Project CLIMANDES
External Evaluation Report

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Acronyms and Abbreviations

AGRO RURAL	Programa de Desarrollo Productivo Agrario Rural, Ministerio de Agricultura y Riego, Peru
ANA	Autoridad Nacional del Agua, Ministerio de Agricultura y Riego, Peru
CBA	Cost-Benefit Analysis
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CDMS	Climate Data Management System
CIIFEN	Centro Internacional para el Estudio del Fenómeno El Niño (International Research Center on the El Niño Phenomenon), Guayaquil, Ecuador
COER	Centro de Operaciones de Emergencia Regional, Puno
CONEAU	Comisión Nacional de Evaluación y Acreditación Universitaria
CORECC	Consejo Regional de Cambio Climático de la región Cusco, Peru
COSUDE	Swiss Agency for Cooperation and Development (Spanish abbreviation)
CPT	Climate Predictability Tool (IRI, Columbia University)
DARE	DAta REscue
ECMWF	European Centre for Medium-Range Weather Forecasts
EER-1	External Evaluation Report of CLIMANDES Phase 1
EET	External Evaluation Team for CLIMANDES 1 and 2
ENSO	El Niño/Southern Oscillation
FAO	United Nations' Food and Agriculture Organization
GFCS	Global Framework for Climate Services (WMO)
GORE Cusco	Gobierno Regional de la Región Cusco
GPCCE	Global Programme Climate Change and Environment of the Swiss Agency for Cooperation and Development
IAI	Inter-American Institute for Global Change Research
INIA	Instituto Nacional de Innovación Agraria, Ministerio de Agricultura y Riego, Peru
LACA&D	Latin American Climate Assessment and Dataset
MeteoSwiss	Federal Office of Meteorology and Climatology, Switzerland
MINAM	Ministerio del Ambiente, Peru
MINEDU	Ministerio de Educación, Peru
NAP	National Adaptation Plan

NFCS	National Framework for Climate Services
NMHSs	National Meteorological and Hydrological Services
PCI	Post-CLIMANDES Initiative
PISCO	Peruvian Interpolated data of SENAMHI's Climatological and Hydrological Observations
PREDES	Centro de Estudios y Prevención de Desastres, Peru
SENAMHI	Servicio Nacional de Meteorología e Hidrología, Peru
RA III	WMO Regional Association III (South America)
RCC-WSA	Regional Climate Center for western South America
RTC	Regional Training Center (WMO)
SDC	Swiss Agency for Cooperation and Development (English abbreviation)
SENAMHI	Servicio Nacional de Meteorología e Hidrología, Peru
SENASA	Servicio Nacional de Sanidad Agraria, Ministerio de Agricultura y Riego
SFDRR	Sendai Framework for Disaster Risk Reduction
UIP	User Interface Platform
UNALM	Universidad Nacional Agraria La Molina, Peru
UniBe	University of Bern, Switzerland
UNFCCC	United Nations Framework Convention on Climate Change
WMO	United Nations' World Meteorological Organization

Foreword

The CLIMANDES project (*Servicios Climáticos con énfasis en los Andes en apoyo a las Decisiones*) was launched in 2012 as a pilot project under the umbrella of the WMO-led Global Framework for Climate Services (GFCS). CLIMANDES sought to provide user-tailored climate information and services to improve socio-economic benefits for the agricultural sector and society at large. As CLIMANDES approaches its completion in March 2019, SDC commissioned a review of the entire project, with emphasis on the achievements obtained during the second operational phase (2016- 2019). This document contains the findings and recommendations resulting from the external review process.

The CLIMANDES External Evaluation Team included the three authors of this report (Podestá, Aguilar and Quiroga). The EET members provide a broad spectrum of training and expertise, but they all share extensive previous experience in Latin America and in climate-related projects. The CLIMANDES External review took place between July 2018, when SDC Contract number 81056121 was signed, and December 2018, when the Final Revised Report of this Review was delivered to SDC.

This review could not have been accomplished within the tight deadlines specified if it had not been for the assistance and good disposition of all CLIMANDES participants. We thank the leadership of the two institutions "twinned" by CLIMANDES (SENAMHI and MeteoSwiss) for their assistance in arranging, with limited lead-time, site visits of short duration and with very tight schedules. We thank CLIMANDES personnel at the two pilot sites in Peru for very well-planned site visits: Sres. Zenón Huamán y Teófilo Zamalloa in Cusco and Sres. Sixto Flores and Claudio Ramos in Puno. Also, MeteoSwiss personnel in Zurich gave us extremely useful briefings and provided well-organized project documents.

We are grateful to the multiple smallholder farmers in both pilot sites who dedicated their valuable time and in some cases travelled several hours to meet with us. In Cusco and Puno we also had the chance to meet very interesting people from institutions such as the Oficina Regional de Gestión de Riesgos y Desastres, INIA, Minagri and Proyecto País (all from Puno), and CORECC, PREDES and GORE Cusco (in Cusco). We thank the municipality of Pusi, which generously supported the costs of participation in our meeting of stakeholders from that location. In particular, we are most grateful to all of the Climandes participants, including personnel at both SENAMHI (Lima and regional offices) and MeteoSwiss, staff from the RTC Lima, and students; all of them generously shared their views and perspectives on CLIMANDES with us.

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We are grateful for the helpful guidance and constant support provided by Ms. Jocelyn Ostolaza Beytía from SDC's Lima office. Finally, we are truly thankful for the trust deposited on the review team by SDC.

