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ETH Zürich
Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Programme «NCCS-Impacts»
«Decision Support for Dealing with Climate Change in Switzerland: a cross-sectoral approach»

Programme Description

13 April 2022

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1   Aim and Scope of the Programme «NCCS-Impacts»

Climate change is under way with full force, thereby adversely affecting more and more facets of nature, health, society and economy. As an Alpine country, Switzerland is particularly vulnerable to these changes. Already today, Switzerland experiences a long-term warming that is about twice as much as the global average. Multi-sectoral climate impacts are anticipated, which calls for adaptation and mitigation efforts including reconsiderations of long-term planning. To this end, federal, cantonal, and local authorities, policy-makers and other stakeholders, such as the private sector, require a solid basis for decision-making. Therefore, the Confederation publishes climate and hydrological scenarios as core climate services at regular intervals. The latest cycle of climate change scenarios published in 2018 («CH2018») identified drier summers, more hot days, heavier precipitation events and snow-scarce winters as main results of the model projections for Switzerland. The data of CH2018 served as input to calculate hydrological scenarios («Hydro-CH2018»), which were published in early 2021. They show far-reaching impacts on future water availability over the course of the year with changes in runoff and a growing hazard potential, among others. Climate and hydrological scenarios are an important and necessary, yet incomplete basis for stakeholder decisions. What is missing is information on future climatic impacts that serves as a basis for climate-smart decision-making and action. Here, the National Centre for Climate Services' (NCCS) new programme «NCCS-Impacts» steps in by elaborating a cross-sectoral compilation of climatic impacts in Switzerland as well as a bundle of climate services for decision-support.

With the NCCS-Impacts programme, the NCCS pro-actively pursues the vision of «climate services for a resilient Switzerland today and tomorrow». The aim of the NCCS programme is to obtain an overview of impacts under future climate change in Switzerland and its ensuing central challenges for the environment, economy and society. It also aims at turning the results into user-centred products in the true fashion of climate services as decision support. The programme hence contributes to closing the gap identified between basic scientific research and climate mitigation and adaptation measures (see Figure 1).

The programme pursues the following overarching goals:
1. Impacts: Systemic overview of climate change impacts on and in Switzerland and the subsequent key challenges for the environment, economy and society.
2. Decision-Support: Broad availability and use of jointly produced climate services for targeted and sustainable management of the risks and opportunities of climate change.
3. Support for Authorities: Cross-sectoral support of the federal government and all actors in their future-oriented actions to meet the challenges of climate change.

Next to the generation of new science-based insights, the programme also has a clear focus on the development and provision of actionable products intended for decision-makers. The programme is specifically looking for solutions (i.e climate services) that help ensure the concerted uptake of information on climate impacts and risks by decision makers in the field of climate adaptation and mitigation and that are relevant for all parts of Switzerland and not limited to local-scale case-studies. For reference, solutions could encompass the following products that build on and translate the newly gained knowledge: audio-visual information distillation, self assessments, country-, region- and industry-specific information, training manuals, reports, factsheets, guidelines and handbooks, gaming approaches, interactive web applications as well as web-based data and information for the NCCS web portal and the NCCS web atlas (non-exhaustive enumeration).
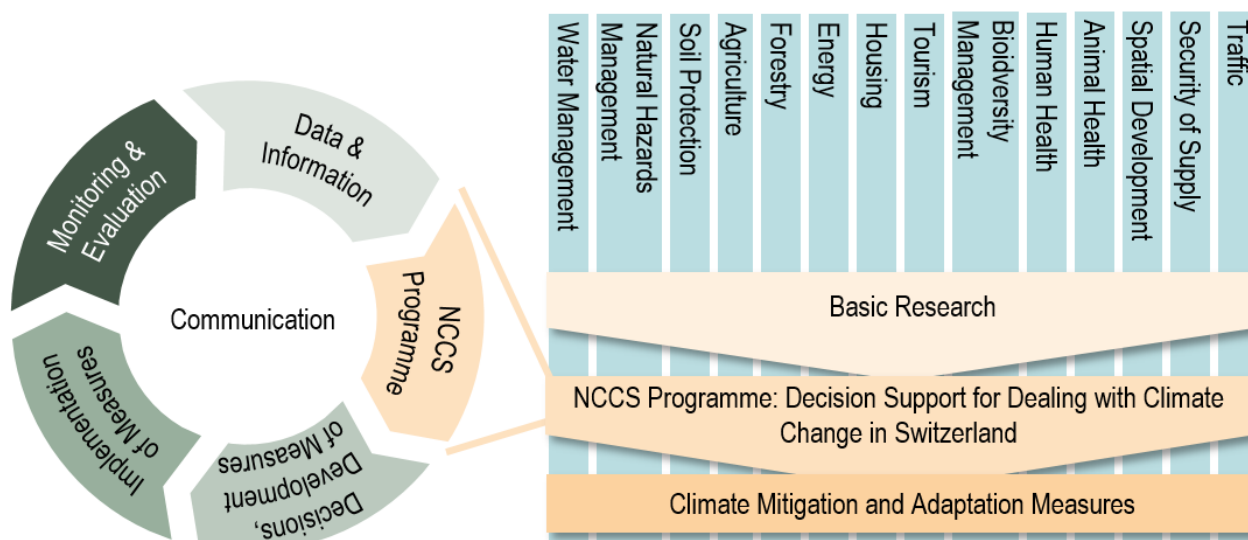
Figure 1. Embedding of the programme NCCS-Impacts in the climate management cycle.

In its core, the programme consists of six cross-sectoral and interlinked climate impacts projects. These were identified as priority needs in a comprehensive stakeholder dialogue with representatives from research, administration and the private sector, and by means of a desk review across various sectors. The work in the different projects will follow a co-production approach. This transdisciplinary approach will enable a coordinated effort between research groups and practitioners towards applied climate change impacts research and decision support in the form of climate services development. With its cross-sectoral setting, NCCS-Impacts deliberately pursues complex challenges in the context of climate change, which necessitate the collaboration of different actors along the climate services value chain.

NCCS-Impacts is politically anchored with the decision of the Federal Council from 12 August 2020 (Anpassung an den Klimawandel in der Schweiz – Aktionsplan 2020-2025), in which several Federal Departments are mandated to implement the cross-sectoral research programme «NCCS-Impacts» within the framework of the NCCS. As a new measure of the Second Action Plan on Climate Adaptation 2020-2025, the programme will also serve as an important basis for the further development of the Federal Council's strategy "Adaptation to Climate Change in Switzerland" beyond 2025. In summer 2020, the NCCS Board of Directors approved the structure, contents, governance and management of NCCS-Impacts for the period 2021-2025.

The programme is centrally managed by the Secretariat of the NCCS at MeteoSwiss. The elaboration of projects is funded by the participating Federal Offices (financial means of policy research) and by in-kind contributions from NCCS members ETH, WSL, Agroscope, and FSVO. Furthermore, the NCCS members provide a substantial amount of in-kind contributions for the management of the projects, as each project is led by one or more NCCS members.

Background information on the National Centre for Climate Services NCCS
In response to the call of the Global Framework for Climate Services (GFCS) of the World Meteorological Organization (WMO) to establish national coordination mechanisms, Switzerland established its National Centre for Climate Services (NCCS) in late 2015. Currently, nine federal offices and research institutions are members of the NCCS, with MeteoSwiss serving as the host institution of the NCCS Secretariat. As a federal network and coordination body, the NCCS bundles existing climate services, promotes dialogue between actors and works together to develop and communicate tailored information, processes and solutions. All members are on a par and have an equal say, hence attention is given to both pure climate information as well as downstream applications along the climate services value chain. With its NCCS-Impacts programme, the NCCS is set to deliver a milestone with respect to the analysis of cross-sectoral climate impacts in Switzerland and the development of actionable decision support.

2 Programme Structure

The six NCCS-Impacts projects dealing with climate impacts and decision support all use the NCCS priority themes Hydro-CH2018 and CH2018 as common information and data basis (see Figure 2). The projects are interlinked through various synergies that need to be addressed and elaborated during the realization phase. Furthermore, all projects are to take into account and elaborate on two common cross-cutting topics:

1. Extremes, such as heat, heavy precipitation, or flooding
2. Social Justice, such as distributive justice, impact diversity across social groups particularly on the vulnerable, disadvantaged and marginalised populations, distribution of costs and benefits, equity-oriented adaptation and mitigation actions to avoid worsening inequities in connection to climate change impacts.

A seventh project of the programme supports - as in-kind contribution through MeteoSwiss - the elaboration, tailoring and distribution of climate information and data to ensure the proper link between the climate impacts projects of the programme and their use of the CH2018 climate scenarios as a common data basis.
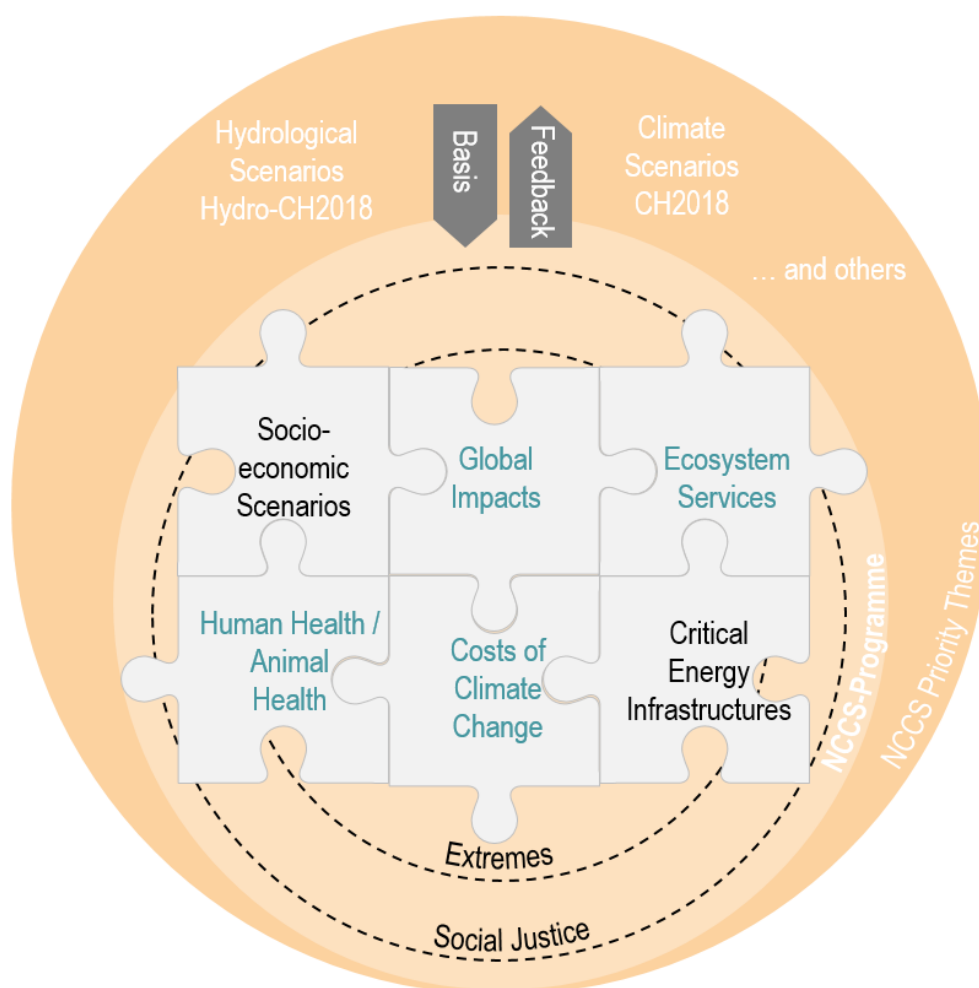

