Further research would not provide better knowledge. This lack of knowledge is related to the fact that the element is influenced in complex ways by other uncertain elements or that it represents future risks.

Manageability analysis

Manageability describes the extent to which the people or institutions responsible for management can realistically influence a problem or process. Assess the manageability of each key social attribute using the categories below. It is important to focus on the area of processing and not drift into discussions of manageability beyond the practical scope of the team. In other words, avoid more general and broad questions that relate to a global context.

Table 22: Rating categories for manageability

Manageability			
Very manageable = 1	**Somewhat manageable = 2**	**Insufficiently manageable = 3**	**Not manageable = 4**
The degraded key attribute can be easily and directly managed through strategies and project activities; usually these relate mainly to local elements.	The degraded key attribute can probably be directly managed to some extent through strategies and project activities, especially if more resources are made available than before.	The degraded key attribute is most likely not directly manageable. Instead, it can be influenced in a meta-systemic and indirect way.	The degraded key attribute is not manageable at all; it is highly unlikely that local management would change anything about it, directly or indirectly.

Strategic relevance summarises the result of the assessments of *overall current criticality*, *current trend of criticality change* and *future criticality:*

Strategic relevance for stress analysis of key attributes: $SR = K_A + K_T + K_Z$ (Strategic relevance = total current criticality + current trend of criticality change + future criticality)

Step 14: Social stress drivers

Identify the social stress drivers

Social stress is caused by the direct and indirect human activities that negatively affect one or more important key social attributes. These are the social stress drivers.

Guiding questions for the identification of social stress drivers are:

> Which human activities have a negative impact on the ability of the various social systems to exist?

> What other processes degrade the functionality of key social attributes by causing social stress?

Social stress drivers

Social stress drivers are the direct and indirect human activities that have a negative impact on one or more key social attributes, causing social stress.

Examples:

- *Discrimination,*
- *Terrorism,*
- *Corruption.*

Step 15: Underlying factors and causes (Part II)

Identify the underlying factors and causes

Underlying factors and causes are human actions or activities that directly or indirectly lead to the emergence of a stressor.

Guiding questions for this process are:

> What are the reasons for the occurrence of a stress driver or an underlying factor?

> Which relevant actors and stakeholders are involved in the creation of a stressor? What are their reasons for doing so?

> Are there factors from the list that positively influence another underlying factor and causer or stress driver?

Underlying factors and causes

Underlying factors and causes are best described as a human action or activity that directly or indirectly leads to the occurrence of a stress driver. The stress driver then leads to stress or stresses in one or more components of an ecosystem. Often the underlying factors and causes work synergistically, but they can also produce opposing effects.

Many of these underlying factors and causes pose risks because they can occur unpredictably in the future or change and contribute to impacts on target systems.

Example:

- *Geopolitical tensions that can lead to sanctions and ultimately poverty.*

Step 16: Revise and complete the systemic relationships

Identify the links between the elements of the systemic situation model

Now it is time to identify the links between the elements. The connections can be between elements of the same category or between neighbouring categories. Sometimes these connections form feedback loops.

The connections are important for your understanding of the dynamics of the systemic situation model. They are used to calculate the systemic activity of the elements.

Systemic activity

Systemic activity is calculated by first counting the number of incoming and outgoing connections for each element. This is then assigned to the categories described below.

Then the activity of each element is calculated according to the number of influenced elements. Finally, the total systemic activity of each element is determined using the following table.

Step 17: Element evaluation

Evaluate the strategic relevance of the elements of the systemic situation model

The strategic relevance of a stress, stress driver, underlying factor or cause refers to the perceived importance of these elements to the vulnerability of the target system. Any element with a high strategic relevance rating should be examined in more detail in the final prioritisation process.

There are two ways to assess the current criticality of the elements. You can either do a detailed assessment by evaluating the scope, severity and irreversibility of the elements, or you can evaluate the current criticality using summary or simplified criteria. The first option gives you a detailed understanding of the current criticality of each element, but takes a little more time. The second option is quicker but less specific. However, you can always come back and revise this step if needed.

Strategic relevance

The strategic relevance summarises the results of the different assessments made in the element rating. It can be used to identify the most relevant elements in the systemic situation model (stresses, drivers of stresses and underlying factors and causes). Therefore, it serves as a stimulus for prioritising the elements, which is important in the subsequent steps for developing strategies.

However, it is important to remember that strategic relevance is a derived value and should not be seen as a substitute for the individually derived outcomes for each element.

Strategic relevance is calculated with this formula: R = CC + CT + CF + SA

-R = strategic relevance,

-CC = current criticality,

-CT = current trend of criticality,

-CF = future criticality,

SA = systemic activity.

Evaluate the elements of the systemic situation model

For each element, record the perceived criticality by assessing the spatial extent, severity and degree of irreversibility or irreversibility. In the context of disaster risk reduction, criticality is a relative measure of the importance of an infrastructure in terms of the consequences that a disruption or loss of function has on the security of supply of essential goods and services to society. In the context of the MARISCO analysis, criticality is seen as a relative measure of the importance of a problem in terms of the consequences that a disruption or functional failure of systems under consideration may entail. A particularly critical factor is of outstanding importance because it influences other elements in such a way that, at least indirectly, it significantly contributes to the sustainable existence of a system. There is no objective or absolute measure of criticality, not even with the greatest scientific support. Rather, it is a matter of capturing opinions in order to make the best possible judgement about the status of a target system. This phase of the analysis can be carried out by a core planning team, with the results later validated by other experts.

Stress, ecological and social stress drivers and their underlying factors and causes are assessed against several criteria to enable a considered and rational prioritisation of system elements for structuring effective conservation strategies. Four main criteria are used to assess the ecological and social stress drivers and their underlying factors and causes:

- Criticality (K)
- Systemic activity (S_A)
- Manageability (M) and
- Knowledge (W)

Strategic relevance (R) is calculated from criticality and systemic activity. Strategic relevance can be used as a gauge to measure the importance of the stress, stress driver and underlying factor or cause to the state of vulnerability of a system. Stresses, stress drivers, underlying factors or causes with high strategic relevance would ideally receive more attention in the strategy development process.

Analysis of the current criticality

In an ideal situation with sufficient time and resources, it is always best to carry out the full assessment of the current criticality of each stress, stress driver and factor and cause based on geographical scope, severity and irreversibility. However, where this is not possible, you can carry out a summary assessment.

Table 23: Rating categories for the current criticality of the stresses

Rating categories for the current criticality of the stresses			
Spatial extent (extent of spatial distribution)			
Local occurrence = 1	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
The stress is probably not widespread in its spatial extent or only in a small area (1-10 %).	The stress is probably widespread in a fairly limited area (11-30 %) in its spatial extent.	The stress is likely to be widespread in its spatial extent over a large part of the area (31-70%).	The stress is likely to be widespread in its spatial extent over all or most of its area (71-100%).
Severity (extent of impact)			
Light = 1	**Moderate = 2**	**Heavy = 3**	**Extreme = 4**
Within the spatial extent, the stress does not cause a reduction in the overall functionality of the system.	Within the spatial extent, stress could lead to a small reduction in the overall functionality of the system over the next 10 years.	Within the spatial extent, the stress is likely to lead to a reduction in the overall functionality of the system within the next 10 years.	Within the spatial extent, the stress will most likely lead to a serious reduction in the overall functionality of the system or even its loss within the next 10 years.
Irreversibility (probability of permanence)			
Short-term disappearance probable = 1	**Probable medium-term and reversible = 2**	**Probably long-term and difficult to reverse = 3**	**Probably more permanent and irreversible = 4**
It is likely that the stress will disappear spontaneously (without management) in the short term (1 to 5 years), which may mean only slightly reversible consequences for the system.	It is likely that the stress will not disappear in the medium term (6 to 20 years) (without management), but this does not mean long-term and irreversible consequences for the system.	It is likely that the stress will persist (without management) for the long term (21 to 100 years), which will also have long-term consequences for the system that are difficult to reverse.	It is very likely that the stress will persist in the long term (probably even longer than a century), which also entails long-term consequences for the system that may be irreversible for decades.

Table 24: Rating categories for current criticality of stress drivers

Rating categories for the current criticality of the stress drivers			
Spatial extent (extent of spatial distribution)			
Local appearance = 1	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
The stress driver is probably very limited in its spatial extent and only affects the system in a small part of the planning area (1-10 %).	The stress driver is likely to be fairly limited in its spatial extent, affecting the system in a medium sized part of the planning area (11-30 %).	The stress driver is probably widespread in its spatial extent and affects the system in a large part of the planning area (31-70 %).	The stress driver is likely to be ubiquitous in its spatial extent, affecting the system in all or most of the planning area (71-100 %).
Severity (extent of impact)			
Light = 1	**Moderate = 2**	**Heavy = 3**	**Extreme = 4**

Rating categories for the current criticality of the stress drivers			
Within the defined geographical scope, the stress driver is unlikely to affect or damage the system.	Within the defined scope, the stress driver could lead to some impairment and damage to the system over the next 10 years.	Within the defined scope, the stress factor is likely to affect and damage the system within the next 10 years.	Within the defined scope, the stress driver will most likely affect and damage the system and even cause its loss within the next 10 years.
Irreversibility (probability of permanence)			
Short-term disappearance probable = 1	**Probable medium-term and reversible = 2**	**Probably long-term and difficult to reverse = 3**	**Probably more permanent and irreversible = 4**
It is likely that the stress driver will spontaneously disappear (without management) in the short term (1 to 5 years), which may mean only slightly reversible consequences for the systems.	It is likely that the stress driver will not disappear in the medium term (6 to 20 years) (without management), but this does not mean that the consequences for the systems are long-term and irreversible.	It is likely that the stress driver will persist in the long term (21 to 100 years) (without management), which will also have long-term consequences for the systems that are difficult to reverse.	It is very likely that the stress driver or cause will persist in the long term (probably even longer than a century) (without management), which also entails long-term consequences for the systems that may be irreversible for decades.

Table 25: Rating categories for current criticality of underlying factors and causes

Rating categories for the current criticality of the underlying factors and causes			
Spatial extent (extent of spatial distribution)			
Local appearance = 1	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
The underlying factor or cause is likely to be very narrow in its spatial extent, affecting other elements in a small part of the planning area (1-10 %).	The underlying factor or cause is likely to be fairly limited in its spatial extent, affecting other elements in a medium sized part of the planning area (11-30%).	The underlying factor or cause is likely to be widespread in its spatial extent and to affect other elements in a large part of the planning area (31-70%).	The underlying factor or cause is likely to be widespread in its spatial extent and to affect other elements in all or most of the planning area (71-100 %).
Severity (extent of impact)			
Light = 1	**Moderate = 2**	**Heavy = 3**	**Extreme = 4**
The underlying factor or cause is unlikely to have a significant impact on the affected elements.	The underlying factor or cause could have some effect on the influenced elements.	The underlying factor or cause is likely to have a significant impact on the affected elements.	The underlying factor or cause will most likely have a significant impact on the influenced elements and become a driving force that ultimately harms one or more systems (at least within the identified scope).
Irreversibility (probability of permanence)			

Rating categories for the current criticality of the underlying factors and causes			
Short-term disappearance probable = 1	**Probable medium-term and reversible = 2**	**Probably long-term and difficult to reverse = 3**	**Probably more permanent and irreversible = 4**
It is likely that the underlying factor or cause will disappear spontaneously (without management) in the short term (1 to 5 years), which may mean only slightly reversible consequences for the systems.	It is likely that the underlying factor or cause will not disappear in the medium term (6 to 20 years) (without management), but this does not mean that the consequences for the systems are long-term and irreversible.	It is likely that the underlying factor or cause will persist (without management) over the long term (21 to 100 years), which will also have long-term consequences for systems that are difficult to reverse.	It is very likely that the underlying factor or cause will persist in the long term (probably even longer than a century) (without management), which also entails long-term consequences for the systems that may be irreversible for decades.

To calculate the **total current criticality of** the stresses, the stress drivers and the underlying factors and causes, the three sub-criteria *spatial extent, severity* and *irreversibility* must be combined. First, the combination of *spatial extent* and *severity* calculates the *magnitude.* Then the combination of *extent* and *irreversibility/permanence is* calculated, resulting in the total current criticality.

Table 26: Matrix for calculating the extent (combination of spatial extent and severity)

Extent				
Spatial expansion (to the right)	**Local occurrence = 1**	**Middle area = 2**	**A large part of the area = 3**	**(Almost) omnipresent = 4**
Severity (bottom)				
Light = 1	1	2	2	3
Moderate = 2	2	2	3	3
Heavy = 3	2	3	3	4
Extreme = 4	3	3	4	4

Table 27: Matrix for calculating the total current criticality (combination of extent and irreversibility)

Total current criticality				
Extent (to the right)	**Low = 1**	**Medium = 2**	**High = 3**	**Very high = 4**
Irreversibility (below)				
Short-term disappearance probable = 1	1	2	2	3
Probable medium-term and reversible = 2	2	2	3	3

Probably long-term and difficult to reverse = 3	2	3	3	4
Probably more permanent and irreversible = 4	3	3	4	4

Table 28: Simplified rating of the overall current criticality

Total current criticality			
Slightly critical = 1	**Moderately critical = 2**	**Critical = 3**	**Very critical = 4**
The stress, stress driver, underlying factor or cause does not play a very important role in generating the vulnerability of the system within the geographical scope of the analysis.	The stress, stress driver, underlying factor or cause plays a moderately important role in generating the vulnerability of the system within the geographical scope of the analysis.	The stress, stress driver, underlying factor or cause plays an important role in generating the vulnerability of the system within the geographical scope of the analysis. It is an important driver of negative changes in the analysed system.	The stress, stress driver, underlying factor or cause plays an extremely important role in generating the vulnerability of the system within the geographical scope of the analysis. It is an important and persistent driver of negative change in the analysed system.

Analysis of past criticality

To determine the past criticality of the stresses, stress drivers and underlying factors and causes, compare the current situation of each element with the (assumed) situation 20 years ago.

Table 29: Rating categories for past criticality

Past criticality (about 20 years ago)			
Lower than current = 1	**Corresponds to the current = 2**	**Higher than current = 3**	**Much higher than current = 4**
The past criticality (20 years ago) of the stress, stress driver, underlying factor or cause was lower than the current criticality.	The past criticality (20 years ago) of the stress, stress driver, underlying factor or cause is more or less the same as the current one.	The past criticality (20 years ago) of the stress, stress driver, underlying factor or cause was higher than the current criticality.	The past criticality (20 years ago) of the stress, stress driver, underlying factor or cause was much higher than the current one.

Analysis of the change trend

An important aspect is the dynamic behaviour or the current trend of change in stress, stress drivers and underlying factors and causes.

Guiding questions for determining the current trend of change are:

> How is the criticality of the element changing at the moment?

> Is criticality increasing or decreasing? Slowly and gradually, or exponentially?

Table 30: Rating categories for the trend of change

Current trend of change in criticality (change in criticality)			
Decreasing = 1	**Stable = 2**	**Gradually increasing = 3**	**Rapidly increasing = 4**
Currently, the criticality of the stress, the stress driver or the underlying factor or cause tends to decrease.	Currently, the criticality of the stress, the stress driver or the underlying factor or cause seems to be quite stable. No change can be seen.	Currently, the criticality of the stress, the stress driver or the underlying factor or cause tends to increase, but rather gradually and seemingly quite predictably.	Currently, the criticality of the stress, the stress driver or the underlying factor or cause tends to increase rapidly and at an accelerated rate (exponentially).

Analysis of future criticality

To determine the future criticality of the stresses, stress drivers and underlying factors and causes, compare the current situation of each element with the (assumed) situation in 20 years. Any change within the element that is not only critical today but is expected to become more critical in the future deserves more attention than an element with decreasing relevance.

Table 31: Rating categories for future criticality

Future criticality (in about 20 years)			
Lower than current = 1	**Corresponds to the current = 2**	**Higher than current = 3**	**Much higher than current= 4**
Future criticality (20 years from now) is expected to be lower than current criticality.	It is assumed that the future criticality (in 20 years) is the same as the current one.	Future criticality (20 years from now) is expected to be higher than current criticality.	Future criticality (20 years from now) is expected to be much higher than current criticality.

Systemic activity of stress drivers and underlying factors and causes

Estimates the degree of influence of a stressor, underlying factor or cause. It is described by the *level of activity* and the *number of elements influenced.*

Table 32: Rating categories for systemic activities

Rating categories for systemic activities			
Level of activity			
Passive = 1	**Inactive = 2**	**Active = 3**	**Very active = 4**
The element is influenced by more elements than it influences itself.	The element is influenced by as many elements as it influences itself.	The element is influenced by fewer elements than it	The element influences other elements much more than it is influenced

(Difference [influencing - influenced] = < 0).	(Difference [influencing - influenced] = 0).	influences itself. (Difference [influencing - influenced] = 1-3).	itself. (Difference [influencing - influenced] = >3).
Number of influenced elements			
Low influence = 1	**Moderately influential = 2**	**Very influential = 3**	**Extremely influential = 4**
The element has influence on 1 element.	The element has influence on 2-3 elements.	The element has an influence on 4-5 elements.	The element has influence on >5 elements.

Table 33: Matrix for calculating the total systemic activity

Total systemic activity				
Level of activity (to the right)	**Passive = 1**	**Inactive = 2**	**Active = 3**	**Very active = 4**
Number of influenced elements				
Slightly influential = 1	1	2	2	3
Moderately influential = 2	2	2	3	3
Very influential = 3	2	3	3	4
Extremely influential = 4	3	3	4	4

The strategic relevance of the stresses summarises the result of the assessments of the *overall current criticality*, the *current trend of criticality change* and the *future criticality:*

Strategic relevance for stress analysis of key attributes: SR = K_A + K_T + K_Z (Strategic relevance = total current criticality + current trend of criticality change + future criticality).

The strategic relevance of the stress drivers and underlying factors and causes summarises the outcome of the assessments of *overall current criticality*, *future criticality*, *current trend of criticality change*, *future criticality* and *overall systemic activity:*

Strategic relevance for the stress drivers and underlying factors and causes: R = K_A + K_T + K_Z + S_A (Strategic relevance = total current criticality + current trend to change criticality + future criticality + total systemic activity).

Knowledge analysis

Using the categories given below, classify the level of knowledge about each stress, stress driver and underlying factor and cause that exists within the team. The 'knowledge' includes all possible dimensions that may be known about an element, such as its importance in the cause-effect network, its behaviour, its dynamics, etc. It does not include an assessment of the knowledge of other institutions operating in the field that are outside the influence of the team.