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Executive Summary

The CLIMANDES project (*Servicios Climáticos con énfasis en los Andes en apoyo a las Decisiones*) was launched in 2012 as a pilot project under the umbrella of the WMO-led Global Framework for Climate Services (GFCS). CLIMANDES sought to provide user-tailored climate information and services to improve socio-economic benefits for the agricultural sector and society. Twinning between the Peruvian National Meteorological and Hydrological Service (SENAMHI) and MeteoSwiss (its counterpart agency in Switzerland) aimed to enhance SENAMHI's human and infrastructural capacities required to produce and disseminate climate information. CLIMANDES involved two phases that encompassed the periods 2012-2015 and 2016-2018 (now extended through early 2019), respectively. The Global Program Climate Change and Environment of the Swiss Agency for Cooperation and Development (SDC) provided CLIMANDES' funding (3.175 and 4.5 M CHF for phases 1 and 2).

As CLIMANDES approaches its completion in March 2019, SDC commissioned a 3-person External Evaluation Team (EET) to conduct a review of the entire project, with emphasis on the achievements obtained during the second operational phase (2016- 2019). This document contains the findings and recommendations resulting from the external review process. The review assessed (i) the relevance of CLIMANDES objectives and approach; (ii) how far the project achieved planned outcomes and objectives; (iii) the extent to which CLIMANDES' strategy was efficient and effective; and (iv) the likely sustainability of the project achievements after SDC funding. Moreover, the Review includes – at the request of SDC – strategic orientation and recommendations for a future initiative on climate services – the "Post-CLIMANDES Initiative." The findings and recommendations are based on thorough analysis of CLIMANDES documents, in-depth interviews with project participants, site visits to Peru and Switzerland (the two geographic foci of CLIMANDES activities), and the authors' collective experience working in the field of climate services.

Main findings

- CLIMANDES has played a transformational role for SENAMHI, helping this institution to leap forward in achieving the human and infrastructural capacities needed to provide climate information services to agricultural production in the Andean region of Peru. CLIMANDES has effectively established SENAMHI's role as the clear leader in the provision of climate services in Peru.
- At the same time, CLIMANDES has "opened SENAMHI's eyes" (as stated by a project participant) about the multiple, diverse challenges involved in producing and communicating useful and usable climate information services. Because of the CLIMANDES experience, SENAMHI has realized that such task requires truly transdisciplinary teams, as well as sustained interaction with a wide variety of stakeholders, from individual smallholder farmers to governmental institutions.
- CLIMANDES has raised awareness among Peruvian governmental organizations at multiple jurisdictions, NGOs, and individuals about the potential of climate information services as an important contribution to improving societal capacity to manage climate-related risks and opportunities.
- The "twinning approach" in CLIMANDES accomplished effectively its purpose of enhancing institutional capacities through mutual learning. The "twinned" NMHSs acknowledged an evolution in the nature of collaborative relations throughout the project. Whereas MeteoSwiss had to "hold SENAMHI's hand" (according to Peruvian participants) during most of Phase 1, both institutions felt they had comparable roles and responsibilities during Phase 2.
- CLIMANDES, with input from farmers and experts from the targeted pilot regions, has successfully identified the weather and climate information most requested by Andean farmers. Demanded

information includes short-term warnings (with lead times of a few days) of the likely occurrence of high-impact events such as freezes, "veranillos" (dry periods during the rainy season), hail, strong winds and rain, and snowfall.

- CLIMANDES has significantly increased the credibility (and therefore, the likely adoption) of SENAMHI's short-term forecasts of high-impact weather events relevant to smallholder farmers in the Andean region. Less success was achieved in enhancing the comprehension of information, still perceived as "confusing and difficult to understand" by smallholder farmers.
- There is little evidence that Andean farmers use the seasonal climate forecasts provided by CLIMANDES/SENAMHI. Nevertheless, some smallholders expressed a willingness to use reliable forecasts if available from SENAMHI. Some government organizations (e.g., the agency managing natural disaster risks in Puno) rely on SENAMHI's seasonal outlooks to guide strategic, long-lead decisions such as the purchase of equipment and supplies.
- The limited use of seasonal climate forecasts is probably associated with the poor skill of those forecasts (a problem not limited to the Peruvian Andes and not likely to improve significantly in the near future), particularly for precipitation. Forecasts of likely temperature conditions apparently have somewhat better skill. In both cases, SENAMHI and its future partners should continue to work on the production and communication of forecasts with the highest possible reliability, including a clearly stated assessment of their uncertainty.
- Despite limited use of seasonal forecasts, the review team found clear evidence of active risk management by Andean farmers. Risk management strategies included the diversification of crops and cropping locations (various crops, each planted at different heights), inter-planting of crops with different tolerance to climate stresses, mixed cropping-animal production systems, self-storage of animal feed, innovative enterprises (cuy breeding), and securing off-farm income through employment in nearby towns. These proactive risk management strategies are extremely wise in light of the currently low skill of seasonal forecasts. Interventions such as index insurance programs and other safety nets should complement individual actions.
- Possibly, CLIMANDES should have placed a lower emphasis on the use of seasonal forecasts with limited skill. The provision of forecasts could have been complemented by climatological and diagnostic information – for instance, to characterize better the likelihood of high-impact events, or to document changes in climate perceived by farmers (e.g., a shortening of the September-March rainfall period, involving both a late start and an early end of the rainy season).
- CLIMANDES has not focused significantly on variability tied to climate change (on multi-decadal temporal scales) and its likely impacts on society. Although understanding how communities cope with and adapt to present-day variability might inform adaptation to climate change, the concept of climate services in Peru will have to evolve rapidly in response to the global climate agenda.
- A major contribution of CLIMANDES has been the implementation of a pilot User Interface Platform (UIP) – possibly the most important, yet least understood component of the GFCS design. Development of the CLIMANDES UIP involved two-stages: the first stage provided the evidence necessary to design subsequent interventions. In the second stage, CLIMANDES implemented a variety of approaches to engage and inform smallholder farmers and other stakeholders (academia, NGOs). For example, multiple climate field workshops facilitated interactions with climate service end-users in rural communities. A major future challenge will be to sustain or scale up the intensive interactions involved in the pilot UIP.
- The analysis of socio-economic benefits (SEB) conducted by the project and the financial Cost Benefit Analysis (CBA) calculated by the review team from their estimations suggest that CLIMANDES was highly efficient in economic terms. Even when considering only the SEBs for two case studies