Figure 2. The programme NCCS-Impacts with the six climate impacts projects. Those projects marked in turquoise are currently open for tender in form of lots.

The projects should be jointly executed by partners from research and practice in order to ensure co-production from start to finish of the project. Due to the complexity and scope of the individual projects, it is believed that a minimum of two partners are needed to sufficiently fulfill the requirements of the projects, which are sought with the current call for tenders. For some of the projects, internal partners from NCCS contribute to the realization of the projects and are hence partners complementing the applicants. These

internal partners from ETH Zurich, WSL, Agroscope and FSVO were determined in an NCCS-internal call in May 2021. This first call was necessary, as these four institutions as mandating organizations and members of the NCCS, are for legal reasons not allowed to participate in the current call for tenders.

From the six climate impacts projects, the following four projects are open for tender in form of lots (for a detailed description see Chapter 3):

Lot 1 - Impacts of global climate change on Switzerland

Lot 2 - Impact of climate change on ecosystem services

Lot 3 - Impact of climate change on health, well-being and performance of humans and animals and on food safety

Lot 4 - Costs of climate change impacts in Switzerland with and without successful global climate change mitigation

The projects on socio-economic scenarios and on critical energy-infrastructure are not subject to the current call for tender. The project on socio-economic scenarios will be carried out by an internal partner from WSL at first. WSL's task is to develop qualitative and semi-quantitative socio-economic scenarios for Switzerland and to derive Swiss shared socioeconomic pathways (SSPs) as narratives. Further project elements will be put out to tender at a later stage. The project on critical energy infrastructures is funded and managed through the SFOE as a joint activity of the SWEET programme and the NCCS-Impacts programme. This call was published in summer 2021. Among others, the selected consortium will re-evaluate climate-relevant hazard files of the national risk analysis of the Federal Office for Civil Protection taking into account the effects of climate change.

3   Projects open for tender / open lots

In this section we inform about the specific content, the overall aim and expected outcome of each of the four projects open for tender in form of lots. Each project, to be carried out in the time period from 2023 to 2025, is made up of several modules (numbered with letter «M») that contain a key question, several research questions and an indicative budget. Applicants to the current call for tenders are asked to provide an offer that addresses all aspects and key questions of the projects as outlined below. If necessary, the indicative budgets per project module may be adjusted. However, the maximum budget per project, and hence the sum of indicative budgets per modules, may not be exceeded in the offer.

The framework of each project puts emphasis on tailoring, communication and exploitation that runs from the start to the end of the project. This means that new science-based results as well as user-centred climate services are expected to be generated in form of customized and practical products and that the project results are turned into climate services directed toward the mitigation and adaptation communities. It is therefore expected that in all project modules the tasks are performed taking on a product- and service-oriented perspective, a demand- and user-driven perspective and a co-production approach. The products to be developed shall be made available in all official languages of Switzerland as well as in English. Translation costs need to be considered in the offer, and are hence financed through the available budget.

As stated in Chapter 2, some modules of the projects are carried out by internal NCCS members and are therefore not part of this public call; nevertheless, the internal NCCS partners will become part of the project team that jointly carries out the project work. The specific contributions of the internal partners are detailed in Chapter 4. It is expected that the offer submitted by the applicants takes into account the work undertaken by the internal project partners and addresses all aspects and questions of the respective lot.

Lot 1: Project "Impacts of global climate change on Switzerland"

Aim: In-depth analysis of the impacts of global climate change on Switzerland's economic performance, food and pharmaceutical supply due to climate-related disruptions in production chains and on international sales markets.	
Outcome: There are two envisioned outcomes. The first outcome is a ready-to-use open-source application to assess the impacts of global climate change on the Swiss production chains. Such an application will come along with a prototype of a web-interface to facilitate system understanding and support decision-making. A second outcome pertains to the development and publication of guidelines and hands-on recommendations on how to effectively identify, assess, manage and deal with the supply chain risks emerging from global climate change. With this first of its kind application and guidelines, internationally exposed businesses are supported to better manage risk exposure along their supply chains by enabling them to carry out their own potential analysis of production chains and impacts on sales markets.	
Target group: The target groups are public and private entities. The former are policy-makers in governmental agencies at different levels. The latter are economic professionals responsible for production and supply chains of Swiss companies whose supply chain depends on productions outside Switzerland and that intend to prepare for climate-related risks affecting their business.	
Implementation: This project is carried out in joint collaboration with an internal NCCS partner from ETH Zurich (Weather and Climate Risks Group, Prof. D. N. Bresch). A summary of the internal contribution is provided here. The main tool for answering the below-mentioned research questions and for reaching the project aims is CLIMADA – an open-source and open-access global platform for probabilistic multi-hazard risk modelling and options appraisal. A private consultant is sought with this call for tenders. Details of CLIMADA and its application to the current project can be found in Chapter 4.1. Important information on the project framework and its foreseen implementation, expected requirements of the private consultant including the sharing of tasks between the internal partner and the private consultant are described in Chapter 4.2. The **maximum budget** for the requested services available through the current tender for lot 1 is **CHF 740'000.-**	

M1	**Climate impacts on internationally entwined production chains**
	Module 1 will examine how global climate impacts are currently affecting Switzerland's internationally entwined production chains and what is to be expected in the future. The time horizon extends to 2060.
	Key question: How will global climate change affect Switzerland's internationally entwined production chains today and in the future (perspective 2060)?

	Research questions:
	• Which of Switzerland's supply and production chains are vulnerable to global climate change impacts, i.e. to climate change impacts abroad?
	• Which impact chains lead to indirect effects of global climate change in Switzerland?
	• How do indirect impacts of global climate change and the opportunities and risks associated with them differ by
	    o Sectors and industries
	    o Groups of countries
	    o Other
	• What scenarios of national structural development and international interdependence are to be expected?
	
	Indicative budget: CHF 230'000

M2	**Impacts of climate change on Switzerland's international sales markets**
	Module 2 will examine how the impacts of global climate change are affecting Switzerland's sales markets today and in the future? The time horizon extends to 2060.
	Key question: How does global climate change affect Switzerland's international sales markets (perspective 2060)?

	Research questions:
	• Which important international sales markets for Switzerland are directly or indirectly affected by climate change?
	• How can impact chains of global climate change on international sales markets of the Swiss economy be described?
	• How do indirect impacts of climate change and the opportunities and risks associated with them differ by
	    o Sectors and industries
	    o Groups of countries

| | | o Coastal and mountain regions, and the like |
| | | o Other |

	Indicative budget: CHF 230'000
M3	**Impacts of a rising sea level on the global economy**
	Module 3 will analyse how a rising sea level could affect the global economy and how this indirectly affects Switzerland.
	Key question: What is the impact on the global economy / «time to emerge» of a rising sea level (perspective 2060)?
	Research questions: • Is there a long-term effect on the economic performance of the global economy? • How are Switzerland's most important trading partners affected? • What kind of global shifts in production and sales are to be expected?
	Indicative budget: CHF 60'000
M4	**Interdependencies between security of supply / basic supply of raw material, food and pharmaceutical products and global climate change**
	Module 4 will investigate the dependency between the qualitative and quantitative security of supply, or basic supply, of raw materials, food and pharmaceutical products and global climate change. According to the FOAG, the self-sufficiency level of food within Switzerland, including imported animal feed, only ranged between 50% and 59% in recent years (1995-2014). Therefore, the impacts of climate change abroad can also have an impact on the security of supply in Switzerland due to the dependence on imported goods. In addition, the pharmaceutical industry in Switzerland relies on ingredients from abroad for pharmaceutical manufacturing. In some cases, these are not sufficiently diversified and are therefore vulnerable to climate change. The same may be true for other raw materials that are further processed in Switzerland. This could have an impact on economic production, on the one hand, and on the basic supply of pharmaceutical products in Switzerland, on the other.
	Key question: How is the security of supply / basic supply of food and pharmaceutical products (quantity/quality) interlinked with global climate change (perspective 2060)?
	Research questions: • What long-term climate change impacts are to be expected that could affect Switerland's supply chains of food, pharmaceutical products and raw materials? • What are the interdependencies between the security of supply / basic supply of food and pharmaceutical products (quantity/quality) and the loss of biodiversity as a consequence of an anticipated global climate change? • How significant are future changes and extreme events? • What kind of international shifts / shortages in the supply of food can be expected? • What kind of international shifts / shortages in the acquisition of pharmaceutical ingredients can be expected? • What kind of international shifts / shortages in the acquisition of raw materials can be expected? • In which ways can potential measures affect social justice (e.g. discrimination or preference of specific countries, suppliers and industries)?
	Indicative budget: CHF 110'000
M5	**Tailoring, communication and exploitation (throughout the project – from beginning to end)**
	In Module 5 and in close cooperation with Modules 1 to 4, stakeholders should be adequately engaged in a co-creation process, as well as the results be turned into products, communicated in a pertinent way and disseminated to target groups. The products shall be made available in German, French, Italian and English with translation costs factored into the offer.
	Key question: How can results be turned into customised and practical decision support tools and services for and with target groups, and how can they be appropriately communicated?