Table 34: Rating categories for knowledge

Knowledge			
Well known = 1	**Somewhat known = 2**	**Not known, but theoretically possible to find out = 3**	**Not known = 4**
The knowledge of the stress, the stress driver, the underlying factor or cause is very high; the planning team has a precise idea of the characteristics, relevance and dynamics of the element.	Knowledge of the stress, stress driver, underlying factor or cause is adequate; the planning team has a fairly good idea of the characteristics, relevance and dynamics of the element. Some knowledge gaps may have been identified.	Knowledge of the stress, stress driver, underlying factor or cause is poor; the planning team does not have a good idea of the characteristics, significance and dynamics of the element. Better knowledge may be available, but the team does not currently have it.	It is not possible to gain good knowledge about the stress, the stress driver, the underlying factor or the cause; the planning team can only make assumptions about the characteristics, relevance and dynamics of the element. Further investigation would not yield better insights. This lack of knowledge is related to the fact that the element is influenced in complex ways by other uncertain elements or that it represents future risks.

Manageability analysis

Assess the manageability of each stress, stress driver and underlying factors and causes using the categories below. It is important to focus on the area of work and not to drift into discussions of manageability beyond the practical scope of the team (in other words, avoid more general and broader questions that relate to a global context).

Table 35: Rating categories for manageability

Manageability			
Very manageable = 1	**Somewhat manageable = 2**	**Insufficiently manageable = 3**	**Not manageable = 4**
The stress, stress driver, underlying factor or cause is easily and directly manageable through strategies and project activities; usually these relate mainly to local elements.	The stress, the stress driver, the underlying factor or cause is likely to be directly manageable to some extent through strategies and project activities, especially if more resources are made available than before.	The stress, the stress driver, the underlying factor or cause is most likely not directly manageable. Instead, it can be influenced in a meta-systemic and indirect way.	The stress, the stress driver, the underlying factor or cause is not manageable at all; it is highly unlikely that local management can directly or indirectly bring about change.

Step 18: Identification of systemic drivers, revision and validation

Identify the systemic drivers

The complexity of ecosystems does not result from a random combination of a large number of interacting factors, but from a certain number of controlling processes and components that are particularly significant for their functionality. Similarly, the behaviour of complex social-ecological systems is usually determined by a number of highly influential elements. These are the systemic drivers.

The rankings can help identify the drivers within the complex system. In general, all elements with high strategic relevance are potential drivers, as they have a strong influence on a large number of elements. These drivers should be taken into account in the next step, the formulation of strategies.

Revision and validation

Any decision made during any part of the MARISCO process is considered preliminary and may be changed at a later stage when more information is available. In this step, we recommend that you revise the systemic situation model and check its coherence.

Some guiding questions are:

> Are some elements missing or is some of the information available more than once?

> Are all the connections made plausible?

> Do the scope and vision still fit the systemic situation model?

> Has your motivation or expectation changed?

Be aware that any change you make will lead to changes within the systemic situation model.

Review and validate the systemic situation analysis with stakeholders and experts

It is advisable to revise and validate the systemic situation analysis with as many actors and experts as possible. This gives you the opportunity to include further knowledge and expertise beyond what is available in your team. Such revisions can be done in mini-workshops, short sessions with groups of "external" experts or directly in the team. The systemic situation model and the tables with the rating results are best suited for this. If the experts' ratings differ significantly from those of the team, they can serve as a basis for critical discussion. This can improve both the process and the general understanding of the elements discussed.

1.5 Phase 5 Strategies

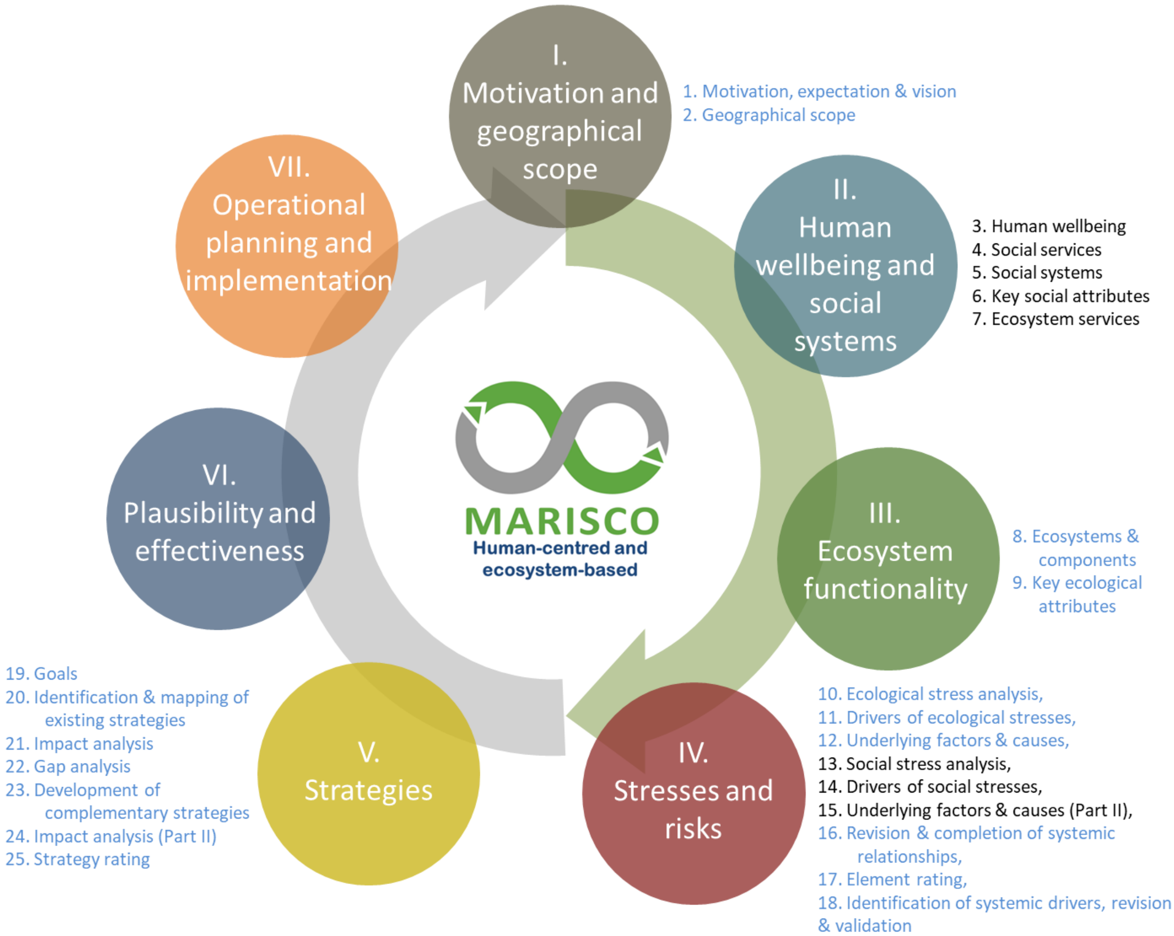

Figure 6: Phase V

Once the full situational analysis of the planning area has been completed and the various stresses, stress drivers and underlying factors and causes have been identified, the next step is to develop a comprehensive strategic plan. An effective strategic plan includes well thought-out objectives. These should be designed to be consistent, complementary, risk resistant and effective in bringing about positive change for the target systems. There is no perfect plan, but it is possible to formulate robust, assessable and meaningfully feedback strategies (the strategy influences the system and the system influences the strategy) that also promote institutional learning and adaptive improvement.

Not only are ecological or social systems vulnerable to unexpected change, strategies are also sensitive to disruptions and threats. The same stress drivers, underlying factors and causes, and risks that affect target systems can also affect the effectiveness of strategies, not to mention posing other unforeseen risks in the future. It is therefore recommended that strategies are developed from the outset with integrated adaptability and incorporating the principles of risk management.

Management of the planning area becomes more effective when it takes a "meta-systemic approach". This approach focuses more on understanding and responding to processes driven by non-linear and interconnected dynamics, as well as the framework conditions that enable such processes. Such a more holistic approach promotes self-organising change and adaptation in the managed system. This type of management should also target the synergistic interactions of as many strategies as possible to achieve critical mass for the transformation of the managed area.

Step 19: Goals

Goals

Before you start planning your actions, it is important to be clear about what you want to achieve. The next stage of the process is to formulate objectives for all target systems, especially for ecosystems. Each target system can be assigned a goal. However, it is more beneficial to create more detailed goals for groups of objects (e.g. forest ecosystems) or subsystems that contain target system groups (e.g. forest peatlands). It is important to remember that all objectives must be impact-oriented, measurable, time-bound and specific. For a goal to be effective, all related objectives should correspond to the stress drivers and their underlying factors and causes.

Goals

A goal is an observable and measurable end result with one or more objectives to be achieved within a more or less fixed time frame.

Example:

-The river valley and surrounding lowlands have improved soil quality, extensive forest cover and provide adequate connectivity for all large carnivores by 2030. They are characterised by at least 60% intact and connected habitats, especially in terms of ecosystem types that are strongly involved in the provision of water-related ecosystem services.

Step 20: Identify and map existing strategies

Identify and map existing strategies into the model

Now list all the existing strategies of the study area, including those that are currently being implemented and those that are planned for the future (for example, as part of a management plan). Once all strategies are identified, they are inserted into the systemic situation model along with the elements they affect. They are then linked with arrows to the stress drivers and underlying factors and causes.

Strategy

A strategy comprises a set of decisions regarding the use of available resources (management). It also includes the establishment of appropriate socio-institutional conditions (governance) that enable effective action to achieve desirable goals and objectives.

Example:

-Promotion of organic farming.

Step 21: Impact analysis

The visualisation process of the actual or potential relationships of the strategies with other elements in the systemic situation model provides a better understanding of the complex environments in which the strategies are to be implemented. It can even lead to the identification of previously overlooked risks. New risks could be those that reduce the feasibility and effectiveness of strategies.

To begin the impact analysis, select a strategy and systematically draw arrows connecting the strategy to other elements in the systemic situation model, in particular: underlying factors and causes, stress drivers, stresses and other strategies. The connecting arrows can be adjusted to distinguish between different types of connection, e.g. *strong* versus *weak* or *positive* versus *negative*.

Table 36: Possible interactions between the strategies and the elements of the systemic model of governance

	Very low	Low	Strong	Very strong	Not specified	Unsafe
Positive	→	→		↑		→
Negative	←	←	↙	↓	↙	←

Step 22: Gap analysis

Check whether all elements in the systemic situation model with high strategic relevance are adequately addressed by the strategies. If not, what kind of strategies could be applied to address the critical elements? If there are obvious gaps, try to fill them by adapting existing strategies or creating new ones in the next step.

Step 23: Develop complementary strategies

Development of complementary strategies

If you have identified underlying factors and causes, stress drivers and stresses of high strategic relevance that are not addressed by existing strategies, discuss whether and what kind of strategies could be applied to address the relevant elements.

Where appropriate, formulate strategies that would reduce and mitigate the problems or adapt to the risks. When formulating strategies, consider their manageability and knowledge assessment. In this regard, less manageable elements require adaptation strategies rather than change strategies. Strategies that address elements that are not sufficiently understood could include research components or precautionary measures.

Change strategies and adaptation strategies

Strategies can also be differentiated according to the manageability of the elements they address within the systemic situation model. If the elements are manageable, then strategies can be designed that aim to reduce or mitigate the negative impact of the element. These strategies are called change strategies. They are most effective when they address the underlying factors and causes of problems because they work towards real systemic change rather than just treating the symptoms. Strategies that target the underlying factors and causes often seek to change socio-economic or political realities. For example, the lack of acceptance and support for conservation measures can be improved through awareness-raising campaigns or direct lobbying.

Less manageable elements require adaptation strategies rather than change strategies. These strategies seek to integrate the problem within the system and also to promote adaptation to its existence and influence.

Many problems associated with global change, such as climate change and globalisation, are likely to receive a low score in terms of manageability. In these cases, management can aim to reduce the vulnerability of the target system by either reducing its sensitivity or increasing its adaptive capacity. For example, the increased risk of flooding can be reduced by improving the buffer capacity of wetlands.

Step 24: Impact analysis (Part II)

To complete the visual assessment, carry out an impact analysis for the complementary strategies. This visualisation process applies the same objectives and procedure as described for the gap analysis two steps earlier. The analysis should also take into account the existing strategies.

To begin the impact analysis, select a strategy and systematically draw arrows connecting the strategy to other elements in the systemic situation model, in particular: underlying factors and causes, stress drivers, stresses and other strategies. The connecting arrows can be adjusted to distinguish between different types of connection.

Step 25: Strategy rating

Evaluate the strategies

Often strategies are set and implemented without a subsequent assessment of their feasibility and potential impact. This can lead to unreflective management where those executing the strategies have little understanding of their effectiveness. An evaluation of strategies helps to adjust the strategy design and prioritise from the portfolio of strategies. This process improves the effectiveness and robustness of the strategies and helps to avoid negative impacts of the implemented strategies that remain unforeseen without proper reflection.

During this step, each strategy is assessed for both feasibility and potential impact.

Feasibility and impact of strategies

Feasibility

Feasibility describes the degree to which a strategy is likely to be implemented under the prevailing conditions in the planning area. It refers to the available resources, but also to risks, constraints and conflicts.

Effect

The impact of a strategy is measured by its effects and changes within and outside the designated planning area and which directly or indirectly generate consequences for the target systems.
Positive impacts refer to the maintenance or improvement of the state of the defined target systems. Negative impacts are those that lead to an increase in stresses, stress drivers and/or their negative underlying factors and causes by either reducing the sensitivity or increasing the adaptive capacity of the target system. For example, the increased risk of flooding can be reduced by improving the buffering capacity of wetlands.

Evaluation of existing strategies

Existing strategies are best evaluated through a peer review process conducted with external evaluators to promote a more balanced and objective perspective. When existing strategies are analysed by the same team that developed or implements them, the assessment results are usually not sufficiently objective. Pre-existing assumptions are confirmed and conflicts and errors may not be fully taken into account. But internal review also opens up opportunities for self-reflective analysis for the teams developing strategies. This in turn improves the detection rate of risks that might otherwise go undetected.

Feasibility

Feasibility describes the degree to which a strategy is likely to be implemented under the prevailing conditions in the planning area. It refers to the available resources, but also to risks, constraints and conflicts.

Degree of acceptance by relevant stakeholders

Since management strategies affect many stakeholders, the successful implementation of a strategy depends directly on the willingness of stakeholders to accept it.

Their willingness depends on the potential harms or benefits that the strategy represents for them. For example, a strategy to restrict mining activities in a river basin will most likely be opposed by miners, but might be supported by local fishermen. It is therefore important to consider both positive and negative impacts of planned strategies and to imagine extremely unfavourable scenarios. This allows robust strategies to be developed and the mentalities of stakeholders to be understood.

Relevant stakeholders are all internal and external groups of people who are directly or indirectly affected by the strategy, have demands and expectations and can therefore influence the strategy. Their attitude towards a strategy can range from very positive to negative.

Table 37: Classification of relevant interest groups

Relevant stakeholders			
Very positive = 4	**Positive = 3**	**Neutral = 2**	**Negative = 1**
The relevant stakeholders in this category are very positive about the strategy and strongly support its implementation.	The relevant stakeholders in this category are positive about the strategy and support its implementation.	The relevant stakeholders in this category have a neutral attitude towards the strategy, they do not support its implementation, but they do not oppose it either.	The relevant stakeholders in this category have a negative attitude towards the strategy and reject its implementation.

Table 38: Rating categories for the degree of acceptance by relevant stakeholders

Degree of acceptance by the relevant stakeholders			
Very good acceptance = 4	**Good acceptance = 3**	**Rather low acceptance = 2**	**Extremely low acceptance = 1**
The strategy is accepted by (almost) all relevant stakeholders.	The strategy is accepted by a large part of the relevant stakeholders.	The strategy is only supported by a small part of the relevant stakeholders, but not rejected.	The strategy is supported by only a few of the relevant stakeholders and rejected by most.

Supportive legal framework

Management activities do not take place in a legal vacuum. Therefore, the legal framework can strongly influence the feasibility of a strategy. While clear, strong and binding legal frameworks can support implementation, conflicting legal frameworks can have the opposite effect. For example, a wetland may be subject to both national and international legal frameworks, such as the Ramsar Convention.

Table 39: Rating categories for supporting legal frameworks

Supportive legal framework			
Strong binding legal framework = 4	**Non-binding legal framework = 3**	**Weak or missing legal framework = 2**	**Contradictory legal framework = 1**
There are clear, strong and binding legal frameworks that support implementation.	There are non-binding legal framework conditions that support implementation.	Weak or diffuse legal frameworks exist or legal frameworks are lacking.	There tend to be contradictory legal frameworks that could hinder implementation.

Resources required

Implementing strategies requires different types of resources: time, financial support, human resources and knowledge. The right combination of resources is important. Even if sufficient financial resources are available, they can be downright wasted through inappropriate knowledge management.

Table 40: Rating categories for necessary resources

Resources needed			
No resource problems = 4	**Some resources available = 3**	**Only limited resources available = 2**	**Not enough resources = 1**
Sufficient financial, human, time and professional resources are available within the managing institution to implement the strategy.	Some resources are available to implement the strategy, at least in part, and it is likely that additional resources can be obtained.	Few limited resources are available for the implementation of the strategy and only very small and rather isolated activities can be carried out. It will be difficult to obtain additional resources.	The resources of the managing institution are not sufficient to implement the strategy and it is unlikely that additional resources can be obtained.

Plausibility of identification with the strategy

The success of a strategy also depends on the involvement of relevant stakeholders. Only stakeholders who have developed a strong identification with the strategy will make an effort to maintain it in the long term. For example, if remuneration is the only motivation for stakeholders to participate in the planning process, they will most likely stop implementing the strategy once the activity is over.

Table 41: Rating categories for plausibility of identification with the strategy

Plausibility of ownership			
Strong personal responsibility = 4	**Some personal responsibility = 3**	**Only limited personal responsibility = 2**	**No personal responsibility = 1**
The managing institution has developed strong ownership of the strategy	The managing institution has developed some ownership of the	The managing institution has developed only limited ownership of the	The managing institution has not developed ownership of the strategy

Plausibility of ownership			
Strong personal responsibility = 4	**Some personal responsibility = 3**	**Only limited personal responsibility = 2**	**No personal responsibility = 1**
and will make significant efforts to maintain it in the long term.	strategy and will make some effort to maintain the strategy, at least in part, in the long term.	strategy and is unlikely to make efforts to sustain the strategy in the long term.	and will not make any effort to maintain it in the long term.

Likelihood of benefiting from external factors, especially opportunities

Not all change is bad. For example, a highly dynamic political situation can promote new laws or programmes that directly benefit the implementation of ecosystem-based management strategies.

Other possibilities are additional funding or cooperation with institutions that deal with similar problems.

Table 42: Rating categories for probability of benefiting from external factors, especially opportunities

Likelihood of benefiting from external factors (especially opportunities)			
Very high = 4	**High = 3**	**Low = 2**	**Very low = 1**
It is very likely that the strategy will be able to take advantage of existing or emerging opportunities such as additional resources or external support.	It is quite likely that the strategy can take advantage of existing or emerging opportunities such as additional resources or external support.	It is not very likely that the strategy will be able to take advantage of existing or emerging opportunities such as additional resources or external support.	It is very unlikely that the strategy will be able to take advantage of existing or emerging opportunities such as additional resources or external support.