(coffee production in Cusco and quinoa production in Puno), the benefit to cost ratio (BCR) is higher than one for a range of discount rates. This means that the expected benefits exceed the costs under highly conservative assumptions.

- One notable aspect of CLIMANDES was its awareness of ancestral knowledge about weather and climate, and the present-day use of predictions issued by holders of this knowledge *("yachachiqs")* to inform farming decisions. Open discussion and respectful acknowledgement of ancestral knowledge can be helpful as an "entry point" or "boundary object" to foster intercultural dialog about weather/climate and build trust among farmers. With due respect for ancestral beliefs, however, the review team was concerned about CLIMANDES/SENAMHI being perceived as endorsing long-term (lead times of months) predictions of climate conditions based on traditional approaches, most of which do not appear have scientific foundation. Reviewers were less concerned about the use of traditional knowledge to anticipate conditions a few days ahead, as probably there are sound physical reasons behind the empirical associations involved.
- The education and training component has yielded mixed results. Blended-mode efforts – combining virtual and classroom training – successfully and efficiently trained tens of junior scholars from SENAMHI, other Peruvian institutions, and Central and South American NMHSs, raising CLIMANDES' visibility across WMO's RA III and RA IV. On the other hand, the formal, degree-granting component of CLIMANDES so far has been unable to update its academic Meteorology curriculum to address the need for competencies on climate services; moreover, recruitment of regional (non-Peruvian) students at Lima's Regional Training Center has been limited.
- The communication and outreach activities conducted by both the Peruvian and Swiss teams have clearly generated a high visibility for CLIMANDES among diverse audiences. It is unclear, however, if the fact that CLIMANDES was one of only eight GFCS pilot projects has been capitalized sufficiently, both inside and outside Peru (e.g., serving as a "visiting card" to potential donors other than SDC).
- It was expected that the WMO's RA III and, in particular, the Regional Climate Center for western South America (RCC-WSA) would serve as institutional vehicles for the diffusion of CLIMANDES results and experience across Andean countries. Unfortunately, not much information was available to document the actual extent of the RCC-WSA's involvement in CLIMANDES.
- The sustainability within Peru of efforts initiated by CLIMANDES depends on the proactive development of strategic partnerships and collaboration agreements between SENAMHI and relevant institutions. There seems to be more progress on this issue at pilot project sites (Cusco and Puno) than at SENAMHI Headquarters – where, perhaps, federal institutions such as Ministries are less nimble. SENAMHI must realize that – regardless of available budgets – it cannot (and should not!) tackle by itself all aspects of the production and dissemination of climate services.
- The design of post-CLIMANDES efforts should consider both the evolving global agendas for climate adaptation and disaster risk reduction and new emerging approaches to development. SDC apparently is considering a regional (supra-national) scale. A project with CLIMANDES depth and breadth conducted in multiple countries seems to be financially not feasible. Therefore, SDC should invest all necessary time and effort to identify sufficiently narrow – yet important and challenging – themes to make a multinational project economically viable.
- Three possible topics are proposed here for a post-CLIMANDES initiative: (i) a problem-based transdisciplinary effort (with participation of social actors) addressing a challenging issue within one of the GFCS priority areas; (ii) a process to nurture the development of National Climate Service Frameworks, a process currently being explored by several Andean countries; and (iii) a collaborative effort to achieve state-of-the-art climate data stewardship in South America.

- Information gathered during site visits suggests that both the WMO's structure and its approach to climate information services are in a state of flux. This situation offers opportunities for innovative approaches to post-CLIMANDES efforts. One possibility put forward by the review team is the establishment of an SDC-funded presence of the GFCS in South America (i.e., a Regional Office or a Focal Point).
- The production and dissemination of climate information and services should not be pursued in isolation from other important and complementary development actions, such as the strengthening of social protection systems and safety nets.

1 Introduction

1.1 Impacts on Peru of Climate Variability and Change

Peru is among the countries most vulnerable to climate variability and change. The country's high vulnerability is associated with the fact that Peru is one of the 16 mega-diverse countries in the world: it has the second largest Amazon forest after Brazil and the most extensive Andean mountain range in South America. Moreover, this country includes 84 out of 117 identified life zones in the planet. Peru has an extremely varied geography and topography, with an arid coastal region ("costa"), the Andes mountain range inland ("sierra"), and tropical areas ("selva") bordering with Colombia and Brazil. Due to the complexity of its topography, the influence of the Humboldt Current and its location in the Intertropical Convergence Zone, Peru covers 28 out of 32 climate zones.