	Research questions:
	• Which participative methods are suitable for adequately engaging with relevant stakeholders in the co-production of climate services?
	  o Final choice and planning of the transdisciplinary approaches, implementation of collaborative formats and evaluation in cooperation with the other modules.
	• What are useful user-centred products to support decision-making, and how can they be planned, designed and implemented as climate services?
	  o Joint development of products, testing and finalizing of products
	• Which formats are suitable for communicating results?

	o Developing a communication concept which is tailored to the project, and implementing the formats (e.g. printed matter, webpages and -applications for NCCS web portal, management summaries, networking events, media relations, etc.) in cooperation with the project and communication leads of the programme. • How can the products be introduced to the target groups? o Designing and starting the roll-out of a concept for the dissemination and exploitation of the new climate services in close cooperation with the persons responsible for the overall communication of the programme. **Indicative budget: CHF 110'000**

Lot 2: Project "Impact of climate change on ecosystem services"

Aim: Impact of climate change on ecosystem services (ES), support for decision-makers in matters of protection and use of ecosystems, and clarification of the importance of ES for climate mitigation and adaptation measures.	
Outcome: Resulting climate services in form of applicable products with relevance for all parts of Switzerland, for example (non-exhaustive enumeration): Web atlas on the NCCS web portal, practical guidelines for the implementation of new scenarios, audio-visual information distillation, reports, sub-sites to the NCCS web portal, brochure, recommendations for action, or other.	
Implementation: This project is structured around one overview module with a cross-sectoral view (M1) and three sub-modules (M2a, M2b, M2c) for ecosystem services in the sectors forest, agriculture and water. It is expected that the development of climate services in form of applicable products is being carried out within the sub-modules of M2. For this project, M1 is open to the current tender. Internal partners will provide module-specific contributions to M2, which are detailed in Chapter 5. M2a (forest) is fully covered by two internal partners and therefore <u>not</u> open to the current call for tenders (see details of their specifications [here]). For M2b (agriculture) an internal partner contributes to the module (see details [here]), while <u>some parts are still open</u> for tender. M2c has no internal partner contribution and is open to the current tender. The **maximum budget** for the requested services available through the current tender for lot 2 is **CHF 600'000.-**	

M1	**Cross-sectoral view on the impact of climate change on ecosystem services**
	Module 1 aims to provide a cross-sectoral view on the impact of climate change on a set of major services provided by forest, agricultural and aquatic ecosystems in Switzerland. It also aims to support stakeholder involvement in the co-creation of results and subsequent transformation of these results into useful products. Communication and dissemination of these products in a coordinated way is also part of this module in close collaboration with the other project modules and the communication team of the programme.
	Key question: How can this project provide a cross-sectoral view on the impact of climate change on services provided by different ecosystems in a coordinated way with the other project modules? How can results be turned into applicable decision support tools and services for and with target groups, and how can they be appropriately communicated?
	Research questions: • How can an integrated, inter-sectoral evaluation of the impact of climate change on a set of major ecosystem services (ES) be reached in this project, in close collaboration with the other project modules? • Which conceptual framework should be used to assess forest, agricultural and aquatic ES in a consolidated and coordinated way (which temporal/spatial resolution, what climatological and socioeconomic input data, which scenarios)? How can interactions between ES be considered? How can consistency in the assessment of multiple ES be ensured regarding methodological aspects and input data? • How can other major direct and indirect drivers of change (e.g. spread of invasive alien species and harmful organisms, pollution, land use) and their impact on ES be considered in the scenarios? • How to engage relevant stakeholders in the co-designing of products developed in the project modules and in their implementation? Which participative methods are suitable? What are the user needs with regard to the impact of climate change on ES? • Which formats (e.g. printed matter, hosting of websites, management summaries, networking events, media relations, etc.) are suitable for communicating results from all project modules and reach target groups? • How can the results and products be communicated and disseminated in a coordinated way in close collaboration with the other project modules and the communication team of the programme? **Indicative budget: CHF 100'000**
M2	**Impact of climate change on ecosystem services**

	Module 2 focuses on the impact of climate change on a set of major services provided by forest, agricultural and aquatic ecosystems in Switzerland up to 2060 and takes future development of other direct and indirect drivers of change (e.g., spread of invasive alien species and harmful organisms, pollution, land use) and their impact on ES into account. Management practices and indirect drivers such as demographics and economy play an important role in these developments. The following descriptions provide the framework of this module.
	Module 2 consists of three sub-modules that investigate the impacts of climate change on a set of major services provided by forest (2a), agricultural (2b) and aquatic (2c) ecosystems. Three major aims are to be fulfilled in each sub-module, in close collaboration with M1:
	1. Identify impact of climate change and other major drivers of change on a set of ES.
	2. Identify impact of climate change and other major drivers on interactions, synergies and competition between different ES.
	3. Identify the suitability of ES for mitigating climate change («climate mitigation») and adapting to climate change («climate adaptation»).
	Products need to be developed for the target groups (e.g., professionals in agriculture, forest and water management) in form of tools to visualize expected changes (aim 1), decision-making tools for the protection and use of ES (aim 2) and recommendations for climate policy in Switzerland (aim 3).

	Key question: Module 2 includes four key questions that need to be addressed in the three sub-modules:
	1. How do ES react to climate change and other major direct and indirect drivers of change in Switzerland (with a perspective to 2060, with or without adaptation) and what are the consequences for management?
	2. Which approaches can support management in a changing climate when conflicting goals between use and protection of ES emerge?
	3. How can ES be used for climate policies (climate mitigation and climate adaptation) in Switzerland?
	4. How can answers and results to key questions 1-3 be turned into decision support tools and services for and with target groups (e.g., managers, practitioners, federal offices), and how can they be appropriately communicated in a coordinated way with the other modules and projects?

	Research questions
	Several specific research questions are derived from each of the four key questions and need to be addressed in the three sub-modules:
	1. Impact of climate change and other major drivers on ES:
	a. What is the influence of climate change (including climatic inter-annual variability and extreme weather events) on ES? To what extent can climate change lead to time shifts in phenological processes, and what consequences for ES are to be expected? Can threshold levels, so-called «tipping points», for ecosystems be identified?
	b. How will other major direct and indirect factors of change (e.g., spread of invasive alien species and harmful organisms, pollution, land use) affect ES in the future? Will these drivers aggravate or attenuate the impact of climate change on ES?
	2. Balance between use and protection of ES:
	a. How will climate change affect interactions, synergies and competition between ES? To what extent will other major direct and indirect drivers of change also influence these interactions? Which trade-offs in the use of ES can be found?
	b. In the light of these changes, how can practices in management be adapted to maintain sustainable ES?
	3. Use of ES for climate policies (climate mitigation and climate adaptation):
	a. When and how can ES be used for adaptation? And, vice versa, what do climate adaptation measures mean for ES? For instance: what are the consequences of a change in tree species for the provision of raw timber, recreation, and water quality?
	b. What conflicting goals emerge from the tension between climate mitigation and climate adaptation measures? What are the risks if certain ES (e.g., natural CO_2 sinks) are promoted? How can such risks be reduced?
	c. How can mutual objectives in terms of climate and energy policies be reconciled (e.g. extensive use of the sustainable biomass potential with the promotion of a cascading use of wood)?
	4. Tailoring, communication and exploitation of results:
	a. How can the envisaged communication products be planned, designed and implemented as climate services, with and for target groups (joint development of products, testing and finalizing of products)?

M2a	**Forest ecosystem services**
	This entire module is carried out by two internal partners from WSL and ETH and is therefore not open to the current call for tenders. Details of these internal contributions can be found here.

M2b	**Agricultural ecosystem services**
	Part of this module is carried out by an internal partner from Agroscope. More details can be found here.

The second part of this module is subject to the current call for tenders. While it should fit into the framework outlined in M2, this contribution focuses on the impact of climate change on pollinators and pollination services to agriculture in Switzerland up to 2060 and takes future development of other direct and indirect drivers of change (e.g., land-use change, habitat fragmentation, pollution, invasive alien species, pathogens) and their impacts on pollination services into account. Management practices and indirect drivers such as demographics and economy play an important role in these developments. The contribution is performed in close collaboration with the internal NCCS member contributing to M2b, and also with the partners responsible for M1, M2a and M2c. Products for the target groups need to be developed in form of tools to visualize expected changes, decision-making tools and recommendations for policy and management in Switzerland.

Key question: How do pollinators and pollination services react to climate change and what is the impact of these changes on agriculture?

This contribution includes three research questions that need to be addressed:
   1. How do pollinators (in particular wild bees vs honey bees) and pollination services react to climate change and other major direct and indirect drivers of change in Switzerland (with a perspective to 2060, with or without adaptation) and what are the consequences for product yield and quality at national scale? Will the current pollination dependent cultures continue to increase?
   2. Which effective adaptive responses to climate change aiming at securing pollination can support management (e.g. increasing crop/farm diversity, targeted habitat conservation, management, restoration)? Are there synergies between conservation measures for pollinators and adaptation measures?
   3. How can answers and results to research questions 1-2 be turned into visualization and decision-support tools and recommendations for policy and management in Switzerland, developed for and with target groups (e.g., managers, practitioners, federal offices), and how can they be appropriately communicated in a coordinated way with the other modules and projects?

Indicative budget: CHF 200'000 |
| **M2c** | **Aquatic ecosystem services (services provided by rivers, lakes, wetlands and groundwater)** |
| | This entire module is open to the current call for tenders and should fit into the framework outlined in M2.