Likelihood of damaging risks to the implementation of the strategy

However, not all dynamic situations are beneficial. Conversely, an uncertain political situation can lead to the cancellation of planned funds or to less interest in ecosystem-based management.

Among other things, extreme weather events and unfavourable economic investments can jeopardise the potential for implementing a strategy.

Table 43: Rating categories for probability of adverse risks to the implementation of the strategy

Likelihood of damaging risks to the implementation of the strategy			
Unlikely to be affected by risks = 4	**Probably not threatened by risks = 3**	**Probably threatened by risks = 2**	**Extremely threatened by risks = 1**
There is (almost) no likelihood of risks that (could) complicate the implementation of the strategy.	There is a low probability of risks that (could) make the implementation of the	There is a high probability of risks that (could) complicate or even hinder the implementation of the strategy.	There is a high likelihood of risks that (could) significantly hinder the implementation of the

Likelihood of damaging risks to the implementation of the strategy			
Unlikely to be affected by risks = 4	**Probably not threatened by risks = 3**	**Probably threatened by risks = 2**	**Extremely threatened by risks = 1**
	strategy somewhat more difficult.		strategy or even render it completely ineffective.

Adaptability to change

Uncertainty and unexpectedly changing circumstances are important fundamentals that management strategies must take into account. The development of versatile strategies that respond adaptively to changing conditions supports the overall risk and vulnerability management of the planning area.

For example, strategies involving the construction of buildings are often less adaptable than "soft strategies" (such as those related to communication).

Table 44: Rating categories for adaptability to change

Adaptability to change			
Very adaptable = 4	**Rather adaptable = 3**	**Not adaptable without significant additional resources = 2**	**Poorly adaptable or not adaptable at all = 1**
Adapting the strategy to changing circumstances or unexpected events can be done easily and without additional resources.	Adapting the strategy to changing circumstances or unexpected events can probably be achieved with some additional resources.	Adapting the strategy to changing circumstances or unexpected events could possibly be achieved, but requires significant additional resources.	The strategy is (possibly) not adaptable to changing circumstances or unexpected events.

Effect

As part of addressing the potential impacts of the strategies, it is advisable to develop extreme scenarios based on assumptions about undesirable side-effects. Ask yourself the following question:

> What could cause the strategies to produce other than the desired effects?

And, very importantly, remember:

> Avoid wishful thinking. Something that is supposed to be successful does not necessarily have to be successful;

> To try to act as the devil's advocate;

> Murphy's Law: "Anything that can go wrong will go wrong".

Generation of social, political and institutional conflicts

It is important that stakeholders are engaged in the strategy implementation process. Sometimes it happens that management objectives conflict with the socio-economic interests of stakeholders. Possible conflicts could be those over land ownership or rights, increasing or removing subsidies or incentives, etc.

Strategies that reduce land drainage and rewetting directly affect the ability of some farmers to use the land to produce the food they need for their livelihoods. They may perceive the strategies as disproportionately negative and form an association demanding the return of their land.

Table 45: Rating categories for the generation of social, political and institutional conflict

Emergence of social, political and institutional conflicts			
Very low risk of conflict arising = 4	**Medium risk of conflict arising = 3**	**High risk of conflict arising = 2**	**Very high risk of conflict arising = 1**
There is no or almost no likelihood that the strategy will lead to conflicts between different stakeholders.	It is possible that some degree of conflict may arise between different interest groups and that these may affect the planning area.	It is likely that there will be relevant conflicts between different stakeholders and that these have the potential to influence the planning area.	It is (almost) certain that there will be relevant conflicts between different interest groups and that these will influence the planning area.

Generation of negative effects on the target systems

Although a thorough analysis has been carried out, it is very likely that there are elements of the complex socio-ecological system that have not been fully understood.

During the implementation process, flawed assumptions may become apparent through unexpected reactions of some system components that exacerbate stress drivers and stresses or create new ones.

Assess the likelihood of strategies causing direct damage to target systems and their components.

A strategy that incentivises the commercialisation of plants could lead to their local extinction if the plants are over-harvested.

Table 46: Rating categories for the generation of negative impacts on the target systems

Emergence of negative impacts on the target systems			
No risk of a negative impact on the target systems = 4	**Low risk of causing negative impacts on target systems = 3**	**High risk of causing negative impacts on target systems = 2**	**Very high risk of causing negative impacts on target systems = 1**
There is no risk that the implementation of the strategy will have a negative impact on the	It is not very likely that the implementation of the strategy will have a negative impact on the	There is a high risk that the implementation of the strategy will have a negative impact on at	There is a very high risk that the implementation of the strategy will have negative impacts on

Emergence of negative impacts on the target systems			
target systems in the planning area.	target systems in the planning area.	least one target system in the planning area.	several target systems in the planning area.

Synergy effects with other strategies

Synergies occur when strategies are carefully constructed to work integratively with other objectives and activities within the planning area.

A strategy that promotes the social and political organisation of local communities can develop significant synergies with communication strategies or legal enforcement.

Table 47: Evaluation categories of synergy effects with other strategies

Synergy effects with other strategies			
Very high probability of synergy effects with other strategies = 4	**High probability of synergy effects with other strategies = 3**	**Mean probability of synergy effects with some strategies = 2**	**Low probability of synergy effects with other strategies, if any = 1**
The strategy is very likely to develop important synergies with several other strategies.	The strategy will most likely develop important synergies with some other strategies.	The strategy is moderately likely to develop synergies with some other strategies.	The strategy is quite isolated and is unlikely to develop synergies with other strategies.

Conflicts with other strategies

Some strategies work directly against other strategies, reducing the overall effectiveness of the strategic portfolio.

A strategy that improves public awareness of an area could lead to increased pressure from visitors.

Once identified, changes need to be made to address the identified conflicts.

Table 48: Evaluation categories for conflicts with other strategies

Conflicts with other strategies			
Low probability of conflict with other strategies, if any = 4	**Mean probability of conflict with other strategies = 3**	**High probability of conflict with other strategies = 2**	**Very high probability of conflicts with many strategies = 1**
The strategy has (almost) no conflicts with other strategies implemented in the planning area.	The strategy conflicts to some extent - but not problematically - with other strategies being implemented in the planning area.	The strategy conflicts with a number of strategies being implemented in the planning area.	The strategy is in strong conflict with a significant number of strategies being implemented in the planning area.

Effectiveness in reducing stress drivers

Effectiveness in reducing stress drivers describes the degree to which they are mitigated or avoided through the implementation of a strategy. This step promotes critical reflection on the actual effects of strategies on stress drivers.

This is neither a measure of efficiency (the cost-benefit ratio), nor of effectiveness (the achievement of defined goals within the defined timeframe) of the strategy, but a measure of the success of strategies to reduce the vulnerability of target systems by directly addressing the stress drivers outlined in the systemic situation model.

A strategy that regulates groundwater abstraction may lead to a direct reduction in the stress driver, while awareness-raising campaigns may have only indirect effects.

Table 49: Rating categories for effectiveness in reducing stress drivers

Effectiveness in reducing stress drivers			
Very high effectiveness in reducing stress drivers = 4	**High effectiveness in reducing stress drivers = 3**	**Low effectiveness in reducing stress drivers = 2**	**Very low effectiveness in reducing stress drivers = 1**
The strategy is very effective: it will lead to a significant and sustainable reduction or even elimination of several stress drivers.	The strategy is quite effective: it will lead to a far-reaching reduction of at least one stress driver.	The strategy is not very effective: it will only lead to a minor reduction in a stressor, and possibly only temporarily.	The strategy is (almost) ineffective: it will not even indirectly lead to a reduction in stress drivers.

Direct increase in the functionality of the target system

Some strategies aim to directly improve the functionality of a target system or at least bring it back to an acceptable level of functionality.

This step attempts to assess the potential change and hopefully increase in functionality of a target system that has been influenced by strategy.

Strategies that reduce drainage and rewet land can directly increase the functionality of target wetlands.

Table 50: Rating categories for the direct increase in the functionality of the target system

Direct increase in the functionality of the target system			
Very positive for the functionality of the target system = 4	**Positive for the functionality of the target system = 3**	**A small and rather indirect contribution to the functionality of the target system = 2**	**No measurable improvement in the functionality of the target system = 1**
The strategy will ensure or fully restore the long-	The strategy will go a long way towards	The strategy will make a small contribution to	The strategy is unlikely to contribute to maintaining

Direct increase in the functionality of the target system			
term functionality of one or more systems.	maintaining or restoring the functionality of one or more systems.	maintaining or restoring the functionality of one or more systems.	or restoring the functionality of any of the systems.

Degree of possible regret

Strategies can fail to achieve their intended effects and still generate secondary positive effects.

Therefore, the failure of such a strategy does not mean a total waste of the resources invested. In the case of positive effects, the strategy would be a "low- or no-duration option".

An environmental education strategy can still contribute to the acceptance of activities by the local population, even if it does not directly change behaviour.

Table 51: Rating categories for Degree of possible regret

Degree of possible regret			
Strategy without regret = 4	**Strategy with low regret = 3**	**High regret strategy = 2**	**Strategy with very high regret = 1**
The strategy will produce clear positive side effects, even if the originally intended effect is not achieved.	The strategy is likely to produce some positive side effects, even if the originally intended effect is not achieved.	The potential level of regret is high. If the originally intended effect is not achieved, the strategy will not generate (significant) positive side effects. The strategy will also be difficult to reverse and could lead to a waste of resources.	The potential level of regret is very high. If the originally intended effect is not achieved, the strategy will not produce positive side effects. The strategy cannot be reversed in time and would clearly lead to a waste of resources.

1.6 Phase 6 Plausibility and effectiveness

Figure 7: Phase VI

All too often, planning teams propose strategies before they have fully reflected on the assumptions made. As a result, scenarios are presented before the cause-and-effect endpoints of strategies have been carefully considered. This can lead to inconsistencies in the effectiveness of proposed strategies. In the case of natural resource management, it is not possible to predict the impacts of a strategy with absolute accuracy because ecosystems - and also the social systems involved - are very complex. Many elements may react in unexpected ways, or new factors and feedbacks may emerge.

The planning tool of "outcome-impact networks" can help us to better envision complexities of managing socio-ecological systems, while also taking into account unavoidable uncertainties. They represent webs of hypotheses and provide initial conceptual models for predicting potential changes that management strategies will bring about in a system. As such, they enable managers to identify potential blind spots and reduce avoidable risks. In some cases, the results of an outcome-impact network analysis may lead to the conclusion that existing or complementary strategies are unlikely to change the situation. In this case, the strategic portfolio would need to be reconsidered.

As outcome-impact networks are a tool for recording the team's perceptions of the effectiveness of their strategies, this step also paves the way for designing an effective monitoring system and operational plans. Some strategies may represent key or 'milestone' strategies that need to be implemented before further steps are taken.

Step 26: Develop result webs

Develop result webs

The process begins with the selection of a strategy from the systemic situation model and the creation of a result web. Now translate the underlying factors and causes or stress drivers that are likely to be influenced by the strategy into assumed outcomes and reformulate them as positive outcomes. To do this, select the respective element and change the text. For the assumed chains of effects given by the systemic relationships in the systemic situation model, the corresponding outcomes must be presented as "if-then" relationships.

Continue to work systematically through the process to transform all underlying factors and causes and stress drivers into assumed outcomes. As the activity progresses, it is possible that other elements not previously thought of will be identified. These then need to be included in the result webs. During the construction of the 'if-then' result webs, it may be decided to include other strategies in the network before the final strategy portfolio is considered complete. However, it is best to start the analysis with simple outcome chains before constructing more complex networks.

Result webs

Result webs graphically represent systemically and logically linked assumptions that must occur for the potential achievement of the impacts of strategies. They comprise the logical sequence of intermediate outcomes to be achieved that would ultimately imply a positive impact on the target systems.

Example:

-An education campaign would lead to an increase in awareness among certain members of a stakeholder group. Raising awareness among stakeholders about the need to retain water in the landscape would change their attitude and lead to a desired outcome for a particular ecosystem.

Goals and objectives

The next step in the process is the formulation of goals and objectives for the outcome-impact networks. During step 20, the identification and mapping of existing strategies, objectives for the target systems have already been defined. You can now assign further objectives. If the situation allows, you should try to create strategies for object groups or subsystems that contain target system groups. To achieve the goals, objectives should be formulated to document partial results to be achieved at the same time.

In order for a goal and objective to be effective, all related goal systems should correspond to the stress drivers and their underlying factors and causes. It is important to remember that all goals and objectives should be outcome-based, measurable, time-bound, specific and practical.

Goals and objectives

Objectives

An objective is a specific result that a person or a system wants to achieve within a certain time frame and with the available resources. In general, objectives are more specific and easier to measure than goals. Objectives are basic tools that underlie all planning and strategy activities.

Example:

-By 2025, soils can absorb more water and have a higher humus content.

Goals

A goal is an observable and measurable end result with one or more objectives to be achieved within a more or less fixed time frame.

Example:

-The river valley and surrounding lowlands have increased soil quality, extensive forest cover and provide adequate connectivity for all large carnivores by 2030. The area is characterised by at least 60% intact and connected habitats, especially in terms of ecosystem types that are strongly involved in the provision of water-related ecosystem services.

1.7 Phase 7 Operational planning and implementation

Figure 8: Phase VII

The steps taken so far represent an important part of an initial knowledge management exercise carried out in the planning area. These steps have succeeded in structuring the existing knowledge from various sources and improving the understanding within the team of the complex systems to be managed. The acquired knowledge was translated into a consistent and risk-resistant strategy portfolio. In the final MARISCO phase, the strategy portfolio will be implemented.

In adaptive management, it is important to track the implementation of activities by collecting relevant information and knowledge. The information collected needs to be assessed and reviewed for its suitability to target adaptation of the underlying concept. The unpredictable nature of management within complex systems requires vigilance and there is a need for continued evaluation and adaptation throughout the management period.

The evaluation process ensures that the knowledge management system is fit for purpose and provides the relevant information and knowledge for further (management) tasks.

The aspect of systematic learning and exchange of experience is also important. Sharing knowledge and experience with peers is crucial to ensure continuous improvement and progress towards best practice.

Step 27: Monitoring design

Design the monitoring plan

The monitoring plan is the plan for the long-term control of the strategic results. It clearly defines indicators, methods, persons responsible, time frame and place of implementation.

To complete the monitoring plan, add the answers to the following guiding questions:

> Monitoring method: How is the indicator measured/what method is used?

> Responsible person: Who will carry out the measurement?

> Time: When is the data collected and at what intervals?

> Location: Where is the data collected or the measurement carried out?

The analysis of monitoring data should not be limited to a single event in the work cycle. To understand what is happening in your planning area and to change things in time, it is important to include the analysis of your monitoring data in your routine work. To do this, you can use the data management system you set up in this step. This way you can use what you have learned and improve the effectiveness of your work by reviewing and, if necessary, adjusting your parameters and core assumptions, monitoring plan, operational plan, work plan and budget.

Monitoring

Monitoring is the periodic process of collecting data that is then used to assess the status of defined indicators. In this way, changes in specific elements or their performance can be monitored.

Comprehensive monitoring consists of several components:

> **Process monitoring** measures the progress of implementation according to the operational plans.

> **Impact monitoring** measures indicators to track the achievement of management goals and objectives.

> **General environmental monitoring** serves to observe environmental changes without these necessarily being related to strategic planning or implementation.

Benefits of monitoring

-A good monitoring system acts like an early warning system,

-It alerts managers to changes in the system, potential errors in strategy and loss of functionality in target systems,

-By identifying problems early, they can be mitigated or adjusted before they manifest or threaten the system,

-monitoring allows tracking the results of strategies to see if they are having the desired effects,

Additional research helps to fill knowledge gaps and blind spots that have arisen during the design and planning phase.

Indicators

An indicator is a measurable quantity that relates to a specific information need, such as the status of an object, the change in a stressor, or progress towards a goal. Indicators can be quantitative measures or qualitative observations.

Good indicators meet the following criteria:

Measurable: Can be recorded and analysed quantitatively or discretely qualitatively.

Unambiguous: Presented or described in such a way that their meaning is the same for all people.
Sensitive: Changes proportionally in response to actual changes in the condition or object being measured.

Examples:
-The pH value can be used to measure the water quality of a river ecosystem.
-The wood biomass in t/ha can be used for a forest ecosystem.

Define indicators and methods

Efforts should be made to identify at least one indicator for each relevant element of the outcome-impact network / systemic situation model. Good indicators are characterised by the fact that they are meaningful and also cost-effective. The methods available should be taken into account when choosing indicators. In more favourable cases, there may already be extensive data from which the processing team can derive suitable indicators. This is followed by the determination of the acceptable range of variation and a rating scale.

In order to determine the classification and thus the status of an indicator, an initial distinction between very good/good and average/bad can be made using best-fit data and information. Once a rough distinction has been made, it is somewhat easier to divide the categories into four levels: very good, good, moderate and poor. Although informed decision-making is important at this stage of the process, this should not preclude attempting to categorise when there is very little information on which to base decisions. MARISCO's focus is on continuing adaptive management planning and knowledge mapping even when circumstances are far from perfect - in this case, when there are noticeable gaps in knowledge availability.

With this approach, the process can move forward without stalling or getting lost in the goal of achieving a knowledge-perfect situation analysis.

Once the assessment status for each indicator is determined, the next step is to determine the current and projected future status for each indicator. The desired future state of the indicator is the state that is aimed for in the future - i.e. by the end of the planning horizon, when the management vision is supposed to have been achieved.

As mentioned above, the available methods should play an important role in the development of your indicators. Likewise, you should consider your target groups and your information needs. Your monitoring plan should also roughly define when, where and by whom the data will be collected. Finally, you should consider how you will store, manage and retrieve the data and how you will analyse and use the data to meet the information needs of your key target groups.

Table 52: Rating criteria for indicators of key ecological attributes

Evaluation criteria for indicators			
Very good = 4	**Good = 3**	**Mediocre = 2**	**Bad = 1**
The indicator is in a desirable state. Only minimal intervention - or no intervention at all - is	The indicator is within an acceptable range of variation. Some intervention may be	The indicator is outside the acceptable range of variation. The functionality of the target system could	The indicator is far outside the acceptable range of variation. The functionality of the

Evaluation criteria for indicators			
Very good = 4	**Good = 3**	**Mediocre = 2**	**Bad = 1**
required to maintain the functionality of the target system.	required to maintain the functionality of the target system.	be at risk if the situation is not changed. Interventions are required.	target system is seriously endangered. Recovery could be difficult.