Peru is South America's most water stressed nation. The country includes 71% of the world's tropical glaciers. Nevertheless, the retreat of mountain glaciers, caused by global warming, has a direct impact on present and future water availability. a scenario that represents a serious threat to a country where precipitation is seasonal and often irregular and where glaciers constitute a major source of freshwater (Gagné et al., 2014). The disappearance of Peru's glaciers is particularly critical in the country's highlands, where farming and husbandry rely on irrigation and where water scarcity generates social conflicts in many places (Lynch, 2012). Fragile Andean ecosystems are particularly vulnerable to the adverse impacts of climate change, deforestation and forest degradation, land-use change, land degradation and natural disasters (including an increased frequency of fires). The high Andean plateau is one of the cradles of global agriculture: crops such as potato, quinoa, and mashua *(Tropaelum tuberosum)* were first domesticated there.

From a macroeconomic perspective, Peru is highly vulnerable to climate change and variability. Various studies have estimated the economic costs caused by climate change to be 1 to 4 percent of the country's GDP by 2030. The agricultural sector is particularly climate-sensitive and climate-related losses could reach up to 90% of the sector's GDP. Peru has 7.6 million hectares of cropland and 32% of the economically active population works in the agricultural sector. High-impact weather events can lead to significant or even total crop losses, as well as endangered food security. Smallholder farmers often have particularly limited options to adapt to, and cope with extreme weather or climatic changes. These limited options make climate services particularly relevant for the targeted population and region.

To address the societal and environmental challenges posed by climate variability and change on resources and communities, Peru has developed a National Strategy on Climate Change in 2014. This framework intends to inform actions by the Peruvian government, including the fulfillment of Peru's commitments to the UNFCCC and advancing the national adaptation agenda. Nevertheless, adaptation and mitigation decisions by Peruvian authorities and by actors from multiple climate-sensitive sectors and human activities need to be based on authoritative, relevant and useful climate data, information and knowledge that expand alternatives and clarify choices for decision makers at the relevant scale and context (McNie, 2012). This context led to the design and implementation of Project CLIMANDES.

1.2 The CLIMANDES Project

As we look to the future, human welfare will increasingly be tied to the extent to which societies are able to manage the risks and opportunities associated with a changing climate (Vaughan and Dessai, 2014). The growing realization of the impacts of climate variability and change on Peru, together with

the need to reinforce the capabilities of SENAMHI – the country's National Meteorological and Hydrological Service – to produce and disseminate authoritative, relevant and useful climate information motivated the development of project "CLIMANDES: Servicios Climáticos con Énfasis en los Andes en Apoyo las Decisiones." CLIMANDES had the overarching goal of developing reliable climate information and forecasts, thus contributing to food security and poverty reduction. CLIMANDES was implemented as a "twinning project" fostering mutual learning between the meteorological agencies of Switzerland (MeteoSwiss) and Peru (SENAMHI); it also involved the participation of academic and civil society organizations in both countries. Project CLIMANDES was funded by the Global Programme Climate Change and Environment (GPCCE) of the Swiss Agency for Cooperation and Development (SDC, also known as Cosude for its Spanish abbreviation) to provide reliable and timely climate services in order to achieve more resilient development in the face of climate variability.

CLIMANDES had two phases of implementation. Phase 1 encompassed the period from August 2012 to July 2015 and received total SDC funding of 3.175 M CHF. Phase 1 had the twin goals of (i) improving climate services for Peru (in particular, for smallholder farmers in the Andes) thus contributing to better policy decisions, food security and poverty reduction, and (ii) to enhance the education of students and professionals trained in meteorology and climatology. Because of CLIMANDES' multiple achievements during Phase 1 (discussed below), CLIMANDES was extended for a second phase, taking place between January 2015 and March 2019. Phase 2 aimed to improve the provision of climate information and services based on weather and climate forecasts in specific sectors such as agriculture, improving socio-economic benefits. The second phase also intended to foster discussion and the capitalization of CLIMANDES experiences throughout the Andean region, possibly through the WMO Regional Climate Center for western South America (RCC-WSA). Phase 2 of CLIMANDES received SDC support for 4.5 M CHF.

1.3 External Review of CLIMANDES

In view of the impending completion (March 2019) of the second and final phase of CLIMANDES, SDC commissioned an External Evaluation Team (EET) to conduct an end-of-phase cum end-of-project review of the Project, with a specific focus on the main achievements obtained during its second operational phase (2016- 2018). The three members of the EET include (i) Enric Aguilar, an expert in Climatology at the Universitat Rovira i Virgili of Tarragona, Spain; (ii) Sonia Quiroga Gómez, from the Universidad de Alcalá, Spain, whose work focuses on quantifying associations between climate and economics; and (iii) Guillermo Podestá from the University of Miami, United States, who studies the production and use of climate information to support decisions in climate-sensitive sectors of society. The three EET members provide a broad spectrum of training and expertise, but they share extensive previous experience in Latin America and in climate-related projects.

The SDC contract states that the final review should aim to (i) assess the relevance of CLIMANDES objectives and approach; (ii) establish how far the project has achieved its planned outcomes and objectives; (iii) the extent to which CLIMANDES' strategy has proven efficient and effective; and (iv) whether the project is likely to have a sustainable impact. Specifically, the external review aims at providing an objective assessment of SDC's engagement on enhancing climate data and services as a key component for effective adaptation to climate variability and change. Ultimately, the evaluation will help to assess the underlying assumptions about CLIMANDES' contribution to broader development goals.