Indicative budget: CHF 300'000 |

Lot 3: Project "Impact of climate change on health, well-being and performance of humans and animals and on food safety"

Aim: To provide decision-making tools in order to maintain and promote the health, well-being and performance of humans and animals in light of climate change.
Outcome: The most important deliverables are factsheets and recommendations to each module M1, M3 and M4.
Other resulting climate services in form of applicable products with relevance for all parts of Switzerland are for example (non-exhaustive enumeration): Web atlas on the NCCS web portal, practical guidelines for the implementation of new scenarios, audio-visual information distillation, reports, sub-sites to the NCCS web portal, brochure, recommendations for action, or other.
Implementation: The project is built in four distinct theme, M1 human health, M2 animal health, M3 food safety et M4 vector-borne diseases. However, each theme should not be treated in its isolated way and should therefore be part of a common vision with a "one health" perspective. The notion of social justice (a meta theme of the programme) should also be explicitly addressed as it has a central impact on health.

In this project, an internal partner will provide a contribution that largely covers Module 2. Module 2 is therefore not open to the current call for tenders. Details of the contribution and the specific service can be found here. |
| The **maximum budget** for the requested services available through the current call for tenders for lot 3 is **CHF 760'000.-** |
| **M1** | **Resilience of the healthcare system** |
| | Module 1 will create decision-making tools for stakeholders in order to strengthen the resilience of the healthcare system, taking into |

		account what is known about excess mortality and additional morbidity caused by heat.
		Key question: How resilient is the healthcare system in light of climate change (focus: extreme heat event)? What are the effects of climate change on patients, healthcare professionals and healthcare infrastructure, and what preventive and adaptive measures can be derived from this for the resilience of the healthcare system? The focus is on increasing heat as an extreme event.

		Research questions:
		
		- What measures have to be taken in order to strengthen resilience (preventive and adaptive) for patients, their relatives, healthcare professionals and infrastructure?
		  - Which subgroups of patients (and relatives) need to be particularly sensitized and strengthened in their resilience, and how can this be done (e.g. in the case of chronically-ill elderly people with dementia who live at home without professional care)?
		  - Which subgroups of health professionals need to be particularly sensitized and strengthened in their resilience and how can this be done (so that they themselves remain healthy and efficient and can care for and treat their patients effectively, e.g. nurses, family doctors, psychiatrists)?
		  - Which subgroups of settings / infrastructures / buildings (e.g. nursing homes, hospices for the dying, neonatal units, palliative-care units) need to be particularly strengthened in their resilience and which professionals need to be sensitized accordingly (e.g. architects, janitors, hygienists)?
		  - Aspects on health equity: Which socio-economic groups / regions are particularly affected?
		
		Indicative budget: CHF 440'000

M2	**Health, well-being and performance of farm animals** (Module not open to the current call for tenders)	
		Module 2 will establish a scientific basis to deal with the negative effects of climate change (e.g. increased heat or other extreme events) on the health of farm animals, their well-being and performance in current farming and production systems in Switzerland. (focus on livestock farming) ➔ The work of this module is largely executed by an internal partner. More details can be found here. This module is therefore not open to the current tender.
M3	**Food safety, including drinking water**	
		Module 3 will explore the impact of climate change on risks for food safety caused by mycotoxins, and the possibility of reducing such risks.
		Key question: What is the direct/indirect impact of climate change on food safety (e.g. the contamination of raw products)?

		Research questions:
		
		- Can future climate change influence the mycotoxin-related risks for food safety in Switzerland? This question will be examined on the basis of the existing literature, namely the reports by EFSA (Climate Change and Emerging Risks for Food Safety; CLEFSA)[1], FAO[2] and RIVM[3] as well as further reports. In addition, potential knowledge gaps should be detected, and the risk assessment should be carried out for the entire production chain.
		- What are the fields of action for reducing the risks induced by climate change and investigated in the first part? This sub-question is directly dependent on the findings from the first part of the research questions.
		
		Comments:
		- Briefing Letter BLV, Dept. Risk Assessment: CLEFSA[4]:
		  The risk posed by the mycotoxins deoxynivalenol and zearalenone could increase moderately.
		- Briefing Letter BLV, Dept. Risk Assessment: Mycotoxine[4]:
		  With reference to the EFSA and RIVM reports, higher mycotoxin levels in food are expected in the future, as well as the appearance of new toxins and new combinations of toxins.
		
		1. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/sp.efsa.2020.EN-1881
		2. http://www.fao.org/documents/card/en/c/ca8185en/
		3. https://rivm.openrepository.com/bitstream/handle/10029/623733/2019-0223.pdf?sequence=1&isAllowed=y
		4. https://www.blv.admin.ch/blv/de/home/lebensmittel-und-ernaehrung/lebensmittelsicherheit/frueherkennung-sicherheit-lebensmittel.html
		
		Indicative budget: CHF 80'000

M4	**Impact of climate change on vector-borne diseases**	
		Module 4 will investigate the development of animal and human vector-borne diseases under the influence of climate change, and the pertaining risks for Switzerland.
		Key question: What are the risks for humans and farm animals posed by diseases which are directly/indirectly vector-borne and

	related to climate change?
	Research questions:
	1. Emerging or increasingly frequent vectors and associated diseases in Switzerland
	• What vectors/diseases will be favoured by climate change in Switzerland in the coming years? Important: examination of frequency and relevance.
	2. Influencing factors
	• What are the relevant factors, directly or indirectly influenced by climate, for the occurrence of vector-borne diseases in humans and animals in Switzerland?
	• What behavioural factors in humans favour a spread of vectors and/or imported pathogens?
	• How well informed are the involved stakeholders in the Confederation and cantons as well as the general public regarding the risk of imported vectors / diseases?
	3. Strategy, Prevention and Combat/Adaptation
	• Within Europe and Switzerland: what strategies and measures are being pursued or implemented to prevent the import and further spread of vectors, and which of these are relevant for Switzerland? What are the interfaces with other policies in- and outside the healthcare sector?
	• What interfaces exist with other policies within and outside the health sector?
	• Within Europe and Switzerland: what measures are being implemented to combat those vectors that are likely to occur more frequently, and which are relevant for Switzerland? What adaptation strategies are needed to make it possible to live with a new vector and to reduce disease in humans and animals?
	• In which settings could the expected diseases mainly spread, and is there an influence in terms of social gradients e.g. occupational, class or educational?
	Indicative budget: CHF 160'000
M5	**Tailoring, communication and exploitation (throughout the project – from beginning to end)**
	In Module 5 and in close cooperation with Modules 1 to 4, stakeholders should be adequately engaged in a co-creation process, as well as the results be turned into products, communicated in a pertinent way and disseminated to target groups. The products shall be made available in German, French, Italian and English with translation costs factored into the offer.
	Key question: How can results be turned into customised and practical decision support tools and services for and with target groups, and how can they be appropriately communicated?
	Research questions:
	• Which participative methods are suitable for adequately engaging with relevant stakeholders in the co-production of climate services?
	○ Final choice and planning of the transdisciplinary approaches, implementation of collaborative formats and evaluation in cooperation with the other modules.
	• What are useful user-centred products to support decision-making, and how can they be planned, designed and implemented as climate services?
	○ Joint development of products, testing and finalizing of products
	• Which formats are suitable for communicating results?
	○ Developing a communication concept which is tailored to the project, and implementing the formats (e.g. printed matter, webpages and -applications for NCCS web portal, management summaries, networking events, media relations, etc.) in cooperation with the project and communication leads of the programme.
	• How can the products be introduced to the target groups?
	○ Designing and starting the roll-out of a concept for the dissemination and exploitation of the new climate services in close cooperation with the persons responsible for the overall communication of the programme.
	Indicative budget: CHF 80'000

Lot 4: Project "Costs of climate change impacts in Switzerland with and without successful global climate change mitigation"

Aim: Calculation and comparison of the costs of climate change (impacts and adaptation) in 2060 under two different climate scenarios.	
Outcome: Resulting climate services in form of applicable products with relevance for all parts of Switzerland, for example (non-exhaustive enumeration): Web atlas on the NCCS web portal, practical guidelines for the implementation of new scenarios, audio-visual information distillation, reports, sub-sites to the NCCS web portal, brochure, recommendations for action, or other.	
Implementation: For this project, no internal partners are assigned and the full project is open to the current call for tenders. The **maximum budget** for the requested services available through the current call for tenders for lot 4 is **CHF 800'000.-**	

M1	**Reference development**
	Module 1 will develop the reference to serve as a basis for Modules 2 to 5. This reference scenario is ideally based on the socio-economic scenario developed in Project 1 and on the reference climate of the period 1991-2020. Furthermore, it should take into account available production and damage statistics as well as current scientific literature.
	Key question: Against which reference development should the costs of climate change be analysed?
	Research questions: • What are the impacts of climate change today (reference period 1991-2020)? • What are the costs associated with today's climate impacts costs and what are the costs of adaptation? • How are the impact and adaptation costs distributed among the Confederation, cantons, municipalities and private individuals? • How will these costs evolve due to socioeconomic changes? **Indicative budget: CHF 80'000**

M2	**Damage and adaptation scenarios**
	Module 2 will develop damage and adaptation scenarios for the most relevant impact areas in Switzerland with and without successful global climate change mitigation measures. Both, gradual changes and extreme events need to be taken into account.
	Key question: What are the effects of climate change on the various impact areas in Switzerland under a successful global mitigation scenario (RCP2.6) and a business as usual scenario (RCP8.5)? What adaptation options exist in the various sectors for these two scenarios?
	Research questions: • What are the impacts of climate change on different impact areas under the two emission scenarios considered? • How do these effects develop with progressing climate change? Are any tipping points foreseeable? • Which sectors are more affected by climate change and therefore need to be considered with great priority? • Which are feasible adaptation strategies and activities in response to these effects? • Is it possible to prioritize certain adaptation strategies and activities? • Can the adaptation strategies and activities be combined to build adaptation pathways? **Indicative budget: CHF 200'000**

M3	**Climate impact costs**
	Module 3 will determine climate change impact costs for the most important impact areas with and without climate change mitigation and adaptation measures. Reference development (Module 1) as well as damage and adaptation scenarios (Module 2) are to be taken into account.
	Key question: What are the costs of climate change in the most relevant impact areas under a successful global mitigation scenario (RCP2.6) and a business as usual scenario (RCP8.5) with and without adaptation measures?
	Research questions: • What costs result from climate change in different sectors under different mitigation scenarios (see prioritizing in Module 2)? • How do impact costs develop with progressing climate change? • How much can the climate change impact costs be lowered with adequate adaptation measures? • How are the costs distributed among the Confederation, cantons, cities, municipalities and private individuals? **Indicative budget: CHF 160'000**

M4	**Adaptation costs**
	Module 4 will assess adaptation costs in the analysed impact areas with and without successful global climate change mitigation measures, based on the adaptation scenarios of Module 2.
	Key question: What are the costs of adapting to the impacts of climate change in Switzerland with and without successful global climate change mitigation measures?