Table 53: Example of key ecological attributes, indicators and indicator scores

Target system	Key attribute	Indicator	Indicator				Current status	Desired state
			Very good	**Good**	**Medium**	**Bad**		
Forest eco-system	Wood biomass	Standing and lying deadwood	Significant density of standing and lying, large, dead trunks throughout the forest	Standing and lying dead logs found in most parts of the forest	Only a few standing and lying dead trunks here and there; hardly any dead branches on the forest floor.	Hardly any or no dead trunks or branches in the forest	Bad	Good
River ecosystem	Water quality	pH	7.8-7.9	7.0-7.7	5.5--6.9	< 5.5	Good	Very good

Methods

Methods are specific techniques used to collect data to measure an indicator.

Methods do not have to be complex or sophisticated - if the information needed can be obtained using a simple, low-cost method, it is far better to use it than to choose a complex, expensive method.

Use only a relatively small part of the budget for measurement. Otherwise you will not have enough money to implement measures and measure the results.

A good method meets the criteria:

Accurate: The data collection method has a small or no margin of error.

Reliable: The results are consistently repeatable - every time the method is applied, it gives the same result.

Cost-effective: The method does not cost too much in relation to the data it produces and the resources available.

Feasible: The method can be implemented by the team members.

Appropriate: Acceptable for and appropriate to site-specific cultural, social and biological norms.

Step 28: Implementation planning

Develop the implementation plan

Implementation plans give people in the responsible organisation a clear picture of their tasks and responsibilities over a period of time. At the beginning, the strategies and activities are translated into practical and concrete tasks. This requires defining the resources needed, such as time, money, labour and others, and the specific responsibilities within the managing unit.

1. Define the resources available for implementation, such as time, money, personnel, knowledge, etc.
2. Break down the strategies and activities into concrete tasks that:
   - Clearly define which tasks need to be carried out,
   - Delegate responsibility to one person or group of people for each activity,
   - Have concrete timelines in which tasks must be completed,
   - Specify the amount of resources to be used for each task,
   - Continue the logic of the systemic situation model and outcome-impact networks to maintain consistency,
   - Detailed enough to give all staff a clear idea of what is expected of them,
   - Follow up on the results, impacts and research.

Implementation plan

An implementation plan consists of the detailed description of all concrete activities to be carried out by the management team.

Task

A task describes a specific action to be realised in the implementation of activities in a work plan, monitoring plan or other components of a strategic plan.

Each task should be defined in such a way that:

-It has clearly identified starting and ending points,
-The time and cost requirements can be easily estimated,
-Their progress and completion can be easily assessed,
- It is distinguishable from other activities.

Step 29: Implementation and monitoring of results and impacts

This is a very important step in the MARISCO cycle as it is where all the planning efforts of the exercise are put into action. Carry out the tasks of the work and monitoring plan according to the schedules and budgets set in the previous steps. To monitor implementation, regularly and systematically assess whether you are on track to achieve the set goals. It may be useful to prepare regular progress reports. This will allow you to make more nuanced reflections as you progress, fill in gaps in your knowledge, determine whether you have achieved the expected intermediate outcomes and assess whether you are on track to achieve long-term success. Review your progress at least once a year (preferably more frequently) and consider your progress in the context of your theory of change, which is detailed in the outcome-impact networks.

Guiding questions:

> Are you on the right track with the implementation of your measures? If not, why not? What adjustments should you make?

> Are you achieving the results you expected and meeting the objectives you defined in your implementation plan? If not, why not?

> Are there other factors that influence the results of your work? What adjustments should you make?

> Have you addressed all the knowledge gaps and uncertainties identified in the systemic situation model? If so, what does this say about your work and any adjustments you need to make? If you did not address these knowledge gaps and uncertainties, what were the reasons and how will you address them in the future?

Beyond the implementation plan

It is also important to check whether the implementation processes that carry your planning are working properly. You may have a plan that has identified the perfect strategies to address the drivers of change within the complex socio-ecological systems of your planning area, but lack efficient implementation or administrative and financial support. Some guiding questions for this analysis are:

> Do you have sufficient resources (e.g. financial, human, administrative, political)?

> Do you have the necessary physical infrastructure and equipment (e.g. office space, computers, vehicles)?

> Do you have the right skills among your team members to implement your work appropriately?

> Does your team work well together (e.g. communication, delegation of responsibilities)?

Step 30 (Non)knowledge management

The management of knowledge and non-knowledge is a crucial task, as it forms the basis for the development of an institution that is capable of learning and adapting. MARISCO software provides an appropriate infrastructure to store, use, adapt and develop existing knowledge at any time and by all relevant persons.

Knowledge management must also include non-knowledge. This includes, among other things, knowledge gaps and new research questions, assessing the relevance of the unknown or reflecting on blind spots.

Proactive knowledge management also integrates the method of *horizon scanning*, i.e. the systematic and active search for and classification of future risks appearing on the 'horizon'.

The starting point for such (non-)knowledge management is the systemic situation model itself and the team's defined assessments of knowledge about the different elements.

Initial guiding questions for such an exercise would be:

> What do we not know about the managed system and why not?

> Should we invest more in improving and reflecting on our knowledge?

> What about the risk of uncertainty or lack of knowledge leading to decisions or practices that might be regretted later?

> What categories of non-knowledge are particularly relevant in the context of your work (e.g. uncertainty, gaps in knowledge, blind spots, ignorance (not wanting to know certain actors)?

(Non)knowledge

Non-knowledge refers to everything that the team could, should or would like to know, but does not or cannot know. It also includes knowledge that the relevant stakeholders do not have or do not want to acquire. In the process of developing the systemic situation model and applying the MARISCO steps (including the assessment of knowledge in relation to the different elements of the model), the team will identify problems caused by knowledge gaps or by (deliberately preserved) ignorance. Ideally, they will be adequately addressed in the strategic portfolio.

Organisation of institutional learning and exchange with other projects/initiatives

Throughout the planning process, continued learning is required to accumulate knowledge about the planning area and about implementation methods and approaches. At the same time, it is also necessary to specifically address errors that occur, unforeseen aspects, wrong assumptions and creative solutions. This also lays the foundation for knowledge exchange with others and creates a productive basis for cooperation with other institutions.

There is no standard recipe for organising institutional learning. What is crucial is an internal exchange about the course of the management process and about the functioning, structure and development of the managing unit. This exchange process will only be productive if all members of the team participate in it without bias. Furthermore, the success of such an exchange depends on the willingness to criticise and, if necessary, adapt existing management practices. The prerequisite for this kind of communication is the social conditions within the management team. Through a programme of active learning and participation, the team should aim to develop and improve its practice, which includes interpersonal skills such as giving and receiving constructive criticism.

In addition to this higher level team learning, there must also be a free exchange of scientific and technical knowledge. Collaborative knowledge exchange between partners in national and international institutions plays a major role in promoting good practice in local projects. Knowledge co-production describes a very important concept to deal with in this context.

Back to go: close the cycle

The MARISCO method is structured as a cycle. Once you have completed step 30, return to step 1.

This does not mean that you are stuck in an endless work cycle, nor that you have to start from scratch again. Rather, it is a reminder that adaptive management is a dynamic process that requires you to constantly learn and improve over time. Achievements and lessons learned, processed and made available through monitoring and knowledge management, need to be analysed to find out what specific adaptations are needed. The systemic situation model should be adapted according to the findings of this assessment.

Sustainable management of complex socio-ecological systems is a continuous, adaptive process that can never end. Regular review and improvement are the essential characteristics of adaptive management. The intervals of evaluation and revision depend on the scope of the planning or management period, but also on the extent of general change in the framework conditions and the systems under consideration. In many cases, an evaluation every one to two years will be useful.

Some guiding questions are:

> Do the vision, the goals and the objectives still fit the target systems?

> Are there new elements or relationships that you have not considered so far and that should be included in your systemic situation model?

> Do you need to change your monitoring plan?

> Do you need to adjust your implementation plan?

> Do you have an exit strategy that ensures the sustainability of your results after you have finished your work?

2. Knowledge mapping

Within the framework of a series of workshops that build on each other, complex and scattered knowledge from a wide range of actors is transparently collected, structured, evaluated and processed for the development of holistic approaches to solutions[2] . To this end, various questions and topics are systematically dealt with in the workshops.

Step by step, systemic knowledge mapping (knowledge 'maps') is developed together with the participants. These knowledge maps systematically represent existing knowledge and non-knowledge of all participants about ecosystems in the study area, their threats and drivers of the respective changes as well as existing management strategies. The ecosystem is understood as a complex dynamic system, but humans and their well-being as part of the ecosystem are at the centre of the consideration.

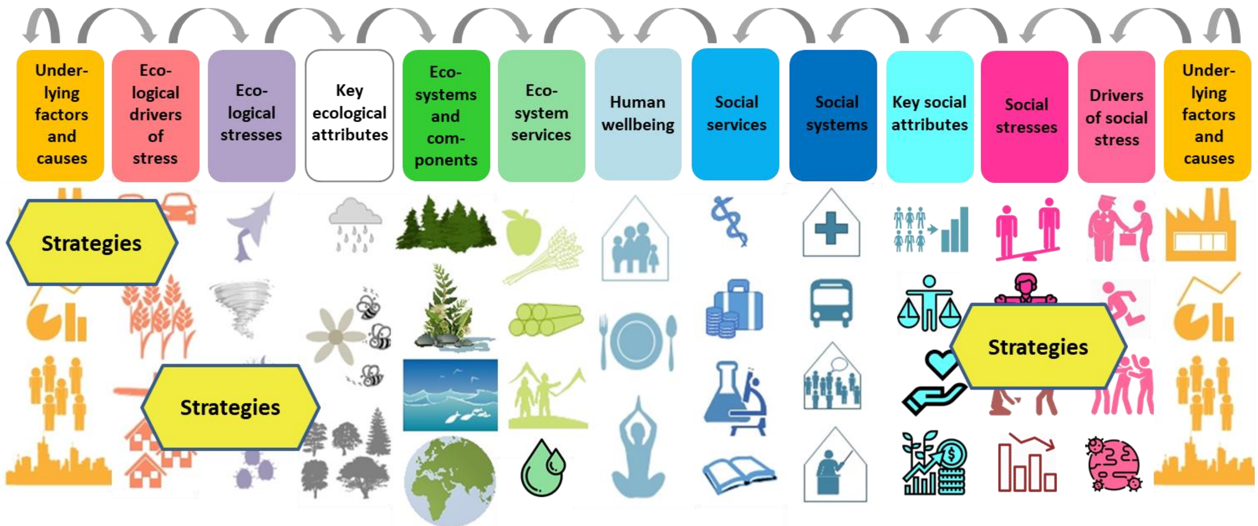

Figure 9: Structure of the knowledge mapping

When creating a knowledge map, the respective occurring ecosystem(s) forms the basis. In the next step, the key ecological attributes of the ecosystems are identified (e.g. rainfall), and the ecosystem services (e.g. drinking water) that are provided for humans are worked out. These ecosystem services contribute directly to human well-being. However, social systems (e.g. schools) also contribute to human well-being with their services (e.g. education) and can then be analysed together. Now the challenges are examined, first recording the stresses occurring in the ecosystems (e.g. drought stress of trees). Then the stress drivers (e.g. prolonged droughts) and causes (e.g. increasing CO_2 emissions) are analysed.

The resulting knowledge maps reflect the knowledge or lack of knowledge and the views and assumptions of the participants and form the basis for developing sustainable solution strategies.

The systematic and systemic way of working using such knowledge maps enables the development of holistic and sustainable approaches to solutions that can leverage at the root causes of the problems that

[2] Schick et al. 2017, 2018, Ibisch & Hobson 2015, Luthardt & Ibisch 2013

arise. This reveals a networked mode of action that, in contrast to the linear view, does more justice to the complexity of our times.

3. Glossary

Adaptive management	Adaptive management is best described as a process that allows for micro breakdowns within a system when an external disturbance indicates that the system needs reorganisation. Adaptive management is error-friendly because it encourages systematic learning from errors in order to build more efficient and resilient systems.
Ecological stress	Ecological stresses describe the symptoms and manifestations of the deterioration of key ecological attributes. They manifest themselves as loss of biomass, information and network, among other things. The implication of stress is that under certain conditions, ecological attributes begin to degrade, which then affects the resilience and adaptive capacity of biodiversity elements such as species or ecosystems. Systems take on different states, they degrade or even collapse. Stress describes a specific state, reaction or symptoms of a system or one of its components to anthropogenic pressures - the so-called stress drivers. These unfavourable states in relation to individual components or attributes can in turn trigger further stresses or also interact cumulatively with other stresses. The cumulative effect of several stresses can lead to an escalating degradation of an ecosystem.
Ecological stress driver	Ecological stress drivers are all pressures that can directly or indirectly affect the natural structure and dynamics of an ecosystem. They represent processes of change that negatively affect target systems by causing stress and increasing their vulnerability. Ultimately, they cause a change of state associated with degradation (which means the loss of guiding factors, biomass, information or networks). There are both obvious and subtle examples of stress drivers. Usually the indirect or imperceptible effects are the most difficult to observe or identify, yet they can cause the greatest disruption to the ecosystem. One example is the complex dynamics of human-induced climate change.
Ecosystem services	Ecosystem services are the benefits that people derive from ecosystems. They include provisioning services such as food and water, regulating services such as flood, drought, soil degradation and disease regulation, and cultural services such as recreation, spiritual, religious and other non-material benefits. Ecosystem services are based on emergent properties of ecosystems. A distinction is made between direct services provided by specific species - e.g. in connection with the production of plant or animal biomass - and indirect services that result from the (inter)interaction of system components (e.g. pollination, climate regulation).
Geographical scope	The geographical scope defines the planning area and includes all components of biodiversity identified as needing protection. When applying an ecosystem-based approach, it is important to identify whole systems where possible, representing not only the components of an ecosystem, but also the processes, structures and dynamics that constitute and control them.
Human well-being	Human well-being encompasses all the key components that people need for a good life. The components of well-being as experienced and perceived by

people are situational and may be strongly influenced by geography, culture and ecological conditions. Nevertheless, it must be assumed that people can universally agree on minimal components of well-being. Hunger, disease or material poverty, the lack of security or esteem, for example, lead to an impairment of human dignity and a fundamentally good life.

Key ecological attribute	Key ecological attributes are best described as the integral elements and properties of ecological systems that maintain their functioning. This includes ensuring that systems have the necessary adaptive and resilient capacity to better cope with disturbance and environmental change. Key ecological attributes include both biological properties of the system itself and corresponding framework conditions that make their existence possible in the first place. These framework conditions mainly include energy supply, water, a certain climatic regime and the availability of nutrients.
Key social attribute	Key social attributes are best described as integral elements and properties of social systems that maintain function and provide the necessary adaptation and resilience to cope with disruption. As with social systems, the organisation and definition of key social attributes is subject to strong cultural differences. They may even vary within members of the same group according to socio-economic status, ethnicity, religion or social function. A basic key social attribute of a social system is often the well-being of individuals. Since human groups and institutions exist as nested systems, often the functionality of subsystems can be a key social attribute.
(Non)knowledge	Non-knowledge refers to everything that the team could, should or would like to know, but does not or cannot know. It also includes knowledge that the relevant stakeholders do not have or do not want to acquire. In the process of developing the systemic situation model and applying the MARISCO steps (including the assessment of knowledge in relation to the different elements of the model), the team will identify problems caused by knowledge gaps or by (deliberately preserved) ignorance. Ideally, they will be adequately addressed in the strategic portfolio.
Result web	Outcome-impact networks illustrate graphically systemic and logically linked assumptions that are formulated for the impacts of strategies. They contain the logical sequence of intermediate outcomes to be achieved that ultimately have a positive impact on biodiversity.
Social service	Social service describe a range of services provided by government, private, for-profit and non-profit organisations, but also by smaller and more informal social institutions such as families or a circle of friends. These services aim to create more effective organisations, build stronger communities and promote equality and opportunity, or simply provide support, affection and care. Basically, provisioning, regulating and cultural social services can be distinguished. Providing refers to supplying people with all the goods and services they need to live. The regulating services organise the coexistence of people and the functions of institutions. These include all legal and political functions. Cultural

services provide people with educational opportunities and all forms of intellectual and spiritual stimulation.

Social stress	Social stress describes the symptoms and manifestations of negative change in key social attributes. As in the ecosystem, they basically present themselves as a loss of a minimum level of mass, information and network and are often related to the deterioration of framework conditions and resources. The effect of stress is that under certain conditions, key social attributes begin to degrade. This in turn ultimately affects the resilience and adaptability of social systems and their components. Over time, this can cause the systems to lose significant functionality or even collapse.
Social stress driver	Social stress drivers are the direct and indirect human activities that have a negative impact on one or more key social attributes, causing social stress.
Social system	Humans are social beings; an important component of our human existence is sharing and caring for each other. Social systems are groups of people interacting with each other. Interaction gives rise to emergent properties of these human groups that would not exist without this interaction. Social interaction leads to the emergence of a larger whole that acts and is recognisable as such. This can happen on the basis of a group identity and symbolic effects, but also through the joint management of resources and through structured decisions and the implementation of joint management. Social systems can be very temporary and intuitive. But they can also exist in the long term and function on the basis of constitutional documents or formal statutes.
Strategy	A strategy comprises a set of decisions regarding the use of available resources (management). It also includes the establishment of appropriate socio-institutional conditions (governance) that enable effective action to achieve desirable goals and objectives.
Stress	A stress is the reaction or probable response observed in an object of biological diversity (medical professionals prefer the term "symptoms"), which may be characterised by changes in the physical, chemical or behavioural state of the object.
Stress driver	A stressor is a human-induced driving factor, a direct or indirect effect, that eventually causes a symptom or reaction (a stress) in a protected object.
Systemic situation analysis	A systemic situation analysis enables a detailed understanding of the circumstances and conditions that characterise the character and state of the socio-ecological systems of the planning area. The systemic situation analysis should adequately reflect the complexity of the socio-ecological system. This means that an effort is made to represent the manifold effects and interactions, at least to some extent. In particular, this also involves the human impacts in the ecosystem, which have often led to a very strong change in the system.

Underlying factor and cause	Underlying factors and causes are best described as a human action or activity that directly or indirectly leads to the occurrence of a stress driver. The stress driver then leads to one or more stresses in one or more components of an ecosystem. Often the underlying factors and causes work synergistically, but they can also produce opposing effects. Many of these underlying factors and causes pose risks because they can occur unpredictably in the future or change and contribute to impacts on target systems.
Vulnerability	Vulnerability is the susceptibility of ecosystems to change. Ecosystems that have been damaged to some degree by an impact can become vulnerable to further change and are threatened as a result. Some ecosystems are inherently less vulnerable to threats than others and have developed the capacity to be sensitive. Vulnerability must be understood as a phenomenon of complex interacting processes and analysed systemically. Vulnerability management in nature conservation is related to risk management, but it is a more comprehensive, functional and dynamic process.