In addition to a critical view on both phases of CLIMANDES, SDC has asked the EET to provide strategic orientation and recommendations towards the design of a future initiative on climate services for sustainable development. This effort, subsequently referred to as the "Post-CLIMANDES Initiative" or PCI, should be consistent with SDC's GPCCE Strategic Framework 2017-2020. Moreover, the PCI must build on the achievements of CLIMANDES and continue to contribute to the implementation of the WMO's

Global Framework on Climate Services (GFCS), promoting and enabling regional climate services that increase resilience to the impacts of climate variability and climate change in South America. SDC requested that recommendations about a future initiative discuss possible objectives, geographic and thematic scope, intervention strategy and design, relevant actors, and the necessary partnerships and institutional arrangements.

2 External Evaluation Process - Methodology

2.1 Purpose and Scope of this Review

In the context of a development or research project, "evaluation" can be defined as the systematic and objective assessment of an ongoing or completed project, its design, implementation and results. The goals are to determine the relevance and fulfilment of the project's objectives, and to assess its efficiency, effectiveness, impact and sustainability. The review also offers an opportunity to take stock of achievements and weaknesses, performance, impacts, good practices, and lessons learned.

Project evaluations may be conceptually classified into two major categories, depending on their major focus. If evaluators prioritize *accountability,* the review will typically concentrate on achieved outcomes, and compare them with the outcomes envisioned in the project's implementation plan; this approach is often referred to as a *summative* review. On the other hand, if the review focuses on *learning,* the evaluation will concentrate on processes and context, and on the exploration of factors that have contributed to, or impeded the project's success; this alternative approach is a *formative* review. In practice, however, project reviews usually do not have a single-minded focus on either accountability or learning. Instead, both perspectives are useful and, therefore, often are addressed simultaneously; what varies among evaluations is the *relative* emphasis placed on either goal. The present review combines summative and formative approaches, as it not only assesses specific CLIMANDES achievements, but it also seeks to extract useful lessons applicable to post-CLIMANDES efforts.

2.2 Limitations of this Review

We should acknowledge from the outset that this review necessarily has limitations. Several factors generally complicate the rigorous evaluation of climate service interventions. For example, assessing the usefulness of climate information for decision support is challenging because different actors can use the same information in multiple ways. Measuring outcomes of decisions is also difficult because of the frequently long time lags in changes within socio-ecological systems. Moreover, identifying causal links from a few units of information to a decision is unrealistic, given that intertwined social, economic, political, and scientific contexts also inform and influence decisions (McNie, 2012). Furthermore, climate information may interact with other agricultural technologies or development interventions, making them synergistic rather than competing; it is difficult, therefore, to isolate the impacts of a "climate service intervention." These and various other limitations were discussed by Tall et al. (2018) and Vaughan and Dessai (2014).

Specifically, this review will not be able to establish a conclusive linkage between changes in the behavior or well-being of targeted smallholder farmers and the enhanced availability and access to climate information resulting from CLIMANDES. That is, we cannot distinctly attribute certain observed changes to the project (Gertler et al., 2011). Admittedly, Phase 2 of CLIMANDES involved three sets of surveys conducted after climate workshops to assess (i) the credibility of SENAMHI as an institution, (ii) the perceived accuracy of the information SENAMHI provides, (iii) the stakeholders' comprehension of climate information received, and (iv) the actual use of the information to support decisions.

Nevertheless, the project's original implementation did not include experimental designs (e.g., separate farming communities with and without provision of climate information) that would have allowed rigorous testing of hypotheses about adoption. Future experimental designs, however, must be cognizant of the fact that information – whether about climate or other topics (e.g., gossip) – is "leaky" in the sense that it flows easily across household and community boundaries (Tall et al., 2018). This is a benefit of climate services from the standpoint of development impact and cost-effectiveness – after all, climate information can be considered a public good (Lechthaler and Vinogradova, 2017). However, it complicates the isolation of treatment and control groups that is ideal for establishing impact.

We stress that our acknowledgment of limitations in the review does not invalidate the many CLIMANDES outputs, or the insights emerging from the project and this review. However, we submit that designing for evaluation from the beginning of a project is a key requirement for enabling climate service assessment and valuation (Tall et al., 2018). That is, prospective evaluation should be planned at the same time as the program is being designed and should be embedded into program implementation (Gertler et al., 2011).

2.3 Steps Involved in the Evaluation Process

2.3.1 Introduction and Planning Meeting

On 10 August 2018, SDC's Regional Office in Lima organized a teleconference to introduce the evaluation team to members of the CLIMANDES Project Steering Committee (PSC). The PSC includes representatives from SDC's Lima and Bern offices, SENAMHI, MeteoSwiss and WMO's Regional Office for the Americas. During the meeting, EET members introduced themselves and briefed the PSC about their plans for the review process, including a discussion of possible dates for visits to CLIMANDES institutions and pilot sites in Peru and Switzerland.

2.3.2 Review of Project Documents

The second step of the evaluation was the thorough analysis of available project documents. A digital repository was created to which institutions participating in, or managing CLIMANDES could upload relevant documents. The review allowed the EET to understand CLIMANDES' history, its institutional design, and all activities envisioned and carried out. Documents reviewed during this stage included:

- Technical proposals for CLIMANDES phases 1 and 2 (i.e., Project Documents) that detailed implementation steps and listed expected outputs, outcomes, and impacts, as well as budget numbers;
- Administrative, financial and operational reports detailing progress in implementation and problems encountered;
- Internal working documents such as primers for field workshops, or forms summarizing feedback received from stakeholders during said workshops;
- Outreach materials (project brochures and factsheets, policy briefs, articles in WMO's newsletter MeteoWorld), and training materials (teaching guides on meteorology for instructors); and
- Scientific publications (papers published in peer-reviewed scientific journals or in preparation, abstracts and posters for scientific meetings).
- Additionally, all presentations prepared for site visits were kindly provided to the EET.