	Research questions:
	• What are the adaptation costs in the different sectors?
	• How will adaptation costs develop with progressing climate change?
	• Is it worth taking adaptation measures at an early stage?
	• Is there an ideal adaptation pathway as far as costs are concerned?
	• How are the costs distributed among the Confederation, cantons, cities, municipalities and private individuals?
	Indicative budget: CHF 120'000
M5	**Economic costs of climate change**
	Module 5 will aggregate the results of Modules 3 and 4 and thereby determine the economic costs of climate change for the various scenarios.
	Key question: What are the overall economic costs of climate change in Switzerland under consideration of the various mitigation and adaptation scenarios?
	Research questions:
	• What are the economic costs of climate change in Switzerland with and without successful global climate change mitigation measures and assuming that no adaptation measures are taken?
	• How can the economic costs of climate change in Switzerland be reduced by suitable adaptation measures (with and without successful global climate change mitigation measures)?
	• How will climate impact costs and adaptation costs develop with time and with progressing climate change?
	• What is the partitioning between climate impact costs and adaptation costs for the different climate scenarios?
	Indicative budget: CHF 120'000
M6	**Tailoring, communication and exploitation (throughout the project – from beginning to end)**
	In Module 6 and in close cooperation with Modules 1 to 5, stakeholders should be adequately engaged in a co-creation process, as well as the results be turned into products, communicated in a pertinent way and disseminated to target groups. The products shall be made available in German, French, Italian and English with translation costs factored into the offer.
	Key question: How can results be turned into customised and practical decision support tools and services for and with target groups, and how can they be appropriately communicated?
	Research questions:
	• Which participative methods are suitable for adequately engaging with relevant stakeholders in the co-production of climate services?
	o Final choice and planning of the transdisciplinary approaches, implementation of collaborative formats and evaluation in cooperation with the other modules.
	• What are useful user-centred products to support decision-making, and how can they be planned, designed and implemented as climate services?
	o Joint development of products, testing and finalizing of products
	• Which formats are suitable for communicating results?
	o Developing a communication concept which is tailored to the project, and implementing the formats (e.g. printed matter, webpages and -applications for NCCS web portal, management summaries, networking events, media relations, etc.) in cooperation with the project and communication leads of the programme.
	• How can the products be introduced to the target groups?
	o Designing and starting the roll-out of a concept for the dissemination and exploitation of the new climate services in close cooperation with the persons responsible for the overall communication of the programme.
	Indicative budget: CHF 120'000

4 Details to Lot 1: Project "Impacts of global climate change on Switzerland"

The project "Impacts of global climate change on Switzerland" will be jointly carried out with an internal NCCS partner, with CLIMADA (see below) serving as the main modelling and appraisal tool. Therefore, some specific background and project information is provided in the following that applies exclusively to lot 1. This information should help the applicant to better understand the main tool, the interactions with the internal partner and the framework of this specific project.
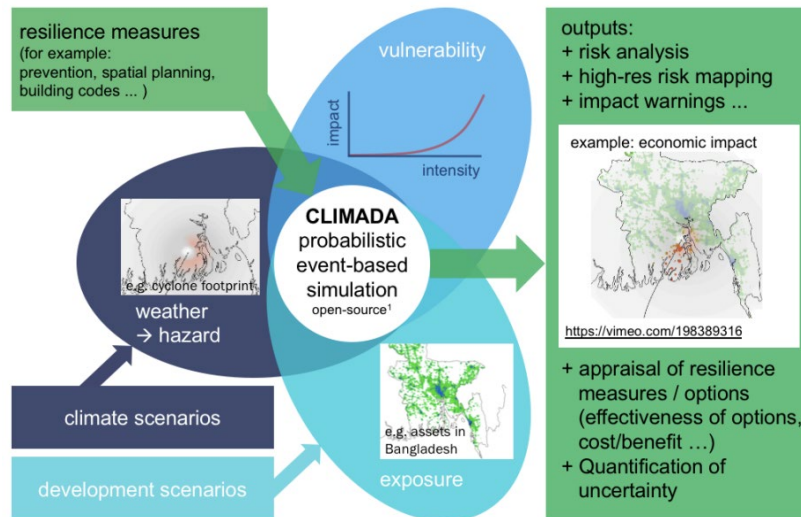
4.1 Details of CLIMADA and its application in the project

CLIMADA – an open-source and open-access global platform for probabilistic multi-hazard risk modelling and options appraisal – is to be used as the main tool for answering the research questions as outlined in lot 1 of Chapter 3 and for reaching the project aims. A first impression of CLIMADA can additionally be obtained in two short videos: https://vimeo.com/677754997 and https://vimeo.com/678230951. Here, we provide an overview of CLIMADA, its modelling components and its linking with Input/Output models.

Overview of CLIMADA	CLIMADA - the open-source and open-access global platform for probabilistic multi-hazard risk modelling and options appraisal
	https://wcr.ethz.ch/research/climada.html (CLIMADA infographic at the bottom of that webpage), links to the GitHub repository, directly at https://github.com/CLIMADA-project/climada_python
	Using state-of-the-art probabilistic modelling, CLIMADA allows estimating the expected economic damage as a measure of risk today: the incremental increase from economic growth and the further incremental increase due to climate change. The economics of climate adaptation methodology as implemented in CLIMADA provides decision makers with a fact base to understand the impact of weather and climate on their economies, including cost/benefit perspectives on specific risk reduction measures.
	The model is well suited to provide an open and independent view on physical risk, in line with e.g. the TCFD (Task Force for Climate-related Financial Disclosure, https://www.fsb-tcfd.org).
	Just for information: CLIMADA also underpins the Economics of Climate Adaptation (ECA) methodology (see https://wcr.ethz.ch/research/casestudies.html). Please note that the present tender looks in essence at supply chain risks and does not require a full or even partial ECA.
	The CLIMADA platform is highly customisable, meaning that users can work with out-of-the-box data provided for different hazards, population and economic exposure, or can provide their own data for part or all of the analysis. The pre-packaged data make CLIMADA particularly useful for users who focus on just one element of risk, since CLIMADA can 'fill in the gaps' for hazard, exposure or vulnerability in the rest of the analysis.The model core is designed to give as much flexibility as possible when describing the

elements of risk, meaning that CLIMADA is not limited to particular hazards, exposure types or impacts.

CLIMADA implements a fully probabilistic risk assessment model. According to the IPCC (IPCC, 2014), natural risks emerge through the interplay of climate and weather-related hazards, the exposure of goods or people to this hazard, and the specific vulnerability of exposed people, infrastructure, and environment. The unit chosen to measure risk has to be the most relevant one in a specific decision problem, not necessarily monetary units. Wildfire hazard might be measured by burned area, exposure by population, or replacement value of homes, and hence risk might be expressed as number of affected people in the context of evacuation or repair cost of buildings in the context of property insurance.

Please refer to Aznar-Siguan and Bresch (2019) and Bresch and Aznar-Siguan (2021) for details. The description of CLIMADA in referenced papers forms an integral part of the present document.

A good first impression can be gained by watching two short CLIMADA videos: https://vimeo.com/677754997 (first) and https://vimeo.com/678230951 (second). *Not of core relevance for the present project, but informative background two additional movies, created for a joint course on climate adaptation by Université de Fribourg and ETH: CLIMADA (12 min: https://vimeo.com/584851312) and Economics of Climate Adaptation (ECA, 18 minutes, https://vimeo.com/584849541) intro.*

References
- Aznar-Siguan, G., and Bresch, D. N., 2019: CLIMADA v1: a global weather and climate risk assessment platform, *Geosci. Model Dev.*, **12**, 3085–3097. https://doi.org/10.5194/gmd-12-3085-2019
- Bresch, D. N. and Aznar-Siguan, G., 2021: CLIMADA v1.4.1: towards a globally consistent adaptation options appraisal tool, *Geosci. Model Dev.*, **14**, 351-363, https://doi.org/10.5194/gmd-14-351-2021

Modelling components of CLIMADA	See mentioned Aznar-Siguan and Bresch (2019) and Aznar-Siguan (2021) as well as the full CLIMADA documentation on https://climada-python.readthedocs.io/en/latest/. Below is only a brief introduction, more details can be found in the mentioned documentation.