4. Classifications

4.1 Human well-being

1. Food security
2. Security
3. Physical health
4. Mental health
5. Information
6. Good social relationships and belonging
7. Experienced esteem
8. Freedom and self-realization
9. Intellectual capacity
10. Morality
11. Good life

4.2 Social services

1. Provisioning
    - 1.1 Goods
        - 1.1.1 Food and live animals
        - 1.1.2 Beverages and tobacco
        - 1.1.3 Crude materials, inedible, except fuels
        - 1.1.4 Mineral fuels, lubricants and related materials
        - 1.1.5 Animal and vegetable oils, fats and waxes
        - 1.1.6 Chemicals and related products, n.e.s.
        - 1.1.7 Manufactured goods classified chiefly by material
        - 1.1.8 Machinery and transport equipment
        - 1.1.9 Miscellaneous manufactured articles
        - 1.1.10 Commodities and transactions not classified elsewhere
    - 1.2 Services
        - 1.2.1 Manufacturing services
        - 1.2.2 Maintenance and repair services
        - 1.2.3 Transport services
        - 1.2.4 Travel services
        - 1.2.5 Construction services
        - 1.2.6 Insurance and pension services
        - 1.2.7 Financial services
        - 1.2.8 Charges for the use of intellectual properties
        - 1.2.9 Telecommunications, computer, and information services
        - 1.2.10 Other business services
        - 1.2.11 Personal, cultural and recreational services
        - 1.2.12 Government services

- 1.3 Infrastructure
  - 1.3.1 Residential buildings
  - 1.3.2 Hotels and similar buildings
  - 1.3.3 Office buildings
  - 1.3.4 Wholesale and retail trade buildings
  - 1.3.5 Traffic and communication buildings
  - 1.3.6 Industrial buildings and warehouses
  - 1.3.7 Public entertainment, education, hospital or institutional care buildings
  - 1.3.8 Other non-residential buildings
  - 1.3.9 Highways, streets and roads
  - 1.3.10 Railways
  - 1.3.11 Airfield runways
  - 1.3.12 Bridges, elevated highways, tunnels and subways
  - 1.3.13 Harbours, waterways, dams and other waterworks
  - 1.3.14 Long-distance pipelines, communication and electricity lines
  - 1.3.15 Local pipelines and cables
  - 1.3.16 Complex constructions on industrial sites
  - 1.3.17 Sport and recreation constructions
  - 1.3.18 Other civil engineering works not elsewhere classified
- 1.4 Employment
  - 1.4.1 Managerial occupations
  - 1.4.2 Professional occupations
  - 1.4.3 Technical and associate professional occupations
  - 1.4.4 Clerical support occupations
  - 1.4.5 Service and sales occupations
  - 1.4.6 Skilled agricultural, forestry and fishery occupations
  - 1.4.7 Craft and related trades occupations
  - 1.4.8 Plant and machine operation and assembly occupations
  - 1.4.9 Elementary occupations
  - 1.4.10 Armed forces occupations

2. Regulating
- 2.1 Regulations by governments
  - 2.1.1 Hard legal instruments (laws, decrees)
  - 2.1.2 Soft legal instruments (soft laws without sanctions)
  - 2.1.3 Hard economic instruments (taxes, fees, permits, cap-and-trade schemes)
  - 2.1.4 Soft Economic instruments (subsidies, public procurement)
  - 2.1.5 Informal instruments (studies, campaigns, websites)
  - 2.1.6 Hybrid instruments (labels, public voluntary programmes)
- 2.2 Self-regulation by markets
  - 2.2.1 Standards
  - 2.2.2 Voluntary agreements
  - 2.2.3 Audit/certification schemes

        - 2.2.4 Codes of conduct
        - 2.2.5 Strategic CSR/stakeholder management
        - 2.2.6 Restraints imposed on a firm by business partners
    - 2.3 Regulation by civil society
        - 2.3.1 Formal standard setting
        - 2.3.2 Less formalised pressuring of businesses and governments
    - 2.4 Co-regulation by governments and civil society
        - 2.4.1 Public co-management of common pool resources
    - 2.5 Co-regulation by governments and markets
        - 2.5.1 Certification schemes
        - 2.5.2 Negotiated agreements
        - 2.5.3 Public-private partnerships
    - 2.6 Co-regulation by civil society and markets
        - 2.6.1 Certification schemes
        - 2.6.2 Private-private partnerships
    - 2.7 Co-regulation by governments, civil society and markets
        - 2.7.1 Standards
        - 2.7.2 Certification schemes
        - 2.7.3 Partnerships
- 3. Cultural
    - 3.1 Physical and tangible expressions of culture
        - 3.1.1 Architecture
        - 3.1.2 Artifacts
        - 3.1.3 Arts
        - 3.1.4 Technology
    - 3.2 Intangible expressions of culture
        - 3.2.1 Knowledge and practices concerning nature and the universe
        - 3.2.2 Oral traditions and expressions
        - 3.2.3 Performing arts
        - 3.2.4 Social practices, rituals and festive events
        - 3.2.5 Traditional craftsmanship

4.3 Social systems

- 1. State systems
    - 1.1 Intergovernmental institutions
        - 1.1.1 Intergovernmental legislative institutions
        - 1.1.2 Intergovernmental executive institutions
        - 1.1.3 Intergovernmental judiciary institutions
    - 1.2 National governmental institutions
        - 1.2.1 National legislative institutions
        - 1.2.2 National executive institutions

- 1.2.3 National judiciary institutions
- 1.3 Regional governmental institutions
    - 1.3.1 Regional legislative institutions
    - 1.3.2 Regional executive institutions
    - 1.3.3 Regional judiciary institutions
- 1.4 Local governmental institutions
    - 1.4.1 Local legislative institutions
    - 1.4.2 Local executive institutions
    - 1.4.3 Local judiciary institutions

2. Markets systems
    - 2.1 Markets
        - 2.1.1 Physical consumer markets (e.g. food, retail, used goods, trade fairs)
        - 2.1.2 Physical business markets (e.g. wholesale, labour market, energy)
        - 2.1.3 Non-physical markets (e.g. media, internet, emissions trading)
        - 2.1.4 Financial markets (e.g. shares, bonds, foreign exchange, money, insurances)
        - 2.1.5 Unauthorized and illegal markets
    - 2.2 Economic entities
        - 2.2.1 Sole proprietorship (Sole traders)
        - 2.2.2 Partnerships (e.g. general partnership, LLP, LP)
        - 2.2.3 Corporations (e.g. non-profit, governmental, private)
        - 2.2.4 Franchises
        - 2.2.5 Cooperatives
        - 2.2.6 Companies (e.g. LLC, Ltd, Unltd, CIC, CIO, governmental)

3. Civil society systems
    - 3.1 Primary groups
        - 3.1.1 Families
        - 3.1.2 Households
        - 3.1.3 Collective households
        - 3.1.4 Communes
        - 3.1.5 Friends
        - 3.1.6 Neighborhoods
        - 3.1.7 Communities
    - 3.2 Social groups
        - 3.2.1 Academia
        - 3.2.2 Activist groups
        - 3.2.3 Clubs (sports, social, etc.)
        - 3.2.4 Collectives
        - 3.2.5 Community foundations
        - 3.2.6 Community organizations
        - 3.2.7 Cultural and educational institutions
        - 3.2.8 Networks
        - 3.2.9 Non-governmental organizations (NGOs)

            3.2.10 Private voluntary organizations (PVOs)
            3.2.11 Religious organizations
            3.2.12 Support groups
            3.2.13 Voluntary associations

4. State systems - Markets & Economic entities
    - 4.1 Government-owned for-profit corporations
        - 4.1.1 Government-owned for-profit corporations
        - 4.2 Government-owned non-profit corporations
        - 4.2.1 Government-owned non-profit corporations
    - 4.3 Public-private partnerships
        - 4.3.1 Public-private partnerships (PPP)
5. State systems - Civil Society
    - 5.1 Citizens' initiatives and civil rights groups
        - 5.1.1 Citizens' initiatives and civil rights groups
        - 5.2 Development organizations
        - 5.2.1 Development organizations
    - 5.3 Interest groups
        - 5.3.1 Interest groups
    - 5.4 Political parties
        - 5.4.1 Political parties
    - 5.5 Public-NGO partnerships
        - 5.5.1 Public-NGO partnerships
    - 5.6 Social movement organizations
        - 5.6.1 Social movement organizations
6. Markets & Economic Entities - Civil Society
    - 6.1 Charities
        - 6.1.1 Charities
    - 6.2 Community interest company
        - 6.2.1 Community interest company
    - 6.3 Consumer organizations
        - 6.3.1 Consumer organizations
    - 6.4 Cooperatives
        - 6.4.1 Cooperatives
    - 6.5 Cooperate citizenship
        - 6.5.1 Cooperate citizenship
    - 6.6 Foundations
        - 6.6.1 Foundations
    - 6.7 Professional associations
        - 6.7.1 Professional associations
    - 6.8 Social enterprises
        - 6.8.1 Social enterprises
    - 6.9 Trade unions

6.9.1 Trade unions

7. State systems - Markets & Economic Entities - Civil Society

    7.1 Certification bodies

        7.1.1 Certification bodies (e.g. eco lables)

    7.2 Media

        7.2.1 Media

    7.3 Think tanks

        7.3.1 Think tanks

    7.4 Voluntary associations

        7.4.1 Voluntary associations

4.4 Key social attributes

1. Master factors

    1.1 Preconditions

        1.1.1 Preconditions

    1.2 Interaction

        1.2.1 Interaction

    1.3 Organization

        1.3.1 Organization

    1.4 Structure

        1.4.1 Structure

    1.5 Legitimacy

        1.5.1 Legitimacy

2. Provisioning

    2.1 Goods

        2.1.1 Food and live animals

        2.1.2 Beverages and tobacco

        2.1.3 Crude materials, inedible, except fuels

        2.1.4 Mineral fuels, lubricants and related materials

        2.1.5 Animal and vegetable oils, fats and waxes

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        2.1.9 Miscellaneous manufactured articles

        2.1.10 Commodities and transactions not classified elsewhere

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        2.2.1 Manufacturing services

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        2.2.3 Transport services

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- 2.3.14 Long-distance pipelines, communication and electricity lines
- 2.3.15 Local pipelines and cables
- 2.3.16 Complex constructions on industrial sites
- 2.3.17 Sport and recreation constructions
- 2.3.18 Other civil engineering works not elsewhere classified

2.4 Employment

- 2.4.1 Managerial occupations
- 2.4.2 Professional occupations
- 2.4.3 Technical and associate professional occupations
- 2.4.4 Clerical support occupations
- 2.4.5 Service and sales occupations
- 2.4.6 Skilled agricultural, forestry and fishery occupations
- 2.4.7 Craft and related trades occupations
- 2.4.8 Plant and machine operation and assembly occupations
- 2.4.9 Elementary occupations
- 2.4.10 Armed forces occupations

3. Regulating

3.1 Regulations by governments

- 3.1.1 Hard legal instruments (laws, decrees)
- 3.1.2 Soft legal instruments (soft laws without sanctions)
- 3.1.3 Hard economic instruments (taxes, fees, permits, cap-and-trade schemes)

- 3.1.4 Soft Economic instruments (subsidies, public procurement)
- 3.1.5 Informal instruments (studies, campaigns, websites)
- 3.1.6 Hybrid instruments (labels, public voluntary programmes)

3.2 Self-regulation by markets

- 3.2.1 Standards
- 3.2.2 Voluntary agreements
- 3.2.3 Audit/certification schemes
- 3.2.4 Codes of conduct
- 3.2.5 Strategic CSR/stakeholder management
- 3.2.6 Restraints imposed on a firm by business partners

3.3 Regulation by civil society

- 3.3.1 Formal standard setting
- 3.3.2 Less formalised pressuring of businesses and governments
- 3.4 Co-regulation by governments and civil society
- 3.4.1 Public co-management of common pool resources

3.5 Co-regulation by governments and markets

- 3.5.1 Certification schemes
- 3.5.2 Negotiated agreements
- 3.5.3 Public-private partnerships

3.6 Co-regulation by civil society and markets

- 3.6.1 Certification schemes
- 3.6.2 Private-private partnerships

3.7 Co-regulation by governments, civil society and markets

- 3.7.1 Standards
- 3.7.2 Certification schemes
- 3.7.3 Partnerships

4. Cultural

4.1 Physical and tangible expressions of culture

- 4.1.1 Architecture
- 4.1.2 Artifacts
- 4.1.3 Arts
- 4.1.4 Technology

4.2 Intangible expressions of culture

- 4.2.1 Knowledge and practices concerning nature and the universe
- 4.2.2 Oral traditions and expressions
- 4.2.3 Performing arts
- 4.2.4 Social practices, rituals and festive events
- 4.2.5 Traditional craftsmanship

5. Supply chains

5.1 Goods and services flows

- 5.1.1 Goods and services flows

5.2 Information flows

5.2.1 Information flows

5.3 Finance flows

5.3.1 Finance flows

6. Number of people

6.1 Number of people

6.1.1 Number of people

7. Information

7.1 Functional diversity

7.1.1 Quantity of societal functions

7.2 Structural diversity

7.2.1 Quantity of societal structures

7.3 Cultural diversity

7.3.1 Quantity of cultures

7.4 Diversity of knowledge

7.4.1 Quantity of knowledge

8. Network

8.1 Distribution and connectivity of social systems

8.1.1 Spatial distribution of social systems

8.1.2 Meta-system connectivity (between different, spatially separated social systems)

8.1.3 Inter-system connectivity (between connected social systems)

8.1.4 Intra-system connectivity (within an individual social system)

8.2 Strength, density and reach of the social system

8.2.1 Relationship strength (emotional intensity, degree of trust, degree of reciprocity, length of time spent together).

8.2.2 Density (number of relationships)

8.2.3 Reach (distance over which the actors' relationships extend beyond their own network)

8.3 Structure and composition of social systems

8.3.1 Complementarity of the actors

8.3.2 Competencies of the actors

8.3.3 Sufficient resources (people, time, money)

8.3.4 Consistent and matching tasks, competencies and responsibilities of the actors

8.3.5 Appropriate regulations on competition

8.4 Interactions and interdependencies within networks

8.4.1 Cooperation

8.4.2 Competition

9. Individual/Population specific key attributes

9.1 Human well-being of individuals

9.1.1 Food security

9.1.2 Security

9.1.3 Physical health

9.1.4 Mental health

9.1.5 Information
9.1.6 Good social relationships and belonging
9.1.7 Experienced esteem
9.1.8 Freedom and self-realization
9.1.9 Intellectual capacity
9.1.10 Morality
9.1.11 Good life
9.2 Population structure and dynamics
9.2.1 Population growth rate (birth, death, migration)
9.2.2 Age distribution
9.2.3 Sex ratio
9.3 Quantity and quality of habitable land
9.3.1 Quantity of habitable land
9.3.2 Abiotic quality of habitable land
9.3.3 Biotic quality of habitable land
10. Communication, economic, energy and resource efficiency
10.1 Communication efficiency
10.1.1 Communication efficiency
10.2 Economic efficiency
10.2.1 Allocative efficiency
10.2.2 Productive efficiency
10.3 Energy efficiency
10.3.1 Energy efficiency
10.4 Resource efficiency
10.4.1 Resource efficiency
11. Higher order emergent properties
11.1 Recovery and resilience
11.1.1 Recovery and resilience
11.2 Adaptive capacity
11.2.1 Adaptive capacity
11.3. Resistance
11.3.1 Resistance
12. Purpose
12.1 Purpose
12.1.1 Purpose

4.5 Ecosystem services

1. Provisioning (Biotic)
1.1 Biomass
1.1.1. Cultivated terrestrial plants for nutrition, materials or energy

1.1.1.1 Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes

1.1.1.2 Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)

1.1.1.3 Cultivated plants (including fungi, algae) grown as a source of energy

1.1.2 Cultivated aquatic plants for nutrition, materials or energy

1.1.2.1 Plants cultivated by in- situ aquaculture grown for nutritional purposes

1.1.2.2 Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)

1.1.2.3 Plants cultivated by in- situ aquaculture grown as an energy source

1.1.3 Reared animals for nutrition, materials or energy

1.1.3.1 Animals reared for nutritional purposes

1.1.3.2 Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)

1.1.3.3 Animals reared to provide energy (including mechanical)

1.1.4 Reared aquatic animals for nutrition, materials or energy

1.1.4.1 Animals reared by in-situ aquaculture for nutritional purposes

1.1.4.2 Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)

1.1.4.3 Animals reared by in-situ aquaculture as an energy source

1.1.5 Wild plants (terrestrial and aquatic) for nutrition, materials or energy

1.1.5.1 Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition

1.1.5.2 Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)

1.1.5.3 Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy

1.1.6 Wild animals (terrestrial and aquatic) for nutrition, materials or energy

1.1.6.1 Wild animals (terrestrial and aquatic) used for nutritional purposes

1.1.6.2 Fibres and other materials from wild animals for direct use or processing (excluding genetic materials)

1.1.6.3 Wild animals (terrestrial and aquatic) used as a source of energy

1.2 Genetic material from all biota (including seed, spore or gamete production)

1.2.1 Genetic material from plants, algae or fungi

1.2.1.1 Seeds, spores and other plant materials collected for maintaining or establishing a population

1.2.1.2 Higher and lower plants (whole organisms) used to breed new strains or varieties

1.2.1.3 Individual genes extracted from higher and lower plants for the design and construction of new biological entities

1.2.2 Genetic material from animals

1.2.2.1 Animal material collected for the purposes of maintaining or establishing a population

1.2.2.2 Wild animals (whole organisms) used to breed new strains or varieties

1.2.2.3 Individual genes extracted from organisms for the design and construction of new biological entities

1.3 Other types of provisioning service from biotic sources

1.3.X.X Other

2. Regulation & Maintenance (Biotic)

2.1 Transformation of biochemical or physical inputs to ecosystems

2.1.1 Mediation of wastes or toxic substances of anthropogenic origin by living processes

2.1.1.1 Bio-remediation by micro-organisms, algae, plants, and animals

2.1.1.2 Filtration / sequestration / storage / accumulation by micro-organisms, algae, plants, and animals

2.1.2 Mediation of nuisances of anthropogenic origin

2.1.2.1 Smell reduction

2.1.2.2 Noise attenuation

2.1.2.3 Visual screening

2.2 Regulation of physical, chemical, biological conditions

2.2.1 Regulation of baseline flows and extreme events

2.2.1.1 Control of erosion rates

2.2.1.2 Buffering and attenuation of mass movement

2.2.1.3 Hydrological cycle and water flow regulation (Including flood control, and coastal protection)

2.2.1.4 Wind protection

2.2.1.5 Fire protection

2.2.2 Lifecycle maintenance, habitat and gene pool protection

2.2.2.1 Pollination (or 'gamete' dispersal in a marine context)

2.2.2.2 Seed dispersal

2.2.2.3 Maintaining nursery populations and habitats (Including gene pool protection)

2.2.3 Pest and disease control

2.2.3.1 Pest control (including invasive species)

2.2.3.2 Disease control

2.2.4 Regulation of soil quality

2.2.4.1 Weathering processes and their effect on soil quality

2.2.4.2 Decomposition and fixing processes and their effect on soil quality

2.2.5 Water conditions

2.2.5.1 Regulation of the chemical condition of freshwaters by living processes

2.2.5.2 Regulation of the chemical condition of salt waters by living processes

2.2.6 Atmospheric composition and conditions

2.2.6.1 Regulation of chemical composition of atmosphere and oceans

2.2.6.2 Regulation of temperature and humidity, including ventilation and transpiration

2.3 Other types of regulation and maintenance service by living processes

2.3.X.X Other

3. Cultural (Biotic)

3.1 Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting

3.1.1 Physical and experiential interactions with natural environment

3.1.1.1 Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions

3.1.1.2 Characteristics of living systems that enable activities promoting health, r ecuperation or enjoyment through passive or observational interactions