The EET is grateful to CLIMANDES managers and participants, who made available a large amount of project documents soon after the team started its review. Timely access to documents had been problematic during the review of Phase 1 but, fortunately, such access was not an issue this time.

2.3.3 Preparation of Inception Report

The review of project documents informed subsequent evaluation plans and helped formulate questions and needs for clarification to be explored during planned site visits. The methodology proposed for the review – including plans for site visits and requests for specific interactions with project participants and stakeholders – was detailed in an Inception Report submitted to the CLIMANDES Project Steering Committee. The Inception Report identified guiding questions addressed to different types of interviewees – although the interviews were to remain loosely structured to foster the emergence of not previously identified topics. A few sample questions include:

- In what capacity(ies) have you been engaged in CLIMANDES activities?
- How specifically has CLIMANDES helped you in your duties or activities? [for SENAMHI/MeteoSwiss staff or project associates]
- What aspects of CLIMANDES have worked well (i.e., were effective) and why?
- What aspects of CLIMANDES have *not* worked so well (i.e., they were problematic or challenging) and why?
- What are the main successes or contributions of CLIMANDES?
- Have you actually used information or products from CLIMANDES to inform your decisions or change your actions? What information have you used? [for stakeholders]

2.3.4 Visits to CLIMANDES Sites

After completing the Inception Report, the EET organized visits to sites related to CLIMANDES activities or project management (e.g., the WMO). During these visits, the EET interacted with CLIMANDES participants, managers, collaborating institutions (governmental and non-governmental), and a diverse set of stakeholders (including meetings with smallholder farmers involved in the project's activities).

2.3.4.1 Visit to Peru

The EET visited Peru on 1-7 September 2018. This visit included the following locations:

- ***Cusco*** (2-4 September 2018). The EET met with staff from SENAMHI's Regional Directorate and staff, and with CLIMANDES staff in Cusco (the Project Coordinator and Communicator). The EET made a visit to the *"tambo"* at Huaccaytaqui, where the team met with local authorities, respected community members and several farmers (male and female) who had participated in CLIMANDES workshops. Other meetings organized by Cusco hosts included potential partners in CLIMANDES follow-on activities, such as a coalition of civil organizations and government agencies focusing on climate change.
- ***Puno*** (4-5 September 2018). The EET met with staff from SENAMHI's Regional Directorate staff and with CLIMANDES' Project Coordinator in Puno. A visit was arranged to Pusi, one of the CLIMANDES Quechua-speaking pilot sites near Puno. The EET met the Pusi Mayor and deputy Mayor (who kindly supported the farmers' travel costs for meeting the EET), and with farmers (in this case, only male because females were involved in another previously scheduled meeting) who had participated in CLIMANDES climate workshops.
- ***Lima*** (6-7 September 2018). Most of the time in Lima was spent at SENAMHI Headquarters, where the leaders of the three main sub-projects of CLIMANDES Phase 2 briefed the EET. The review team also met with SENAMHI's senior management (the President of the institution and his closest advisors). Representatives from the WMO Regional Training Center at UNALM met with EET members at SENAMHI. A short visit was arranged to the Education Section of the Ministry of the

Environment to discuss CLIMANDES' ongoing and planned contributions to environmental education in Peru.

2.3.4.2 Visit to Switzerland

The EET visited Switzerland on 16-19 September 2018. This visit included the locations/institutions listed below.

- ***Geneva*** (17 September 2018). The EET visited WMO Headquarters to discuss CLIMANDES management and education issues. The team met with Ms. Lina Sjaavik (representing WMO in the CLIMANDES PSC and the day-to-day management team), Mr. Mustafa Adiguzel from the Education and Training Office. The EET also was briefed by Mr. José Luis Camacho from the Agricultural Meteorology Division and Ms. Roberta Boscolo from the World Climate Research Programme on the advanced status of planning for project ENANDES, a large project involving Colombia, Peru and Chile that should be considered when planning a post-CLIMANDES initiative.
- ***Zurich*** (18 September 2018). The team visited MeteoSwiss Headquarters, where they received briefings on the status of Phase 2 activities. In-depth discussions with subsets of MeteoSwiss staff followed the briefings and helped to clarify details of each Phase 2 component. A presentation about Switzerland's National Center for Climate Services (an interesting model for post-CLIMANDES efforts) was kindly provided by Ms. Cornelia Schwierz from MeteoSwiss.
- ***Bern*** (19 September 2018). One member of the EET visited SDC's Headquarters in Bern. After briefing SDC management about progress in the evaluation, an extended dialog focused on the nature and attributes of Post-CLIMANDES efforts that might be supported by SDC.

3 Assessment of CLIMANDES Phase 1 Results

Phase 1 of Project CLIMANDES – "Improving Climate Services in the Andean Region, WMO Regional Training Centre and related activities within the GFCS in Peru", hereafter referred to as "CLIMANDES-1" – took place between August 2012 and July 2015 with support from SDC. The project was implemented by SENAMHI and by La Molina National Agricultural University (UNALM) on the Peruvian side and by MeteoSwiss with contributions from the University of Bern (UniBe) and Meteodat on the Swiss side. The World Meteorological Organization (WMO) was responsible for overall project management and for the submission of financial and activity reports to SDC.