Process of modelling
The process of modelling is extracted from the paper Aznar-Siguan & Bresch (2019), which distinguishes three main packages, *hazard*, *entity* and *engine*:
Hazard describes weather events such as storms, floods, droughts, or heat waves both in terms of probability of occurrence as well as physical intensity. They are defined by the base class Hazard, which gathers the required attributes that enable the impact computation (such as centroids, frequency per event, and intensity per event and centroid) and common methods such as readers and visualization functions. Each hazard class collects historical data and transforms them, if necessary, in order to construct a coherent event database. Stochastic events are generated taking into account the frequency and main intensity characteristics (such as local water depth for floods or gust speed for storms) of historical events, producing an ensemble of probabilistic events for each historical event. CLIMADA provides an event-based probabilistic approach, which does not depend on a hypothesis of a priori general probability

distribution choices. The source of the historical data (e.g. inventories or satellite images) and the methodologies used to compute the hazard attributes and its stochastic events depend on each hazard type and are defined in its corresponding Hazard-derived class. This procedure provides a solid and homogeneous methodology to compute impacts worldwide. In the case where the risk analysis comprises a specific region where good quality data or models describing the hazard intensity and frequency are available, these can be directly ingested by the platform through the reader functions, skipping the hazard modelling part (in total or partially), and allowing for an easy and seamless coupling of CLIMADA with external sources. Hence, the impact model can be used for a wide variety of applications, e.g. deterministically to assess the impact of a single (past or future) event or to quantify risk based on a (large) set of probabilistic events. Note that since the Hazard class is not an abstract class, any hazard that is not defined in CLIMADA can still be used by providing the Hazard attributes
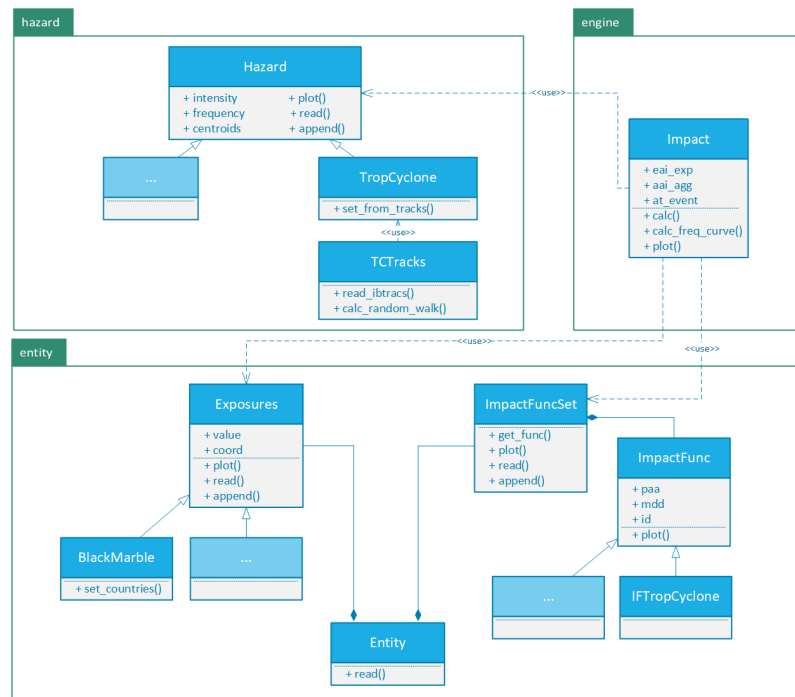
Source: Aznar-Siguan & Bresch (2019): CLIMADA v1: a global weather and climate risk assessment platform

More information can be found in the CLIMADA tutorials (Jupyter notebooks) at https://github.com/CLIMADA-project/climada_python/tree/main/doc/tutorial (and referenced in mentioned documentation).

As of today, CLIMADA provides global coverage of major climate-related extreme-weather hazards at high resolution via a data API (application programming interface), namely (i) tropical cyclones, (ii) river flood, (iii) agro drought and (iv) European winter storms, all at 4km spatial resolution - wildfire to be added soon. For all hazards, historic and probabilistic event sets exist, for some also under selected climate forcing scenarios (RCPs) at distinct time horizons (e.g. 2040). See https://github.com/CLIMADA-project/climada_python/blob/main/doc/tutorial/climada_util_api_client.ipynb for a tutorial how to access and use the API and its data in CLIMADA.
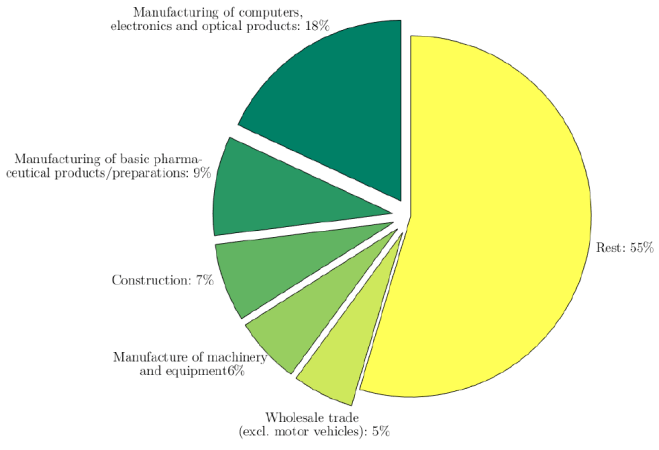
Technical operability
CLIMADA is open-source and open-access, free for use under GNU GPL3 license (https://github.com/CLIMADA-project/climada_python/blob/main/LICENSE), i.e. commercial use is explicitly allowed with no warranty of any kind. Far beyond the project, the CLIMADA platform will be maintained (as already today) in a professional fashion, CLIMADA code (via GitHub) and CLIMADA data (via API) will be accessible 24/7 (Jenkins integration testing etc.). The WCR Group at ETH already employs a professional programmer (ETH SIS IT, 60%) for maintenance and code quality control etc. – who will also oversee the additional development in this program and ensure maintenance and quality control beyond the end of the project.

Linking CLIMADA with Input/Output model	In addition to CLIMADA as specified and described above and in related documents, the coupling with Input/Output models is performed as briefly set out here.
	Input-output (I/O) modelling is an analytical framework proposed by Leontief (1951) to model and describe interdependencies between economic sectors. It relies on general equilibrium and it is used to analyse ripple effects of economic shocks. The I/O modelling framework relies on the use of Input-Output tables, which describe flows of goods across sectors within an economy. Among Input-Output tables are Multi-Regional Input-Output Tables (MRIOT), which describe flows of goods across sectors and across different geographic areas such as regions and countries. In 1958, Ghosh adapted the original model proposed by Leontief (Gosh, 1958). The CLIMADA modelling platform currently supports both Leontief and Ghosh models, it comes with built-in state-of-the-art global Multi-Regional Input-Output tables like WIOD (https://www.rug.nl/ggdc/value-chain/wiod/) and EXIOBASE (https://www.exiobase.eu) and it allows a global supply chain risk analysis to the agricultural and service sectors due to droughts and tropical cyclones respectively.
	In particular, CLIMADA has currently built-in exposures for the service and agricultural sectors. The former is based on Eberenz et al., 2020. The latter is modelled using crop models outputs provided by *the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) (https://www.isimip.org/)*. For tropical cyclones and the service sector, CLIMADA has built-in calibrated impact functions for various regions worldwide (Eberenz et al., 2021).
	A tutorial on how to run a full (direct and indirect) impact analysis using CLIMADA can be found at: https://github.com/CLIMADA-project/climada_petals/blob/main/doc/tutorial/climada_engine_SupplyChain.ipynb
	References • Eberenz, S., Lüthi, S., and Bresch, D. N., 2021: Regional tropical cyclone impact functions for globally consistent risk assessments, *Nat. Hazards Earth Syst. Sci.*, **21**, 393-415, https://doi.org/10.5194/nhess-21-393-2021 • Eberenz, S., Stocker, D., Röösli, T., and Bresch, D. N., 2020: Asset exposure data for global physical risk assessment, *Earth Syst. Sci. Data*, **12**, 817-833, https://doi.org/10.5194/essd-12-817-2020 • Leontief, W. W. (1951). Input-Output Economics. Scientific American, 185:15–21. • Ghosh, A. (1958). Input-output approach in an allocation system. Economica, 25(97):58–64. https://doi.org/10.2307/2550694 .

4.2 Foreseen implementation of the project

As mentioned above, the project on impacts of global climate change on Switzerland is to be carried out as joint collaboration with the Weather and Climate Risks Group ("WCR") of the internal NCCS partner ETH Zurich led by Prof. D. N. Bresch. With this call for tenders a private consultant / bidder consortium is sought that closely collaborate with WCR during the project phase. In the following, details are given on what the applicant is required to perform with CLIMADA and how project tasks are expected to be shared between the private consultant and WCR. Additionally, the framework of the project is given by providing pre-defined milestones, deliverables and risks/challenges. The applicant is asked to provide an offer that takes into account this information.

CLIMADA application by the consultant	The consultant will operate CLIMADA in his/her own premises/workstations/servers. This requires in-house expertise in Python and object-oriented programming.
	The consultant will be required to: • deeply familiarise him-/herself with CLIMADA (extensively documented, see above) • collect data iro exposure for sectors beyond agriculture and services, namely for Forestry, Mining & Quarrying, Utilities and Manufacturing. The ideal target resolution for exposure data globally would be in the order of 10 kilometres or higher so as to make it compatible with other datasets already existing within CLIMADA. • collect data iro vulnerability (damages) for sectors and hazards in order to develop impact functions for all combinations of exposure and hazard worldwide. Impact functions for agriculture exposed to

drought and services exposed to tropical cyclones worldwide do already exist (see above). This task is core to the project and quite resource intensive - a best-effort approach will need to be applied with pragmatism.

- calibrate impact functions for world regions and specific sectors and hazards as present in CLIMADA. This will require approaches such as literature review and expert elicitation plus some pragmatism, as data will likely not exist to run a purely mathematical calibration exercise. This task is core to the project and quite resource intensive.
- apply CLIMADA and its coupling with I/O models in order to come up with indirect impacts of selected sectors in Switzerland. Outputs are by sector and region or country, such as e.g.:

FIGURE 3.3: Impact of the Taiwan manufacturing sector on the Swiss economy: showing the five Swiss sectors most exposed to indirect risk through dependencies on Taiwanese manufacturing.

Figure from MSc thesis of Kaspar Tobler (2017), Impact of the Taiwan manufacturing sector being hit by tropical cyclones on the Swiss economy, showing the five Swiss sectors most exposed to indirect risks through dependencies on Taiwanese manufacturing.

- develop a prototypic web-interface to CLIMADA and its coupling with I/O models. The web-interface shall allow users to upload their own exposure and supply-chain data, run CLIMADA and I/O models and visualise results in a stylised fashion, such as e.g. above illustration. This task is core to the project and quite resource intensive.

The consultant will *not* be required to
- further develop CLIMADA core code. All functionality required for the present project either exists or will be developed by WCR, such as coupling with the I/O model.
- develop new hazards within CLIMADA. The sea level rise hazard (see Module 3 of the project description) will be developed by WCR, following a simple bathtub-approach.
- develop exposure (asset) datasets for agriculture (as briefly mentioned above) and services (as briefly mentioned above), as they exist in CLIMADA already.
- develop impact functions for agriculture exposed to drought (as briefly mentioned above) and services exposed to tropical cyclones (as briefly mentioned above).