3.1.2 Intellectual and representative interactions with natural environment

3.1.2.1 Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge

3.1.2.2 Characteristics of living systems that enable education and training

3.1.2.3 Characteristics of living systems that are resonant in terms of culture or heritage

3.1.2.4 Characteristics of living systems that enable aesthetic experiences

3.2 Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting

3.2.1 Spiritual, symbolic and other interactions with natural environment

3.2.1.1 Elements of living systems that have symbolic meaning

3.2.1.2 Elements of living systems that have sacred or religious meaning

3.2.1.3 Elements of living systems used for entertainment or representation

3.2.2 Other biotic characteristics that have a non-use value

3.2.2.1 Characteristics or features of living systems that have an existence value

3.2.2.2 Characteristics or features of living systems that have an option or bequest value

3.3 Other characteristics of living systems that have cultural significance

3.3.X.X Other

4. Provisioning (Abiotic)

4.1 Water

4.1.1 Surface water used for nutrition, materials or energy

4.1.1.1 Surface water for drinking

4.1.1.2 Surface water used as a material (non-drinking purposes)

4.1.1.3 Freshwater surface water used as an energy source

4.1.1.4 Coastal and marine water used as energy source

4.1.2 Ground water for used for nutrition, materials or energy

4.1.2.1 Ground (and subsurface) water for drinking

4.1.2.2 Ground water (and subsurface) used as a material (non-drinking purposes)

4.1.2.3 Ground water (and subsurface) used as an energy source

4.2 Other aqueous ecosystem outputs

4.2.X.X Other

4.3 Non-aqueous natural abiotic ecosystem outputs

4.3.1 Mineral substances used for nutrition, materials or energy

4.3.1.1 Mineral substances used for nutritional purposes

4.3.1.2 Mineral substances used for material purposes

4.3.1.3 Mineral substances used for as an energy source

4.3.2 Non-mineral substances or ecosystem properties used for nutrition, materials or energy

4.3.2.1 Non-mineral substances or ecosystem properties used for nutritional purposes

4.3.2.2 Non-mineral substances used for materials

4.3.2.3 Wind energy

4.3.2.4 Solar energy

4.3.2.5 Geothermal

4.3.2.6 Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy

5. Regulation & Maintenance (Abiotic)

5.1 Transformation of biochemical or physical inputs to ecosystems

5.1.1 Mediation of waste, toxics and other nuisances by non-living processes

5.1.1.1 Dilution by freshwater and marine ecosystems

5.1.1.2 Dilution by atmosphere

5.1.1.3 Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)

5.1.2 Mediation of nuisances of anthropogenic origin

5.1.2.1 Mediation of nuisances by abiotic structures or processes

5.2 Regulation of physical, chemical, biological conditions

5.2.1 Regulation of baseline flows and extreme events

5.2.1.1 Mass flows

5.2.1.2 Liquid flows

5.2.1.3 Gaseous flows

5.2.2 Maintenance of physical, chemical, abiotic conditions

5.2.2.1 Maintenance and regulation by inorganic natural chemical and physical processes

5.3 Other type of regulation and maintenance service by abiotic processes

5.3.X.X Other

6. Cultural (Abiotic)

6.1 Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting

6.1.1 Physical and experiential interactions with natural abiotic components of the environment

6.1.1.1 Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions

6.1.2 Intellectual and representative interactions with abiotic components of the natural environment

6.1.2.1 Natural, abiotic characteristics of nature that enable intellectual interactions

6.2 Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting

6.2.1 Spiritual, symbolic and other interactions with the abiotic components of the natural environment

6.2.1.1 Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions

6.2.2 Other abiotic characteristics that have a non-use value

6.2.2.1 Natural, abiotic characteristics or features of nature that have either an existence, option or bequest value

6.3 Other abiotic characteristics of nature that have cultural significance

6.3.X.X Other

4.6 Ecosystems

Terrestrial

T1 Tropical-subtropical forests biome

T1.1 Tropical subtropical lowland rainforests

T1.2 Tropical subtropical dry forests and thickets

T1.3 Tropical-subtropical montane rainforests

T1.4 Tropical heath forests

T2 Temperate-boreal forests and woodlands biome

T2.1 Boreal and temperate high montane forests and woodlands

T2.2 Deciduous temperate forests

T2.3 Oceanic cool temperate rainforests

T2.4 Warm temperate laurophyll forests

T2.5 Temperate pyric humid forests

T2.6 Temperate pyric sclerophyll forests and woodlands

T3 Shrublands and shrubby woodlands biome

T3.1 Seasonally dry tropical shrublands

T3.2 Seasonally dry temperate heaths and shrublands

T3.3 Cool temperate heathlands

T3.4 Rocky pavements, lava flows and screes

T4 Savannas and grasslands

T4.1 Trophic savannas

T4.2 Pyric tussock savannas

T4.3 Hummock savannas

T4.4 Temperate woodlands

- T4.5 Temperate subhumid grasslands
- T5 Deserts and semi-deserts
  - T5.1 Semi-desert steppes
  - T5.2 Succulent or Thorny deserts and semi-deserts
  - T5.3 Sclerophyll hot deserts and semi-deserts
  - T5.4 Cool deserts and semi-deserts
  - T5.5 Hyper-arid deserts
- T6 Polar-alpine (cryogenic) biome
  - T6.1 Ice sheets, glaciers and perennial snowfields
  - T6.2 Polar alpine rocky outcrops
  - T6.3 Polar tundra and deserts
  - T6.4 Temperate alpine grasslands and shrublands
  - T6.5 Tropical alpine grasslands and herbfields
- T7 Intensive land-use biome
  - T7.1 Annual croplands
  - T7.2 Sown pastures and fields
  - T7.3 Plantations
  - T7.4 Urban and industrial ecosystems
  - T7.5 Derived semi-natural pastures and old fields

Subterranean
- S1 Subterranean lithic biome
  - S1.1 Aerobic caves
  - S1.2 Endolithic systems
- S2 Anthropogenic subterranean voids biome
  - S2.1 Anthropogenic subterranean voids

Subterranean-Freshwater
- SF1 Subterranean freshwaters
  - SF1.1 Underground streams and pools
  - SF1.2 Groundwater ecosystems
- SF2 Anthropogenic subterranean freshwaters biome
  - SF2.1 Water pipes and subterranean canals
  - SF2.2 Flooded mines and other voids

Subterranean-Marine
- SM1 Subterranean tidal biome
  - SM1.1 Anchialine caves
  - SM1.2 Anchialine pools
  - SM1.3 Sea caves

Terrestrial-Freshwater
- TF1 Palustrine wetlands
  - TF1.1 Tropical flooded forests and peat forests
  - TF1.2 Subtropical-temperate forested wetlands
  - TF1.3 Permanent marshes

- TF1.4 Seasonal floodplain marshes
- TF1.5 Episodic arid floodplains
- TF1.6 Boreal, temperate and montane peat bogs
- TF1.7 Boreal and temperate fens

Freshwater

- F1 Rivers and streams
  - F1.1 Permanent upland streams
  - F1.2 Permanent lowland rivers
  - F1.3 Freeze-thaw rivers and streams
  - F1.4 Seasonal upland streams
  - F1.5 Seasonal lowland rivers
  - F1.6 Episodic arid rivers
  - F1.7 Large lowland rivers
- F2 Lakes
  - F2.1 Large permanent freshwater lakes
  - F2.2 Small permanent freshwater lakes
  - F2.3 Seasonal freshwater lakes
  - F2.4 Freeze-thaw freshwater lakes
  - F2.5 Ephemeral freshwater lakes
  - F2.6 Permanent salt and soda lakes
  - F2.7 Ephemeral salt lakes
  - F2.8 Artesian springs and oases
  - F2.9 Geothermal pools and wetlands
  - F2.10 Subglacial lakes
- F3 Artificial wetlands
  - F3.1 Large reservoirs
  - F3.2 Constructed lacustrine wetlands
  - F3.3 Rice paddies
  - F3.4 Freshwater aquafarms
  - F3.5 Canals, ditches and drains

Freshwater-Marine

- FM1 Semi-confined transitional waters
  - FM1.1 Deepwater coastal inlets
  - FM1.2 Permanently open riverine estuaries and bays
  - FM1.3 Intermittently closed and open lakes and lagoons

Marine

- M1 Marine shelf
  - M1.1 Seagrass meadows
  - M1.2 Kelp forests
  - M1.3 Photic coral reefs
  - M1.4 Shellfish beds and reefs
  - M1.5 Photo-limited marine animal forests

- M1.6 Subtidal rocky reefs
- M1.7 Subtidal sand beds
- M1.8 Subtidal mud plains
- M1.9 Upwelling zones

M2 Pelagic ocean waters
- M2.1 Epipelagic ocean waters
- M2.2 Mesopelagic ocean waters
- M2.3 Bathypelagic ocean waters
- M2.4 Abyssopelagic ocean waters
- M2.5 Sea ice

M3 Deep sea floors
- M3.1 Continental and island slopes
- M3.2 Submarine canyons
- M3.3 Abyssal plains
- M3.4 Seamounts, ridges and plateaus
- M3.5 Deepwater biogenic beds
- M3.6 Hadal trenches and troughs
- M3.7 Chemosynthetic-based ecosystems (CBE)

M4 Anthropogenic marine biome
- M4.1 Submerged artificial structures
- M4.2 Marine aquafarms

Marine-Terrestrial

MT1 Shorelines biome
- MT1.1 Rocky shorelines
- MT1.2 Muddy shorelines
- MT1.3 Sandy shorelines
- MT1.4 Boulder and cobble shores

MT2 Supralittoral coastal biome
- MT2.1 Coastal shrublands and grasslands

MT3 Anthropogenic shorelines biome
- MT3.1 Artificial shorelines

Marine-Freshwater-Terrestrial

MFT1 Brackish tidal biome
- MFT1.1 Coastal river deltas
- MFT1.2 Intertidal forests and shrublands
- MFT1.3 Coastal saltmarshes and reedbeds

4.7. Key ecological attributes

1. Energy input

1.1 Solar radiation
- 1.1.1 Energy input through solar radiation

1.1.2 Reduction of energy input of solar radiation through filtering or shading elements and surface albedo (e.g. sediments, cloud or vegetation cover)

1.2 Heat flow (turbulent and latent heat flows)

1.2.1 Energy input through oceanic circulation

1.2.2 Energy input of atmospheric circulation and wind patterns

1.2.3 Geothermal input (e.g. hot springs, geysers, fumaroles, hydrothermal vents)

1.2.4 Energy input through evaporation

1.2.5 Anthropogenic energy input (e.g. urban heat islands, power plant discharges)

1.3 Other energy inputs

1.3.1 Mechanical input of wind on water surfaces

1.3.2 Energy input through lightning

2. Atmosphere

2.1 Air quality

2.1.1 Quantity and quality of solid pollutants and particles (e.g. dust, ash, heavy metals)

2.1.2 Quantity and quality of gaseous pollutants (e.g. carbon dioxide (CO_2), methane (CH_4), ozone (O_3), sulphur oxides, nitrogen oxides, volatile organic compounds)

2.2 Global climate conditions

2.2.1 Global annual average temperatures and temperature variability

2.2.2 Global annual average humidity, humidity variability and cloud cover

2.2.3 Global wind and pressure patterns

2.2.4 Global precipitation patterns (e.g. amount, distribution, form)

2.2.5 Interannual and long-term global climatic variability

2.3 Weather and local climate conditions

2.3.1 Local annual average temperatures and temperature variability

2.3.2 Frequency, intensity or length of events of extreme temperature

2.3.3 Local annual average humidity, humidity variability and cloud cover

2.3.4 Local wind and pressure patterns

2.3.5 Frequency, intensity or length of events of extreme winds

2.3.6 Local precipitation patterns (e.g. amount, distribution, form)

2.3.7 Frequency, intensity or length of events of extreme precipitation

2.3.8 Interannual and long-term local climatic variability

3. Hydrosphere

3.1 Physical water characteristics

3.1.1 Water temperature

3.1.2 Water turbidity

3.1.3 Total dissolved solids (TDS)

3.1.4 Electrical conductivity

3.1.5 Transparency

3.1.6 Other physical water characteristics (e.g. color, odor, taste, density, redox potential)

3.2 Water chemistry

3.2.1 pH

3.2.2 Quantity and quality of dissolved gases (e.g. oxygen (O_2), carbon dioxide (CO_2), hydrogen sulfide (H_2S), methane (CH_4))

3.2.3 Water salinity (Quantity and quality of main ions, e.g. bicarbonate (HCO_3^-), carbonate (CO_3^-), chloride (Cl^-), sulfate (SO_4^{2-}), sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}))

3.2.4 Quantity and quality of biogenic elements (e.g. nitrogen (N), phosphor (P), silicon (Si), iron (Fe))

3.2.5 Quantity and quality of organic compounds (e.g. organic carbon, amino acids, proteins, oils)

3.2.6 Quantity and quality of microelements, toxic inorganic substances, heavy metals and pollutants (e.g. cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), zinc (Zn))

3.3 Hydrologic regimes

3.3.1 Water levels

3.3.2 Water-level variability in wetlands (including extreme lows)

3.3.3 Groundwater flows

3.3.4 Flood occurrence, frequency, intensity, and area flooded (including hydroperiod)

3.3.5 Runoff and flow of water (e.g. amount, speed of runoff)

3.3.6 Evaporation

3.3.7 Currents and upwelling

3.3.8 Wave and spray patterns

3.4 Snow/ice regimes

3.4.1 Snow pack

3.4.2 Snow loads

3.4.3 Snow cover period

3.4.4 Thickness of permanent ice sheets, melting of glaciers and permanent snow cover

3.4.5 Duration and thickness of seasonal ice sheets and freezing of water bodies

3.4.6 Melting of permafrost soils

4. Lithosphere

4.1 Physical soil parameters

4.1.1 Soil temperature

4.1.2 Soil moisture

4.1.3 Soil structure

4.1.4 Slope (e.g. aspect, steepness)

4.1.5 Soil texture, particle size distribution patterns, aggregation, density, drainage, and water-holding capacity

4.1.6 Floor structure of aquatic systems (e.g. rivers, lakes, oceans)

4.1.7 Coastline morphology (e.g. due to sea level rise, fluctuation and costal impact)

4.1.8 Channel morphology (e.g. sinuosity, thread)

4.1.9 Erosion, transport and deposition of sediments

4.2 Chemical soil characteristics

4.2.1 Chemical soil characteristics (e.g. pH, salinity, cation exchange capacity)

- 4.2.2 Organic matter and macronutrient concentrations (nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S), magnesium (Mg))
- 4.2.3 Micronutrients / trace inorganic chemicals concentrations (boron (B), chlorine (Cl), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), molybdenum (Mo), nickel (Ni))
- 4.2.4 Availability of other elements and substances (e.g. heavy metals, xenobiotic substances such as pesticides, PCB, dioxins)

4.3 Geomorphological processes

- 4.3.1 Physical weathering processes (e.g. due to changes in temperature extremes, winds)
- 4.3.2 Chemical weathering processes
- 4.3.3 Tectonic and volcanic processes
- 4.3.4 Surface movements (e.g. avalanches, erosion, landslides)

5. Matter cycle-related processes

5.1 Oxygen cycle

- 5.1.1 Oxygen reservoirs and fluxes (e.g. oxygen concentrations, solubility)

5.2. Carbon cycle

- 5.2.1 Carbon reservoirs and fluxes (including the processes of ocean soaking, photosynthesis and carbonate formation)

5.3 Nitrogen cycle

- 5.3.1 Nitrogen reservoirs and fluxes (including fixation, assimilation, ammonification, nitrification and denitrification rates)

5.4 Phosphorus cycle

- 5.4.1 Phosphorus reservoirs and fluxes (Availability, concentration and runoff of phosphorus)

5.5 Other nutrient cycles (calcium, sulphur, iron, etc.)

- 5.5.1 Nutrient reservoirs and cycles

6. Biomass

6.1 Primary production

- 6.1.1 Primary production (including photosynthetic and chemosynthetic producers)

6.2 Above ground biomass

- 6.2.1 Quantity and quality of above ground plant biomass (e.g. leaves, twigs, branches, stems, fruits)
- 6.2.2 Quantity and quality of above ground animal biomass
- 6.2.3 Quantity and quality of above ground microorganism biomass (e.g. bacteria, fungi)

6.3 Below ground biomass

- 6.3.1 Quantity and quality of below ground plant biomass (e.g. roots, rhizomes)
- 6.3.2 Quantity and quality of below ground animal biomass
- 6.3.3 Quantity and quality of below ground microorganism biomass (e.g. bacteria, fungi)

6.4 Aquatic biomass

- 6.4.1 Quantity and quality of aquatic plant biomass
- 6.4.2 Quantity and quality of aquatic animal biomass
- 6.4.3 Quantity and quality of aquatic microorganism biomass (e.g. bacteria, fungi)

- 6.5 Extent of ecosystems
    - 6.5.1 Extent of ecosystems
- 7. Information
    - 7.1 Intraspecific / Genetic diversity
        - 7.1.1 Quantity of genes
    - 7.2 Interspecific diversity / species richness
        - 7.2.1 Quantity of species
    - 7.3 Morphofunctional diversity (variety of lifeforms and diversity of functional groups)
        - 7.3.1 Quantity of morphofunctional groups
    - 7.4 Diversity of ecological traits
        - 7.4.1 Quantity of ecological traits
    - 7.5 Habitat diversity
        - 7.5.1 Quantity of habitats
    - 7.6 Ecosystem diversity
        - 7.6.1 Quantity of ecosystems
- 8. Network
    - 8.1 Distribution and connectivity of ecosystems
        - 8.1.1 Spatial distribution of ecosystem types
        - 8.1.2 Meta-ecosystem connectivity (between different, spatially separated ecosystems)
        - 8.1.3 Inter-ecosystem connectivity (between adjacent ecosystems, e.g. terrestrial/aquatic)
        - 8.1.4 Intra-ecosystem connectivity (within an individual ecosystem)
    - 8.2 Extent, distribution and connectivity of communities
        - 8.2.1 Spatial extent of communities
        - 8.2.2 Spatial distribution of communities
        - 8.2.3 Connectivity of different communities
        - 8.2.4 Connectivity of an individual community
    - 8.3 Structure and composition of communities
        - 8.3.1 Community composition
        - 8.3.2 Presence of key ecological guilds
        - 8.3.3 Presence of keystone species
        - 8.3.4 Food web structure
        - 8.3.5 Basic biotic structural elements (e.g., structure-constituting species such as trees or corals)
    - 8.4 Synecological interactions and interdependencies
        - 8.4.1 Predator-prey interactions
        - 8.4.2 Competition
        - 8.4.3 Parasitism
        - 8.4.4 Mutualism (including pollination, seed dispersal, etc.)
        - 8.4.5 Commensalism
        - 8.4.6 Amensalism