The project addressed the needs (1) to improve academic and professional training in meteorology and climatology in the Andean region, and (2) to improve climate products to detect and monitor climate change in Peru, and to provide elements for better policy decisions. The intended long-term impact of this project was to ensure that "the country has sufficient capacity to provide quality climate products and services for taking decisions for the public". This overarching impact was associated to two expected outcomes:

- A strengthened WMO Regional Training Center (RTC) in Lima to train experts in meteorology and climatology (Module1);
- Public institutions using climate information properly for decision-making as part of the GFCS (Module 2).

Phase 1 went through an extensive external evaluation process performed under SDC contract 81031720 by Manola Brunet (lead), Enric Aguilar and Javier Sigró, from the Center for Climate Change, C3, Universitat Rovira i Virgili, Tarragona, Spain. The External Evaluation Report (EER-1) for CLIMANDES-1

highlighted the impacts and benefits of the project, in particular how its activities provided useful examples for the implementation of the GFCS. On the other hand, the EER-1 also identified tasks that did not reach fully the expected results, or that showed room for improvement. The EER-1 findings informed the design of CLIMANDES Phase 2, being planned at the time.

In the remainder of this section, we provide a summary of CLIMANDES-1, based on the EER-1, which included an in-depth review of CLIMANDES-1 documents, on-site interviews with SENAMHI and UNALM (Lima) and visits to WMO (Geneva), MeteoSwiss (Zurich) and SDC (Bern). EER-1 assessed the efficiency of CLIMANDES-1's expected results (see Table 5 and Table 6 in the Annexes). These analyses allowed the EER-1 consulting team to identify project achievements (Section 3.1), deficiencies (Section 3.2) and to formulate recommendations (Section 3.3), which were considered in the proposal for CLIMANDES-2.

3.1 Achievements of CLIMANDES Phase 1

The most remarkable achievements of CLIMANDES-1 identified by the external evaluation team of Phase 1 can be summarized as follows:

- The establishment of a WMO Regional Training Center in Peru, expected to help train human resources in the Andean region.
- A set of well-defined e-learning modules offering virtual, self-paced training on basic aspects of climate science.
- Training of personnel from SENAMHI, other Peruvian organizations and other NMHSs from the region on the subject of Climate Services.
- Enhanced institutional capacity at SENAMHI to produce and deliver climate services.
- Improved availability and quality of climatological data.
- Implementation of a visualization portal for climate indicators, providing basic climate monitoring and prediction products.
- Improved characterization of policy makers and end users' needs at Cusco and Junín pilot areas.
- An improved strategy – based on the previously listed characterization – to involve stakeholders and end users in the uptake of climate information.
- Improved visibility of SENAMHI among Peruvian authorities as a reliable provider of climate information services.
- Identification of CLIMANDES-1 as a global reference for the national implementation of the GFCS.

Similarly, the proposal for Phase 2 highlighted the following key outputs (as identified by CLIMANDES participants) related to Expected Outcome 1:

- The curriculum for the meteorological study program at RTC-UNALM was restructured, as well as the syllabi and study structure. All of them are now consistent with WMO's Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology Nº 1083, Volume I (2012).
- E-learning courses and basic training for virtual instructors were designed, a classroom for weather forecasting simulations has been opened, and training for climate and weather observers has been implemented. For this purpose, diverse tools and the e-learning modules were made available at both national and regional levels.
- Full scholarships to study meteorology in RTC-UNALM were granted. Two undergraduate students from INAMHI Ecuador received scholarships.

- Fifteen training courses in different areas of meteorology and climatology were offered for forecasters of NMHSs in AR III, instructors, and students of the RTC-UNALM. The courses focused on the development and implementation of short-term forecasts in the Andean Region. A professor from the RTC-UNALM conducted doctoral studies (unfinished) at UniBe. Five teachers and forecasters received funds to visit NOAA and CPTEC.
- The project developed educational materials and guidelines to train teachers in primary and secondary education in meteorology, climatology and climate change.
- Over 250 school teachers received training on methods for teaching meteorology. To guarantee official validity of this training, Peru's Ministry of Education participated in this activity. About 7000 students benefited from this program in 2015 alone. In subsequent years, this number might increase significantly and sustainably through support from regional governments.
- CLIMANDES assisted Engineering students who wrote theses on meteorological subjects, as well as support for publication of those works in SENAMHI's journal.

Again, the Proposal for Phase-2 identified the following key outputs related to Expected Outcome 2 of Phase 1:

- Multiple climate workshops were held with users in the pilot regions of Cusco and Junín.
- A demand study allowed the identification of the climate information needs of farmers, the general public, and authorities in the regions of Junín and Cusco. The study revealed a need for monthly seasonal forecasting for planning agricultural and livestock activities.
- Various on-site twinning sessions in Peru and Switzerland allowed the exchange of technical knowledge in the fields of data quality control and homogenization procedures, and database structure and performance.
- The document "CLIMANDES Technical Report-2013-001: Criteria for the SENAMHI temperature and precipitation quality control system", which concerns the rules governing data quality control for temperature and precipitation, was revised. The rules were integrated into the SENAMHI data warehouse for the automatic detection of data errors.
- The homogenization procedure HOMER was operationally implemented at SENAMHI.
- Climate Change Indices (CCIs) for selected stations in the pilot regions were calculated using quality-controlled and homogenized data, and were published on the CLIMANDES webpage.
- Depending on the characteristics of the CCIs, the decision makers now can appreciate in a quantitative manner the changes and trends in particular indices related to their area of interest (e.g., the number of consecutive dry days).
- Systematic collection of metadata was started through station visits conducted in the pilot regions.