References
- MSc theses of Kaspar Tobler and Ediz Herms (will be made available upon publication of this tender)

Interplay between WCR and private consultant - Addressing of key questions - Sharing of tasks - Requirement of private consultant - Synergies	**Addressing of key questions** The key questions and the main research questions are defined in the project description and will need to be addressed by both project partners (WRC and private consultant) in joint collaboration. **Sharing of tasks** Tasks of Weather and Climate Risks Group (WCR) at ETH Zurich - Maintenance of the CLIMADA platform - Further development of the CLIMADA platform and its functionality as core developer, including the coupling with input/output models (one of the key innovations on the WCR side within this project). - Further development of the hazard component of CLIMADA, namely development of a simple sea level rise hazard (a new hazard for the benefit of this project and beyond). - Technical support for private consultant - Lead authorship in scientific publications. Collaborators including staff on the consultant's side will be welcome as co-authors.

For these tasks, the WCR will hire a fulltime Postdoc for the duration of the project (Oct. 2022 – Dec. 2025, subject to change according to project start).

Tasks of Private Consultant
- Engage in stakeholder dialogues and expert elicitations
- deeply familiarise him-/herself with CLIMADA
- collect data iro exposure and vulnerability
- calibrate impact functions for world regions and specific sectors and hazards.
- apply CLIMADA and its coupling with I/O models in order to come up with indirect impacts of selected sectors in Switzerland.
- develop a prototypic web-interface to CLIMADA and its coupling with I/O models.

Joint Tasks between WCR and Private Consultant
- Integrate new exposure and impact function datasets within the CLIMADA platform.
- Test new versions of CLIMADA
- Joint development and dissemination of a web application prototype for the target users as the main product of the project. WCR provides the functionality, the consultant the web-interface.
- Joint evaluation of the research questions as outlined in the project description.
- Developing and publishing recommendations towards target users regarding internationally exposed Swiss companies.

Requirements of private consultant
- Advanced (expert) understanding of Python, especially object-oriented programming
- Understanding of environmental modelling and well-versed in data collection and handling
- Understanding of basics of economic modelling and input/output models in particular
- Understanding of climate change and its economic implications
- Strong background in communication
- Networking abilities among internationally exposed Swiss companies and experts in impact modelling for the identified regions and sectors.

Synergies
- There will be synergies with on-going projects the WCR Group at ETH is involved in, namely H2020 RECEIPT (and to some extent H2020 CASCADES) plus the Weather4UN project (lead with MeteoSwiss). H2020 RECEIPT led to the development of climate impact storylines. The Weather4UN pushes for impact-oriented and -based warnings globally that might also support companies to integrate in their disaster risk management.
- Both the RECEIPT and Weather4UN projects are underpinned by CLIMADA and especially RECEIPT helps to further develop the I/O model coupling. The tendered project will thus be able to make use of the storyline approach and the latest CLIMADA developments especially regarding I/O model coupling.

Please note the predecessor project «Auswirkungen des Klimawandels im Ausland – Risiken und Chancen für die Schweiz» (BAFU, 2020) which was co-led by WCR. The tendered project will build on this work and expand it in quantitative terms.

Intellectual property
- All CLIMADA code and its further development is protected by a GNU GPL3 licence (https://github.com/CLIMADA-project/climada_python/blob/main/LICENSE). This shall remain the case for the present project, including any occasional development of CLIMADA by the consultant (although not envisaged, as this is taken care of by WCR).
- All CLIMADA Data is developed and provided under a CC BY 4.0 licence (https://creativecommons.org/licenses/by/4.0/). All data provided via the CLIMADA Data API also falls under CC BY 4.0.

References
- BAFU, 2020: «Auswirkungen des Klimawandels im Ausland – Risiken und Chancen für die Schweiz», https://www.bafu.admin.ch/ui-2002-d
- H2020 RECEIPT, https://climatestorylines.eu/
- Weather4UN, https://www.eda.admin.ch/eda/en/fdfa/fdfa/aktuell/newsuebersicht/2020/04/weather4un.html (more to come)

Milestones	Note that each of the following milestones goes with communication towards and to engage with stakeholders. 1. Detailed project management plan. Conceptual work (CLIMADA-I/O model coupling…), content work (Supply chain risk analysis…) and communication (web-interface…) to run in parallel throughout the project. [~1 month] 2. Consultant familiar with CLIMADA. Checkpoint: Consultant able to finalise supply chain risk analysis for the Swiss agricultural sector due to global climate change. [~2 months] 3. Overview of all data possibly available for exposure and vulnerability as globally as possible for sector(s) of interest beyond agriculture. [~2 months] 4. First pass of data collection and processing iro exposure and vulnerability complete for sector(s) of interest beyond agriculture. [~4 months] 5. Impact functions for world regions and specific sectors and hazards calibrated, including necessary iterations in data collection and processing. [~12 months. *Note: the data collection and impact function calibration will be done in an iterative fashion, hence in total over 18 months.*] 6. Supply chain risk analysis (indirect impacts) for the Swiss sector(s) of interest beyond agriculture due to global climate change done. [~3 months] 7. Web-interface prototype developed and tested. [~6 months] 8. Final report with guidelines and hands-on recommendations to deal with supply chain risks emerging from global climate change. [~4 months] 9. Communication and dissemination of project results. [~2 months]
Deliverables	1. Project Management Plan, including a communication plan 2. Interim report: Supply chain risk analysis for the Swiss agricultural sector due to global climate change. 3. Interim report iro data availability 4. Interim report iro data collection and processing 5. Interim report iro data collection iro exposure and vulnerability 6. Impact functions ready for use in CLIMADA 7. Interim report: Supply chain risk analysis (indirect impacts) for the Swiss sector(s) of interest beyond agriculture due to global climate change. 8. Web-interface prototype 9. Final report and recommendations directed toward target users
Main challenges and risks	**Challenges** • Cooperation between WCR Group and consultant [shared] • Data availability and quality adequacy for tasks [consultant] • Uncertainties in (direct) impact modelling given sparsity of reported impact data and uncertainties along the full model chain, given aggregation at I/O model level etc. [shared] • Cooperation with leading, internationally exposed (Swiss) businesses [consultant] • Development of user-friendly CLIMADA web-interface prototype [shared] **Risks** • Data not being available or of inadequate quality for tasks. Mitigating action: Use proxy data and/or expert elicitation to fill the gaps in a pragmatic fashion. [consultant] • Deep issues in coupling CLIMADA with advanced I/O models on WCR side. Mitigating action: Revert to proven approach as already implemented with basic I/O model (tutorial even exists already, see above). [WCR] • Consultant struggling with irreducible complexity of model chain (CLIMADA-I/O models …). Mitigating action: Spend more time to familiarise, WCR to coach. This will likely reduce time left on WCR side for content work. [consultant] • Loss of personnel within WCR Group at ETH Zurich (loss of PostDoc knowledge at key strategic position). Mitigating action: Re-hire in academia, may take 6-8 months. [WCR]

5 Internal contributions

In the following, a summary of each project contribution by an NCCS internal partner is given. Please note that some of the contributions are still in the negotiation phase and their content therefore subject to change. More information on these internal contributions will be made available upon publication of this call for tenders.

Lot 1: Internal Contribution by ETH Zurich

Internal Contribution	
Ready to use open-source platform to comprehensively assess climate impacts in and through international production chains	
Contributor(s)	Prof. Dr. David N. Bresch (Weather and Climate Risks Group, ETH Zurich)
Addressed project modules and covered research questions	This internal contribution extends the existing CLIMADA tool to enable the analysis of internationally exposed Swiss companies to climate-change-induced hazards worldwide. For answering the research questions and reaching the project goals as outlined in the project description, CLIMADA is used as the main tool. Therefore, this internal contribution is involved in all of the research questions and modules of the project description.
Summary	Damages from extreme events worldwide (e.g. storms, floods, drought, wildfires) lead to considerable direct and indirect economic losses, bound to increase due to economic development and climate change. Indirect impacts due to trade flows interruptions often lead to domino effects on supply chains, connecting remote regions of the world. In an increasingly interconnected world, this represents a growing risk to businesses, ultimately affecting people and the long-term development of a region. The envisaged risk assessment method builds on an existing open-source and open-access global platform for probabilistic multi hazard risk modelling and options appraisal (CLIMADA). CLIMADA has recently been extended to allow Input-Output analysis and capture the flows of goods and services between sectors and countries worldwide. This extension was recently applied to assess trade flows interruptions from thousands of events at high resolution (4km) globally. Analyses of this type will aid in the identification of sector-specific measures to address the impacts of climate change along the whole chain of impact and will enable businesses to assess and better manage risk exposure in their supply chains. Since CLIMADA is open-source and open-access and its I/O modelling extension makes use of freely available input/output data, outputs are ready to be used by a broad range of stakeholders and ready for implementation into bespoke decision-support systems. CLIMADA provides a data API and easy front-end capabilities, too. This project needs a strong private-sector consulting partner and also to convene and engage with a panel of leading, internationally exposed (Swiss) businesses serving advisory to tackle the sketched challenge in a transdisciplinary approach

Lot 2: Internal Contributions to Module 2a by ETH Zurich and WSL

Internal Contribution	
Establishing dynamic climate impacts on forest ecosystem services in managed Swiss forests	
Contributor(s)	Prof. Dr. Harald Bugmann (ETH)
Addressed project modules and covered research questions	M2a: - Identify impact of climate change on Swiss forest ecosystems and a suite of ecosystem services (ES): aboveground carbon storage, timber & bioenergy production, protection from gravitative natural hazards, and diversity in terms of tree species and vertical stand structure - Identify the impact of climate change on the interactions, synergies and competition between these ES. - Identify the suitability of ES for mitigating climate change («climate mitigation», particularly C storage vs. timber/bioenergy production) and adaptation to climate change («climate adaptation», particularly adjustments to species composition by management of existing trees vs. bringing in new species).
Summary	Swiss forest ecosystems are increasingly experiencing the consequences of global climate change (e.g., drought-induced mortality wave of 2018-2020). Many Swiss forests, particularly those in the Alps, are pivotal for human livelihoods and are sensitive to future climate change. Furthermore, Swiss forests have a substantial role to play in the context of climate mitigation and the bio-economy (e.g., carbon sequestration and storage, bioenergy). Yet, their future development is uncertain as it is subject to climate-induced chronic changes (e.g., slowly increasing or decreasing growth rates) that may lead to tipping points (e.g., tree mortality), and to extreme events (e.g., long-lasting severe droughts, wind storms, wildfires, etc.). Swiss forest management is currently using simple analogue models for decision support under climate change (e.g., "TreeApp", https://tree-app.ch/) that are focusing on a static consideration of the match between climate and so-called "forest site types". However, there is little information for forest practice on the temporal development of climate impacts, linked to the key question when the time has come to adapt to the new climate, e.g. by planting new tree species, or ending the current rotation because risks to established stands are becoming too large.