8.4.7 Beneficial anthropogenic influences (e.g. conservation actions, agricultural practices, management measures, disturbances such as military activities)

9. Species specific key attributes
- 9.1 Physiology and behavior of individuals
  - 9.1.1 Species morphology
  - 9.1.2 Species metabolism and physiology
  - 9.1.3 Species immune function
  - 9.1.4 Species growth rate
  - 9.1.5 Species photosynthetic rate
  - 9.1.6 Species rate, timing, and frequency of life-cycle events
  - 9.1.7 Species behavior (e.g. foraging, migration)
- 9.2 Viable population size, structure and natural population dynamics (including dispersal, recruitment, colonization, etc.)
  - 9.2.1 Population growth rate (birth, death, migration), including dynamics of meta populations
  - 9.2.2 Size and age distribution
  - 9.2.3 Sex determination and sex ratio
  - 9.2.4 Gene flow
  - 9.2.5 Dispersal, recruitment, and colonization
- 9.3 Habitat quantity and quality (including abiotic and biotic habitat components)
  - 9.3.1 Quantity of suitable habitat
  - 9.3.2 Abiotic habitat components and factors (e.g. soundscapes, natural light regimes, but also cf. 1.1 to 3.1)
  - 9.3.3 Biotic habitat components and interactions (e.g. resource and food availability, but also cf. 4.1 to 4.3)

10. Energy, matter and water efficiency of ecosystems
- 10.1 Energy efficiency
  - 10.1.1 Total dissipation due to photosynthetic activity, respiration and transpiration, ecosystem biomass and diversity
  - 10.1.2 Quantity of exergy captured by the ecosystem
  - 10.1.3 Quantity of exergy stored in the ecosystem (e.g. due to changed surface albedo of vegetation cover)
  - 10.1.4 Exergy through flow through the system
  - 10.1.5 Retention time (stored biomass / through flow) of energy within the system
  - 10.1.6 Relative entropy production of the biological components, according to the respiration to biomass ratio
  - 10.1.7 Release of energy during fire events (frequency, intensity, timing, duration or extent)
- 10.2 Matter efficiency
  - 10.2.1 Increased efficiency of matter cycles due to changes of existing cycles, or replacement of less effective cycles by more effective ones

10.2.2 Increased strength of greenhouse effect modification due to improvement of carbon cycling qualities of ecosystems
10.2.3 Oxygen concentration modifications through vegetation cover of surfaces
10.2.4 Decomposition and mineralization rates (e.g. due to changes in temperature, soil moisture, heavy metal accumulation)
10.2.5 Biogeomorphological processes through local biota
10.3 Water efficiency
10.3.1 Water cycling feedback due to changed vegetation cover of surfaces
10.3.2 Soil moisture recycling due to changed vegetation root systems
10.3.3 Production of compounds acting as cloud condensation nuclei by organisms
10.3.4 Acquisition of subsidiary water due to foliar water uptake
11. Resilience and resistance
11.1 Recovery
11.1.1 Recovery (including primary and secondary succession)
11.2 Adaptive capacity
11.2.1 Adaptive capacity (including diversity of genes, species and ecosystems)
11.3. Resistance
11.3.1 Resistance (including abiotic and biotic resistance)

4.8 Ecological stresses

1. Changed energy input
1.1 Changed solar radiation
1.1.1 Reduced energy input through solar radiation due to increase in shading or filtering elements and surface albedo (e.g. solid pollutants, sediments, cloud or vegetation cover)
1.1.2 Increased energy input of solar radiation due to reduction of filtering or shading elements and surface albedo (e.g. filtration of sediments, logging of riverine forests, decrease of snow cover)
1.2 Changed heat flow
1.2.1 Changed energy input due to change of oceanic circulation
1.2.2 Changed energy input due to change of atmospheric circulation and wind patterns
1.2.3 Changed geothermal input (e.g. hot springs, geysers, fumaroles, hydrothermal vents)
1.2.4 Changed energy input due to change of evaporation
1.2.5 Changed anthropogenic energy input (e.g. urban heat islands, power plant discharges)
1.3 Changed other energy inputs
1.3.1 Changed energy input due to change of atmospheric circulation and wind patterns (mechanical energy input)
1.3.2 Changed energy input due to changed lightning frequency
2. Changes in the atmosphere
2.1 Changed air quality

    - 2.1.1 Changed air quality due to changed quantity and quality of solid pollutants and particles (e.g. dust, ash, heavy metals)
    - 2.1.2 Changed air quality due to changed quantity and quality of gaseous pollutants (e.g. carbon dioxide (CO_2), methane (CH_4), ozone (O_3), sulphur oxides, nitrogen oxides, volatile organic compounds)
  - 2.2 Changed global climate conditions
    - 2.2.1 Changed global annual average temperatures and temperature variability
    - 2.2.2 Changed global annual average humidity, humidity variability and cloud cover
    - 2.2.3 Changed global wind and pressure patterns
    - 2.2.4 Changed global precipitation patterns (e.g. amount, distribution, form)
    - 2.2.5 Changed interannual and long-term global climatic variability
  - 2.3 Changed weather and local climate conditions
    - 2.3.1 Changed local annual average temperatures and temperature variability
    - 2.3.2 Changed frequency, intensity or length of events of extreme temperature
    - 2.3.3 Changed local annual average humidity, humidity variability and cloud cover
    - 2.3.4 Changed local wind and pressure patterns
    - 2.3.5 Changed frequency, intensity or length of events of extreme winds
    - 2.3.6 Changed local precipitation patterns (e.g. amount, distribution, form)
    - 2.3.7 Changed frequency, intensity or length of events of extreme precipitation
    - 2.3.8 Changed interannual and long-term local climatic variability
- 3. Changes in the hydrosphere
  - 3.1 Changed physical water characteristics
    - 3.1.1 Changed water temperature
    - 3.1.2 Changed water turbidity
    - 3.1.3 Changed total dissolved solids (TDS)
    - 3.1.4 Changed electrical conductivity
    - 3.1.5 Changed transparency
    - 3.1.6 Other changed physical water characteristics
  - 3.2 Changed water chemistry
    - 3.2.1 Changed pH
    - 3.2.2 Changed quantity and quality of dissolved gases (e.g. oxygen (O_2), carbon dioxide (CO_2), hydrogen sulfide (H_2S), methane (CH_4))
    - 3.2.3 Changed water salinity (Changed quantity and quality of main ions, e.g. bicarbonate (HCO_3^-), carbonate (CO_3^-), chloride (Cl^-), sulfate (SO_4^{2-}), sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}))
    - 3.2.4 Changed quantity and quality of biogenic elements (e.g. nitrogen (N), phosphor (P), silicon (Si), iron (Fe))
    - 3.2.5 Changed quantity and quality of organic compounds (e.g. organic carbon, amino acids, proteins, oils)
    - 3.2.6 Changed quantity and quality of microelements, toxic inorganic substances, heavy metals and pollutants (e.g. cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), zinc (Zn))

- 3.3 Changed hydrologic regimes
  - 3.3.1 Permanent change of water levels
  - 3.3.2 Changed water-level variability in wetlands (including extreme lows)
  - 3.3.3 Changed groundwater flows
  - 3.3.4 Changed flood occurrence, frequency, intensity, and area flooded (including hydroperiod)
  - 3.3.5 Changed runoff and flow of water (e.g. amount, speed of runoff)
  - 3.3.6 Changed evaporation
  - 3.3.7 Changed currents and upwelling
  - 3.3.8 Changed wave and spray patterns
- 3.4 Changed snow / ice regimes
  - 3.4.1 Changed snow pack
  - 3.4.2 Changed snow loads
  - 3.4.3 Changed snow cover period
  - 3.4.4 Changed thickness of permanent ice sheets, melting of glaciers and permanent snow cover
  - 3.4.5 Changed duration and thickness of seasonal ice sheets and freezing of water bodies
  - 3.4.6 Increased or decreased melting of permafrost soils

4. Changes in the lithosphere
   - 4.1 Changed physical soil characteristics
     - 4.1.1 Changed soil temperature
     - 4.1.2 Changed soil moisture
     - 4.1.3 Changed soil structure
     - 4.1.4 Changed slope (e.g. aspect, steepness)
     - 4.1.5 Changed soil texture, particle size distribution patterns, aggregation, density, drainage, and water-holding capacity
     - 4.1.6 Changed floor structure of aquatic systems (e.g. rivers, lakes, oceans)
     - 4.1.7 Changed coastline morphology (e.g. due to sea level rise, fluctuation and costal impact)
     - 4.1.8 Changed channel morphology (e.g. sinuosity, thread)
     - 4.1.9 Changed erosion, transport and deposition of sediments
   - 4.2 Changed chemical soil characteristics
     - 4.2.1 Changed chemical soil characteristics (e.g. pH, salinity, cation exchange capacity)
     - 4.2.2 Changed organic matter and macronutrient concentrations (nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S), magnesium (Mg))
     - 4.2.3 Changed micronutrients / trace inorganic chemicals concentrations (boron (B), chlorine (Cl), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), molybdenum (Mo), nickel (Ni))
     - 4.2.4 Changed availability of other elements and substances (e.g. heavy metals, xenobiotic substances such as pesticides, PCB, dioxins)
   - 4.3 Changed geomorphological processes

4.3.1 Changed physical weathering processes (e.g. due to changes in temperature extremes, winds)
4.3.2 Changed chemical weathering processes
4.3.3 Changed tectonic and volcanic processes
4.3.4 Changed surface movements (e.g. avalanches, erosion, landslides)

5. Changed matter cycle-related processes
    5.1 Changed oxygen cycle
        5.1.1 Changed oxygen reservoirs and fluxes (e.g. changes in oxygen concentrations, solubility)
    5.2 Changed carbon cycle
        5.2.1 Changed carbon reservoirs and fluxes (e.g. changes in emissions (e.g. due to changes in respiration, combustion and decomposition rates) and sequestration (e.g. assimilation during photosynthesis)
    5.3 Changed nitrogen cycle
        5.3.1 Changed nitrogen reservoirs and fluxes (e.g. use of fertilizers, biomass burning, combustion of fossil fuels)
    5.4 Changed phosphorus cycle
        5.4.1 Changed phosphorus reservoirs and fluxes (e.g. eutrophication due to emissions of industry, farmlands, animal feed and household consumption, soil erosion)
    5.5 Changed other nutrient cycles (calcium, sulphur, iron, etc.)
        5.5.1 Changed nutrient reservoirs and fluxes (e.g. changes due to anthropogenic release)
6. Changes in biomass
    6.1 Changed primary production
        6.1.1 Changed primary production (e.g. due to increasing temperatures, but also changed availability of primary net production due to human appropriation)
    6.2 Changed above ground biomass
        6.2.1 Changed quantity and quality of above ground plant biomass
        6.2.2 Changed quantity and quality of above ground animal biomass
        6.2.3 Changed quantity and quality of above ground microorganism biomass
    6.3 Changed below ground biomass
        6.3.1 Changed quantity and quality of below ground plant biomass (e.g. roots, rhizomes)
        6.3.2 Changed quantity and quality of below ground animal biomass
        6.3.3 Changed quantity and quality of below ground microorganism biomass (e.g. bacteria, fungi)
    6.4 Changed aquatic biomass
        6.4.1 Changed quantity and quality of aquatic plant biomass
        6.4.2 Changed quantity and quality of aquatic animal biomass
        6.4.3 Changed quantity and quality of aquatic microorganism biomass (e.g. bacteria, fungi)
        6.5 Changed extent of ecosystems
        6.5.1 Changed extent of ecosystems (e.g. due to changed climatic conditions, human activities)

7. Changes in information

- 7.1 Changed intraspecific / genetic diversity
  - 7.1.1 Changed quantity of genes due to the loss of existing or appearance of new genes
- 7.2 Changed interspecific diversity / species richness
  - 7.2.1 Changed quantity of species due to the loss of existing or appearance of new species
- 7.3 Changed morphofunctional diversity (variety of lifeforms and diversity of functional groups)
  - 7.3.1 Changed quantity of morphofunctional groups due to the loss or dissolving of known or appearance of new morphofunctional groups
- 7.4 Changed diversity of ecological traits
  - 7.4.1 Changed quantity of ecological traits due to the loss or dissolving of known or the appearance of new ecological traits
- 7.5 Changed habitat diversity
  - 7.5.1Changed quantity of habitats due to the loss or dissolving of known or the emergence of formerly unknown habitats (includes novel habitats)
- 7.6 Changed ecosystem diversity
  - 7.6.1 Changed quantity of ecosystems due to the loss or dissolving of known or the emergence of formerly unknown ecosystems (includes novel ecosystems)

8. Changes in network

- 8.1 Changed distribution and connectivity of ecosystems
  - 8.1.1 Changed spatial distribution of ecosystem types
  - 8.1.2 Changed meta-ecosystem connectivity (between different, spatially separated ecosystems)
  - 8.1.3 Changed inter-ecosystem connectivity (between adjacent ecosystems, e.g. terrestrial/aquatic)
  - 8.1.4 Changed intra-ecosystem connectivity (within an individual ecosystem)
- 8.2 Changed extent, distribution and connectivity of communities
  - 8.2.1 Changed spatial extent of communities
  - 8.2.2 Changed spatial distribution of communities
  - 8.2.3 Changed connectivity of different communities
  - 8.2.4 Changed connectivity of an individual community
- 8.3 Changed the structure and composition of communities
  - 8.3.1 Changed community composition (including abundance changes due to changed species interactions between or within trophic levels)
  - 8.3.2 Changes in key ecological guilds
  - 8.3.3 Changes in keystone species
  - 8.3.4 Changed food web structure
  - 8.3.5 Changed basic biotic structural elements (e.g. structure-constituting species such as trees or corals)
- 8.4 Changed synecological interactions and interdependencies
  - 8.4.1 Changed predator-prey interactions (e.g. loss of interaction due to local extinction, abundance loss or phenological mismatch of a partner species, development of new

interactions due to appearance of new prey species or predators, changed fitness, competitiveness or behavior of a partner species)

8.4.2 Changed interactions between competitors (e.g. loss of interaction due to local extinction, abundance loss or phenological mismatch of a competitor, appearance of new competitors, changed fitness, competitiveness or behavior of a competitor)

8.4.3 Changed host-parasite interactions (e.g. loss of interaction due to local extinction, abundance loss or phenological mismatch of an interacting species, development of new interactions due to appearance of new host species or parasites, changed fitness, competitiveness or behavior of an interacting species)

8.4.4 Changed mutualism (e.g. loss of interaction due to local extinction, abundance loss or phenological mismatch of an interacting species, development of new interactions due to appearance of new species, changed fitness, competitiveness or behavior of an interacting species)

8.4.5 Changed commensalism (e.g. loss of interaction due to local extinction, abundance loss or phenological mismatch of an interacting species, development of new interactions due to appearance of new species, changed fitness, competitiveness or behavior of an interacting species)

8.4.6 Changed amensalism (e.g. loss of interaction due to local extinction, abundance loss or phenological mismatch of an interacting species, development of new interactions due to appearance of new species, changed fitness, competitiveness or behavior of an interacting species)

8.4.7 Changed beneficial anthropogenic influences (e.g. end of conservation projects or management measures, abandonment of agricultural lands or changed agricultural practices, intensification or abandonment of disturbances),

9. Direct stresses to individuals and populations, including habitat related stresses

9.1 Changed physiology and behavior of individuals

9.1.1 Changed morphology

9.1.2 Changed metabolism and physiology

9.1.3 Changed immune function

9.1.4 Changed growth rate

9.1.5 Changed photosynthetic rate

9.1.6 Changed rate, timing, and frequency of life-cycle events

9.1.7 Changed behavior (e.g. foraging, migration)

9.2 Changed population size, structure, dynamics and growth rate

9.2.1 Changed population growth rate (birth, death, migration), including dynamics of meta populations

9.2.2 Changed size and age distribution (e.g. loss of tall old trees, individuals in reproductive age)

9.2.3 Changed sex determination and sex ratio

9.2.4 Changed gene flow

9.2.5 Changed dispersal, recruitment, and colonization

9.3 Changed habitat quantity and quality

9.3.1 Reduction of local or global quantity of suitable habitat (includes physical surface conversions, elevational and latitudinal shifting, occurrence of new barriers and poor connectivity between recent and potential future habitats)
9.3.2 Changed abiotic habitat components and factors (e.g. changed soundscapes, changes in natural light regimes, but also cf. 1.1 to 3.1)
9.3.3 Changed biotic habitat components and interactions (e.g. changed resource and food availability, but also cf. 4.1 to 4.3)

10. Changed energy, matter and water efficiency of ecosystems
    - 10.1 Changed energy flow and efficiency
        - 10.1.1 Changed total dissipation due to changes in photosynthetic activity, respiration and transpiration, ecosystem biomass and diversity
        - 10.1.2 Changed quantity of exergy captured by the ecosystem
        - 10.1.3 Changed quantity of exergy stored in the ecosystem (e.g. due to changed surface albedo of vegetation cover)
        - 10.1.4 Changed exergy through flow through the system
        - 10.1.5 Changed retention time (stored biomass / through flow) of energy within the system
        - 10.1.6 Changed relative entropy production of the biological components, due to changes in the respiration to biomass ratio
        - 10.1.7 Changed release of energy due to changes in the fire regime (frequency, intensity, timing, duration or extent)
    - 10.2 Changed matter efficiency
        - 10.2.1 Reduced efficiency of matter cycles due to changes of existing cycles, or replacement of more effective cycles by less effective ones
        - 10.2.2 Reduced strength of greenhouse effect modification due to changes of carbon cycling qualities of ecosystems
        - 10.2.3 Changed oxygen concentration modifications due to changes in vegetation cover of surfaces
        - 10.2.4 Changed decomposition and mineralization rates (e.g. due to changes in temperature, soil moisture, heavy metal accumulation)
        - 10.2.5 Changed biogeomorphological processes due to changes in local biota
    - 10.3 Changed water efficiency
        - 10.3.1 Changed water cycling feedback due to changed vegetation cover of surfaces
        - 10.3.2 Changed soil moisture recycling due to changed vegetation root systems
        - 10.3.3 Changed production of compounds acting as cloud condensation nuclei due to changes in vegetation densities
        - 10.3.4 Changed acquisition of subsidiary water due to changed foliar water uptake
11. Changed resilience and resistance
    - 11.1 Changed recovery
        - 11.1.1 Changed recovery (e.g. due to loss of biological legacies, etc.)
    - 11.2 Changed adaptive capacity
        - 11.2.1 Changed adaptive capacity (e.g. due to loss of diversity)

11.3 Changed resistance

11.3.1 Changed resistance (e.g. due to anthropogenic disturbances)

4.9 Ecological stress drivers

1. Residential & Commercial Development
    - 1.1 Housing & Urban Areas
    - 1.2 Commercial & Industrial Areas
    - 1.3 Tourism & Recreation Areas
2. Agriculture & Aquaculture
    - 2.1 Annual & Perennial Non-Timber Crops
    - 2.2 Wood & Pulp Plantations
    - 2.3 Livestock Farming & Ranching
    - 2.4 Marine & Freshwater Aquaculture
3. Energy Production & Mining
    - 3.1 Oil & Gas Drilling
    - 3.2 Mining & Quarrying
    - 3.3 Renewable Energy
4. Transportation & Service Corridors
    - 4.1 Roads & Railroads
    - 4.2 Utility & Service Lines
    - 4.3 Shipping Lanes
    - 4.4 Flight Paths
5. Biological Resource Use
    - 5.1 Hunting & Collecting Terrestrial Animals
    - 5.2 Gathering Terrestrial Plants
    - 5.3 Logging & Wood Harvesting
    - 5.4 Fishing & Harvesting Aquatic Resources
6. Human Intrusions & Disturbance
    - 6.1 Recreational Activities
    - 6.2 War, Civil Unrest & Military Exercises
    - 6.3 Work & Other Activities
7. Natural System Modifications
    - 7.1 Fire & Fire Suppression
    - 7.2 Dams & Water Management / Use
    - 7.3 Other Ecosystem Modifications
    - 7.4 Removing / Reducing Human Maintenance
8. Invasive & Problematic Species, Pathogens & Genes
    - 8.1 Invasive Non-Native / Alien Plants & Animals
    - 8.2 Problematic Native Plants & Animals
    - 8.3 Introduced Genetic Material
    - 8.4 Pathogens & Microbes

9. Pollution
   - 9.1 Household Sewage & Urban Waste Water
   - 9.2 Industrial & Military Effluents
   - 9.3 Agricultural & Forestry Effluents
   - 9.4 Garbage & Solid Waste
   - 9.5 Air-Borne Pollutants
   - 9.6 Excess Energy

10. Geological Events
   - 10.1 Volcanoe eruptions
   - 10.2 Earthquakes / Tsunamis
   - 10.3 Avalanches / Landslides

11. Climate Change
   - 11.1 Ecosystem Encroachment
   - 11.2 Changes in Geochemical Regimes
   - 11.3 Changes in Temperature Regimes
   - 11.4 Changes in Precipitation & Hydrological Regimes
   - 11.5 Severe / Extreme Weather Events

4.10 Social stress drivers

1. Bad governance
   - 1.1 Conflicts of interest
   - 1.2 Corruption
   - 1.3 Government ineffectiveness
   - 1.4 Lack of regulatory quality
   - 1.5. Lack of rule and law
   - 1.6 Lack of voice and weak accountability
   - 1.7 Oppression
   - 1.8 Political instability
   - 1.9 Other governance-related drivers of social stress

2. Bad management
   - 2.1 Conflicts of interest
   - 2.2 Corruption
   - 2.3 Ineffective management
   - 2.4 Financial mismanagement
   - 2.5 Lack of voice and weak accountability
   - 2.6 Other management-related drivers of social stress

3. Economic drivers of social stress
   - 3.1 Anti-competitive practices
   - 3.2 Economic oppression
   - 3.3 Unethical and unfair business practices
   - 3.4 Harmful working conditions

- 3.5 Unfree labor
- 3.6 Trade barriers
- 3.7 Ethically disputed business practices towards animals
- 3.8 Other impairments of economy

4. Conflicts and competition
   - 4.1 Cultural conflicts
   - 4.2 Ethnic conflicts
   - 4.3 Organizational conflicts (including cognitive, content, process and task conflicts)
   - 4.4 Role conflicts
   - 4.5 Social conflicts
   - 4.6 Harmful competition
5. Discrimination
   - 5.1 Discrimination by age
   - 5.2 Discrimination by culture
   - 5.3 Discrimination due to disability or illness
   - 5.4 Discrimination based on ethnicity
   - 5.5 Discrimination by gender
   - 5.6 Discrimination by physical appearance
   - 5.7 Discrimination based on religion
   - 5.8 Discrimination of sexual orientation
   - 5.9 Discrimination by social class
   - 5.10 Other forms of discrimination
6. Crime
   - 6.1 Acts leading to death or intending to cause death
   - 6.2 Acts leading to harm or intending to cause harm to the person
   - 6.3 Injurious acts of a sexual nature
   - 6.4 Acts against property involving violence or threat against a person
   - 6.5 Acts against property only
   - 6.6 Acts involving controlled psychoactive substances or other drugs
   - 6.7 Acts involving fraud, deception or corruption
   - 6.8 Acts against public order, authority and provisions of the State
   - 6.9 Acts against public safety and state security
   - 6.10 Acts against the natural environment
   - 6.11 Other criminal acts
7. Violence
   - 7.1 Violence targeting individuals
   - 7.2 Violence targeting groups
8. Diseases & other health issues
   - 8.1 Airborne diseases
   - 8.2 Foodborne diseases
   - 8.3 Infectious diseases
   - 8.4 Lifestyle diseases

8.5 Non-communicable diseases
8.6 Other health issues
9. Accidents
9.1 Industry-related accidents
9.2 Infrastructure-related accidents
9.3 Transport-related accidents
9.4 Other accidents
10. Disasters
10.1 Nuclear disasters
10.2 Biological disasters (epidemics, pandemics, see also 6. Diseases and other health problems)
10.3 Chemical disasters
10.4 Data-related disasters (see also 8.2 and 8.3)
10.5 Electromagnetically triggered disasters
10.6 Disasters caused by the release of mechanical or thermal energy
11. Adverse technological developments
11.1 Biotechnology
11.2 Computer security exploits
11.3 Digital threats
12. Information-related drivers of social stress
12.1 Misinformation
12.2 Disinformation
12.3 Malinformation

4.11 Social stress

1. Changes in master factors
1.1 Changes in preconditions
1.1.1 Changes in preconditions
1.2 Changes in interaction
1.2.1 Changes in interaction
1.3 Changes in organization
1.3.1 Changes in organization
1.4 Changes in structure
1.4.1 Changes in structure
1.5 Changes in legitimacy
1.5.1 Changes in legitimacy
2. Changes in provision
2.1 Changes in the quantity and/or quality of goods
2.1.1 Changes in the quantity and/or quality of food and live animals
2.1.2 Changes in the quantity and/or quality of beverages and tobacco
2.1.3 Changes in the quantity and/or quality of crude materials, inedible, except fuels

- 2.1.4 Changes in the quantity and/or quality of mineral fuels, lubricants and related materials
- 2.1.5 Changes in the quantity and/or quality of animal and vegetable oils, fats and waxes
- 2.1.6 Changes in the quantity and/or quality of chemicals and related products, n.e.s.
- 2.1.7 Changes in the quantity and/or quality of manufactured goods classified chiefly by material
- 2.1.8 Changes in the quantity and/or quality of machinery and transport equipment
- 2.1.9 Changes in the quantity and/or quality of miscellaneous manufactured articles
- 2.1.10 Changes in the quantity and/or quality of commodities and transactions not classified elsewhere

2.2 Changes in the quantity and/or quality of services

- 2.2.1 Changes in the quantity and/or quality of manufacturing services
- 2.2.2 Changes in the quantity and/or quality of maintenance and repair services
- 2.2.3 Changes in the quantity and/or quality of transport services
- 2.2.4 Changes in the quantity and/or quality of travel services
- 2.2.5 Changes in the quantity and/or quality of construction services
- 2.2.6 Changes in the quantity and/or quality of insurance and pension services
- 2.2.7 Changes in the quantity and/or quality of financial services
- 2.2.8 Changes in the quantity and/or quality of charges for the use of intellectual properties
- 2.2.9 Changes in the quantity and/or quality of telecommunications, computer, and information services
- 2.2.10 Changes in the quantity and/or quality of other business services
- 2.2.11 Changes in the quantity and/or quality of personal, cultural and recreational services
- 2.2.12 Changes in the quantity and/or quality of government services

2.3 Changes in the quantity and/or quality of infrastructure

- 2.3.1 Changes in the quantity and/or quality of residential buildings
- 2.3.2 Changes in the quantity and/or quality of hotels and similar buildings
- 2.3.3 Changes in the quantity and/or quality of office buildings
- 2.3.4 Changes in the quantity and/or quality of wholesale and retail trade buildings
- 2.3.5 Changes in the quantity and/or quality of traffic and communication buildings
- 2.3.6 Changes in the quantity and/or quality of industrial buildings and warehouses
- 2.3.7 Changes in the quantity and/or quality of public entertainment, education, hospital or institutional care buildings
- 2.3.8 Changes in the quantity and/or quality of other non-residential buildings
- 2.3.9 Changes in the quantity and/or quality of highways, streets and roads
- 2.3.10 Changes in the quantity and/or quality of railways
- 2.3.11 Changes in the quantity and/or quality of airfield runways
- 2.3.12 Changes in the quantity and/or quality of bridges, elevated highways, tunnels and subways

- 2.3.13 Changes in the quantity and/or quality of harbors, waterways, dams and other waterworks
- 2.3.14 Changes in the quantity and/or quality of long-distance pipelines, communication and electricity lines
- 2.3.15 Changes in the quantity and/or quality of local pipelines and cables
- 2.3.16 Changes in the quantity and/or quality of complex constructions on industrial sites
- 2.3.17 Changes in the quantity and/or quality of sport and recreation constructions
- 2.3.18 Changes in the quantity and/or quality of other civil engineering works not elsewhere classified

2.4 Changes in the quantity and/or quality of employment

- 2.4.1 Changes in the quantity and/or quality of managerial occupations
- 2.4.2 Changes in the quantity and/or quality of professional occupations
- 2.4.3 Changes in the quantity and/or quality of technical and associate professional occupations
- 2.4.4 Changes in the quantity and/or quality of clerical support occupations
- 2.4.5 Changes in the quantity and/or quality of service and sales occupations
- 2.4.6 Changes in the quantity and/or quality of skilled agricultural, forestry and fishery occupations
- 2.4.7 Changes in the quantity and/or quality of craft and related trades occupations
- 2.4.8 Changes in the quantity and/or quality of plant and machine operation and assembly occupations
- 2.4.9 Changes in the quantity and/or quality of elementary occupations
- 2.4.10 Changes in the quantity and/or quality of armed forces occupations

3. Changes in regulating

3.1 Changes in regulations by governments

- 3.1.1 Changes in hard legal instruments (laws, decrees)
- 3.1.2 Changes in soft legal instruments (soft laws without sanctions)
- 3.1.3 Changes in hard economic instruments (taxes, fees, permits, cap-and-trade schemes)
- 3.1.4 Changes in soft Economic instruments (subsidies, public procurement)
- 3.1.5 Changes in informal instruments (studies, campaigns, websites)
- 3.1.6 Changes in hybrid instruments (labels, public voluntary programs)

3.2 Changes in self-regulation by markets

- 3.2.1 Changes in standards
- 3.2.2 Changes in voluntary agreements
- 3.2.3 Changes in audit/certification schemes
- 3.2.4 Changes in codes of conduct
- 3.2.5 Changes in strategic CSR/stakeholder management
- 3.2.6 Changes in restraints imposed on a firm by business partners

3.3 Changes in regulation by civil society

- 3.3.1 Changes in formal standard setting

3.3.2 Changes in less formalized pressuring of businesses and governments
3.4 Changes in co-regulation by governments and civil society
3.4.1 Changes in public co-management of common pool resources
3.5 Changes in co-regulation by governments and markets
3.5.1 Changes in certification schemes
3.5.2 Changes in negotiated agreements
3.5.3 Changes in public-private partnerships
3.6 Changes in co-regulation by civil society and markets
3.6.1 Changes in certification schemes
3.6.2 Changes in private-private partnerships
3.7 Changes in co-regulation by governments, civil society and markets
3.7.1 standards
3.7.2 Changes in certification schemes
3.7.3 Changes in partnerships
4. Changes in culture
4.1 Changes in physical and tangible expressions of culture
4.1.1 Changes in architecture
4.1.2 Changes in artifacts
4.1.3 Changes in arts
4.1.4 Changes in technology
4.2 Changes in intangible expressions of culture
4.2.1 Changes in knowledge and practices concerning nature and the universe
4.2.2 Changes in oral traditions and expressions
4.2.3 Changes in performing arts
4.2.4 Changes in social practices, rituals and festive events
4.2.5 Changes in traditional craftsmanship
5. Changes in supply chains
5.1 Changes in goods and services flows
5.1.1 Changes in goods and services flows
5.2 Changes in information flows
5.2.1 Changes in information flows
5.3 Changes in finance flows
5.3.1 Changes in finance flows
6. Changes in the number of people
6.1 Changes in the number of people
6.1.1 Changes in the number of people
7. Changes in information
7.1 Changes of the genetic diversity
7.1.1 Changes of the quantity of genes
7.2 Changes of the functional diversity
7.2.1 Changes of the quantity of societal functions
7.3 Changes of the structural diversity

7.3.1 Changes of the quantity of societal structures

7.4 Changes of the cultural diversity

7.4.1 Changes of the quantity of cultures

7.5 Changes of the diversity of knowledge

7.5.1 Changes of the quantity of knowledge

8. Changes in network

8.1 Changes in the distribution and connectivity of social systems

8.1.1 Changes in the spatial distribution of social systems

8.1.2 Changes in meta-system connectivity (between different, spatially separated social systems)

8.1.3 Changes in inter-system connectivity (between connected social systems)

8.1.4 Changes in intra-system connectivity (within an individual social system)

8.2 Changes in the strength, density and reach of the social system

8.2.1 Changes in relationship strength (emotional intensity, degree of trust, degree of reciprocity, length of time spent together).

8.2.2 Changes in density (number of relationships)

8.2.3 Changes in reach (distance over which the actors' relationships extend beyond their own network)

8.3 Changes in the structure and composition of social systems

8.3.1 Changes in the complementarity of the actors

8.3.2 Changes in the competencies of the actors

8.3.3 Changes in the availability of resources (people, time, money)

8.3.4 Changes in the consistency and task-matching, competencies and responsibilities of the actors

8.3.5 Changes in regulations on competition

8.4 Changes in interactions and interdependencies

8.4.1 Changes in cooperation

8.4.2 Changes in competition

9. Changes in individual/population specific key attributes

9.1 Changes in the human well-being of individuals

9.1.1 Changes in food security

9.1.2 Changes in security

9.1.3 Changes in physical health

9.1.4 Changes in mental health

9.1.5 Changes in information

9.1.6 Changes in good social relationships and belonging

9.1.7 Changes in experienced esteem

9.1.8 Changes in freedom and self-realization

9.1.9 Changes in intellectual capacity

9.1.10 Changes in morality

9.1.11 Changes in good life

9.2 Changes in population size, structure and dynamics

9.2.1 Changes in the population growth rate (birth, death, migration)
9.2.2 Changes in the age distribution
9.2.3 Changes in the sex ratio
9.2.4 Changes in the gene flow
9.3 Changes in the quantity and quality of habitable land
9.3.1 Changes in the quantity of habitable land
9.3.2 Changes in the abiotic quality of habitable land
9.3.3 Changes in the biotic quality of habitable land
10. Changes in communication, economic, energy and resource efficiency
10.1 Changes in the communication efficiency
10.1.1 Changes in the communication efficiency
10.2 Changes in the economic efficiency
10.2.1 Changes in the allocative efficiency
10.2.2 Changes in productive efficiency
10.3 Changes in the energy efficiency
10.3.1 Changes in the energy efficiency
10.4 Changes in the resource efficiency
10.4.1 Changes in the resource efficiency
11. Changes in emergent properties
11.1 Changes of the recovery
11.1.1 Changes of the recovery
11.2 Changes of the adaptive capacity
11.2.1 Changes of the adaptive capacity
11.3. Changes of the resistance
11.3.1 Changes of the resistance
12. Changes of the purpose
12.1 Changes of the purpose
12.1.1 Changes of the purpose

4.12 Underlying factors and causes

1 Demographic
2 Governance-related
3 Industrial production-related
4 Infrastructure-related
5 Institutional
6 Natural
7 Natural resource-use related
8 Psychological
9 Socio-cultural
10 Socioeconomic
11 Spatial

12 Technological
13 Other

4.13 Strategies

A. Target restoration / stress reduction actions
- 1. Land / Water Management
    - 1.1 Site / Area Stewardship
    - 1.2 Ecosystem & Natural Process (Re)Creation
- 2. Species Management
    - 2.1 Species Stewardship
    - 2.2 Species Re-Introduction & Translocation
    - 2.3 Ex-Situ Conservation

B. Behavorial change / threat reduction actions
- 3. Awareness Raising
    - 3.1 Outreach & Communications
    - 3.2 Protests & Civil Disobedience
- 4. Law Enforcement & Prosecution
    - 4.1 Detection & Arrest
    - 4.2 Criminal Prosecution & Conviction
    - 4.3 Non-Criminal Legal Action
- 5. Livelihood, Economic & Moral Incentives
    - 5.1 Linked Enterprises & Alternative Livelihoods
    - 5.2 Better Products & Management Practices
    - 5.3 Market-Based Incentives
    - 5.4 Direct Economic Incentives
    - 5.5 Non-Monetary Values

C. Enabling condition actions
- 6. Conservation Designation & Planning
    - 6.1 Protected Area Designation &/or Acquisition
    - 6.2 Easements & Resource Rights
    - 6.3 Land / Water Use Zoning & Designation
    - 6.4 Conservation Planning
    - 6.5 Site Infrastructure
- 7. Legal & Policy Frameworks
    - 7.1 Laws, Regulations & Codes
    - 7.2 Policies & Guidelines
- 8. Research & Monitoring
    - 8.1 Basic Research & Status Monitoring
    - 8.2 Evaluation, Effectiveness Measures & Learning
- 9. Education & Training
    - 9.1 Formal Education

9.2 Training & Individual Capacity Development

10. Institutional Development

10.1 Internal Organizational Management & Administration

10.2 External Organizational Development & Support

10.3 Alliance & Partnership Development

10.4 Financing

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