| | Over the past 20+ years, research in the professorship of Forest Ecology has focused on developing robust and reliable tools for projecting the future dynamics of forest ecosystems in Switzerland (and beyond) under changing climatic drivers at both the stand and the landscape scale. In the context of this project, landscapes are case study regions that are typically 10-20 km^2 in size. To date, the related impact assessments were restricted to 71 "representative" stand types and a few landscapes. Furthermore, we have developed a coherent system for quantifying ecosystem services based on simulated forest properties, focusing on carbon storage, timber production, protection from multiple gravitative natural hazards (e.g., avalanches, rockfall), and some aspects of biodiversity. |
| | In this project, we will bridge the gap between research and practice regarding the future dynamics of Swiss forests under the impacts of climate change. Using established tools (i.e., the forest model For-Clim and the landscape model LandClim), we will determine the temporal development of a wide range of Swiss forest stand types, considering extreme events and multiple alternative management scenarios (e.g., current best practice management vs. a climate-adaptive scheme that features different thinning intensities and rotation periods). These will be developed in close cooperation with diverse forest stakeholders, with whom we have already established a reliable network. We will employ a probabilistic approach to attribute the reasons for the simulated changes (including climate, site properties, management, and model uncertainty). The results from this project will be made publicly available via an existing web portal that will be developed further in the project by A. Gessler et al. |

Internal Contribution	
Impact of climate change on forest ecosystem services and potential adaptation strategies	
Contributor(s)	Prof. Dr. Arthur Gessler (WSL)
Addressed project modules and covered research questions	M2a: - Identify and display the impact of climate change on the ecosystem services of Swiss forest ecosystems - Show how appropriate adaptation measures and strategies mitigate the climate change effects on ecosystem services - Provide tools to visualize the potential change in ecosystem services over time and across Switzerland (temporal and spatial patterns)
Summary	The WSL has already laid the foundation for such a contribution to the NCCS with the project 'FORClimateS' (2019 - 2020), in which existing forest ecosystem information were aggregated, synthesized and integrated into the NCCS priority theme "Forest functions and climate change". The project delivered two interactive web-based tools called Forest Tree Explorer (FORTE) and four educational storylines on the effects of climate change on forest ecosystem functioning with data and expertise from five research units at WSL (https://www.nccs.admin.ch/nccs/de/home/das-nccs/themenschwerpunkte/waldfunktionen-und-klimawandel.html). This content provides the public with relevant and robust information on (1) projected changes in the structure and function of forest ecosystems both in the short and long term. Moreover, it displays (2) close to real-time information on growth and stress-related parameters of trees and forests. It is our aim to build on this work by expanding the focus of this content to include impacts of extreme weather events under different climate scenarios. Currently, much of the forest ecosystem projections available are modelled with dated (IPCC AR4, 2007) and often coarsely resolved climate scenario forcing data. Recalculating these results using homogenised scenarios with consistent down-scaled climate and hydrological projections provided by CH2018 (Swiss Climate Scenarios) and Hydro CH2018,(Swiss Hydrological Scenarios) is therefore indispensable. In close collaboration with the project of H. Bugmann we will implement the quantified ecosystem services from the project contribution "Establishing dynamic climate impacts on forest ecosystem services in managed Swiss forest" to be displayed in the updated FORTE. For that purpose we will (a) directly map the ecosystem services form ForClim-/LandClim- simulations (including protection from natural hazards) and (b) based on the ForClim-/LandClim results implement additional biodiversity related multifunctionality measures (see Van der Plas et al . 2017 Ecological Letters doi: 10.1111/ele.12868). Moreover, we aim to extend the application of these tools to also include appropriate adaptation strategies and their consequences for forest ecosystem services including silvicultural production. Again, we will implement the results of different management strategies developed in close collaboration with stakeholders from H. Bugmann's project contribution. With our approach we will thus be able to not only visualize projected ecosystem services under realistic future climate scenarios and by including the increasing probability of extreme events, but we will also be able to show the effectiveness of different forest management adaptation strategies (adjustment in species composition, rotation time or thinning intensity) over time and visualized across Switzerland.

	The ecosystem services addressed will include timber production, carbon storage, protection against natural hazards, and aspects of biodiversity.

Lot 2: Internal Contribution to Module 2b by Agroscope

The following internal contribution is still in the negotiation phase, which is why only a provisional summary of the work is provided.

Internal Contribution	
Agricultural ecosystem services under climate change: linking adaptation and mitigation	
Contributor(s)	Dr. Pierluigi Calanca (Agroscope)
Affected Project Modules	Module 2b
Summary	The goal of the present contribution is to assess the impacts of climate change on provisioning (crop yield and product quality, grassland production) and regulating (water availability, atmospheric CO2 uptake) ecosystem services (ES) delivered by the agricultural sector and to identify which measures of adaptation are likely to be most promising to counteract these impacts and ensure the delivery of agricultural ES. This proposal has the ambition to expand current knowledge on the synergies between adaptation and mitigation and develop scientific baselines for informing stakeholders and policy makers.
	We aim at structuring the contribution around case studies targeting cropping systems (arable crops, possibly special crops) and grasslands in selected regions of Western and North-Eastern Switzerland that have been prone to seasonal drought in the recent past and likely to witness a more frequent occurrence of such situations in the future. We will carry out numerical simulations using process-based crop models that integrate a detailed description of management and of the biogeochemical cycles. This will allow to translate climate change scenarios (CH2018) into impact projections. Emphasis will be on modelling soil water availability, with the aim to examine, on the one hand, its effects on soil carbon stocks and, on the other hand, the potential of soil management, including the management soil organic matter, for improving water retention.
	In a first step, numerical experiments will conducted without considering adaptation of crop and soil management. The work will focus on the effects of decadal trends and shifts in climate variability (including extreme events) on crop phenology, crop growth, crop water requirements, and soil carbon stocks. Results will be analyzed to pinpoint situations in which adaptation is needed to maintain agricultural ES. Adaptation options under consideration (e.g. crop and cultivar choices, cultivation methods, grazing regimes, irrigation, and a range of soil management practices apt to promote soil water retention and carbon storage) will be evaluated in relation to their effectiveness under climate change (i.e. synergies between adaptation/mitigation benefits) in a second round of simulations. Stakeholders active in the case study areas will be involved to determine options deserving further investigation and discuss, more in general, the relevance of the results for the practice.
	Simple upscaling schemes (statistical meta-models) will be developed to transfer key findings to other regions and/or time horizons.

Lot 3: Internal Contribution to Module 2 by FSVO

The following internal contribution is still in the negotiation phase, which is why only a provisional summary of the work is provided.

Internal Contribution	
Cooling the livestock – mitigation of heat stress through early detection and efficient cooling methods in pigs and poultry	
Contributor(s)	Dr. Madeleine F. Scriba (FSVO)
Affected Project Modules	Module 2
Summary	Climate change leads to local increases in temperature and to a higher frequency of severe weather events as described in the latest cycle of climate change scenarios published in 2018 (CH2018). Heat has a strong impact on livestock production systems from an economic and welfare point of view. Hot temperatures reduce reproductive performance and production output (growth, meat, milk and egg yield),

	metabolic status (physiological functions: e.g., body temperature, mineral balance, energy status), and immune system functioning of farm animals. In particular, heat stress affects pigs because of their lack of functional sweat glands and results in a prolonged fattening period, a higher piglet mortality and reduced fertilization success as well as higher mortality. Similarly, chicken can only regulate their body temperature through adaptive behaviours. During heat periods, productivity decreases and flock mortality increases. Pigs and poultry have a high metabolic activity due to their extreme performance and, thus, are particularly affected by climate change. In summary, exposure to heat stress has a very strong negative effect on animal health, welfare, and performance in both, pigs and poultry.
	The proposed project will consist of two veterinary medicine dissertations (26 months / student). We aim in a first step to identify and validate behaviour, health, and production parameters, which are suitable for the detection of early heat stress in pigs of all production stages (lactating and dry sows, boars, weaner piglets, fattening pigs) and in poultry (broilers and laying hens). The evaluated indicators include changes in behaviour (e.g., panting, activity, social distancing, water and food consumption, resource use), physiology and health (e.g., body temperature, infectious diseases, cardio-vascular functioning), and production output (e.g., feed conversion ratio, daily weight gain, fattening period length, egg quantity and quality, mortality). In a second step, the identified and validated indicators will be used to evaluate the efficiency of different adaptation options (cooling systems) on farms differing in barn structures and housing systems. Cooling methods include, e.g., type of ventilation, showers and foggers as well as other technical installations and management procedures used on Swiss farms.
	Our aim is to establish a scientific basis to identify and deal with negative effects of extreme and prolonged heat and to provide a decision support in form of recommendations to early detect and combat heat stress in pigs and poultry. We will focus on readily available parameters that indicate early heat stress and will aid producers to prevent production losses, health problems and welfare issues. As we emphasize applicability in Swiss climate conditions, our recommendations on cooling systems will enhance communication between stakeholders and inform both, the industry and policy-makers. Our research will contribute significantly to a resilient and sustainable animal production with high animal welfare standards in Switzerland.

A further assigned partner will additionally work on Module 2 answering the following three research questions, which are therefore also not part of this call for tenders:

- Risk assessment: What emerging or increasing negative effects on animal health, welfare and performance must be expected in Switzer-land and what does it mean for the Swiss livestock industry?
- Adaptive strategies: What is the effect of preventive measures or adaptation options (e.g. biosecurity measures, husbandry) on infectious diseases in livestock to reduce the negative impacts of climate change? The focus of the animal species examined is based on the results of the risk assessment.
- Direct payment systems, political context: Where, in the current overall political context, could existing direct payment systems operating in livestock husbandry have an inhibiting or promoting influence on the above-mentioned solution approaches?