3.2 Deficiencies identified in CLIMANDES Phase 1

In addition to multiple successes and important achievements, the EER-1 identified several issues that were not as satisfactory as the listed achievements. Some of these issues included:

- Inefficient coordination and management procedures that often caused delays in project implementation.
- Political and institutional constraints at UNALM that delayed implementation of the Meteorology curriculum designed during CLIMANDES-1.
- Limited inclusion of climatology-related topics – needed to train competent climate service providers – in the academic programs offered by UNALM, even in the updated curriculum.

- Limited availability of human resources at UNALM (due to multiple competing demands on their time) that has impacts on specific research components and support to post-graduate programs.
- Limitations in the UniBe e-learning modules associated with the technical solution adopted – based on licensed software instead of open software.
- Limited implementation of exploratory climate services in the pilot regions of Cusco and Junín, and delayed provision of user-oriented climate services and forecasts.
- Limited strategy to engage policy makers.

3.3 Recommendations for CLIMANDES Phase 2

The external reviewers of CLIMANDES -1 formulated the following recommendations so that the deficiencies identified in Phase 1 could be addressed as part of the implementation of Phase 2:

- Improve management practices, and coordination and monitoring procedures in CLIMANDES Phase 2.
- Include an internal evaluation process as an important component of project management.
- Reduce the time-consuming administrative burden on CLIMANDES participants.
- Begin the search for funding to ensure the sustainability of CLIMANDES after SDC support ends.
- Align CLIMANDES goals and objectives with Peruvian national policies to promote understanding of, and response to climate change.
- Make better use of opportunities offered by the WMO Regional Association III – e.g., calls for scholarships and internships – to attract external students and personnel to the Lima RTC.
- Foster a stronger involvement of UNALM to ensure the success and sustainability of the RTC.
- Finish, maintain, and promote the initial e-learning modules, involving UniBe in these tasks.
- Reinforce the new competencies acquired by conducting regular capacity development activities.
- Consolidate data rescue (DARE) procedures and ensure the integration into operational mode of the climate time-series quality control and homogenization procedures
- Develop a strategy to involve policy-makers.
- Implement a user-friendly visualization portal for climate information and products.
- Address deficiencies found in the fast data exchange and transmission required to facilitate nowcasting and hydrometeorological warnings.

4 Assessment of CLIMANDES Phase 2 Results

An agreement was signed in December 2015 between SDC and the WMO regarding financial assistance to the project "CLIMANDES 2: Andes-Based Climate Services for Decision-Makers phase 2." This is the second phase of the CLIMANDES twinning project between the Peruvian National Meteorological and Hydrological Service (SENAMHI) and the Federal Office of Meteorology and Climatology of Switzerland (MeteoSwiss) aimed at improving climate services for the Andean Region. Phase 2 of the project was implemented in cooperation with the Agrarian University La Molina (UNALM, Peru), the University of Bern (Switzerland) and Meteodat GmbH (Switzerland), while WMO provided overall project management.

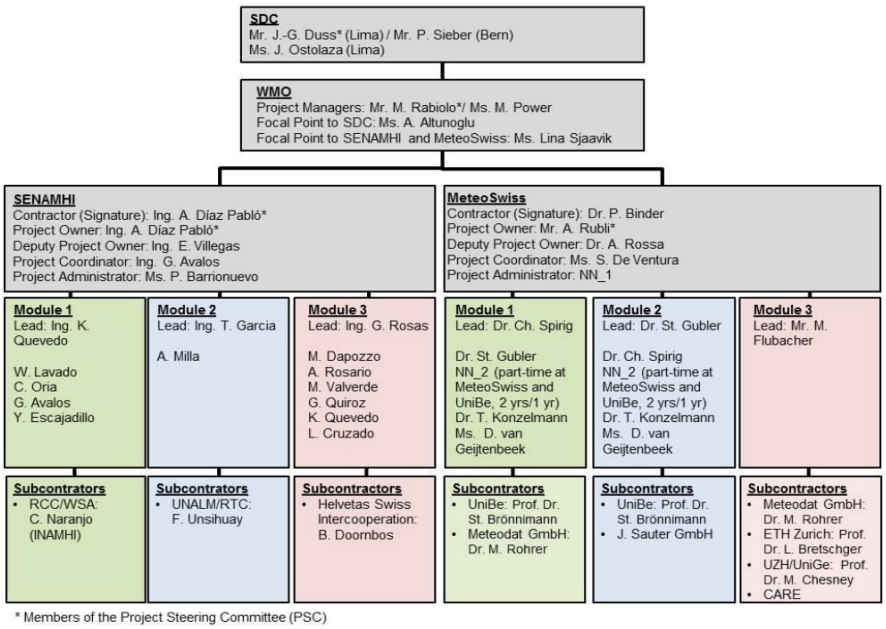
The expected impact of CLIMANDES-2 can be stated as "User-tailored climate services for the Andean Region improve socio-economic benefits for the agricultural sector and for society at large." The specific objective of this phase is to "contribute to the improvement of the capacities to generate user-tailored climate services with socio-economic benefits in the agricultural sector." Three main outcomes were envisioned for CLIMANDES-2:

- Outcome 1: SENAMHI produces and shares user-tailored climate services, mainly for the agricultural sector in the Andean Region. User-tailored climate services for the agricultural sector improve socio-economic benefits for Peru and the Andean Region.
- Outcome 2: Climatology and meteorology-related professionals and students are able to develop high-quality climate information services for the Andean Region and the rest of Peru.
- Outcome 3: Stakeholders in the agricultural sector are aware of the socio-economic benefits (SEBs) of climate services and, consequently, help influence public policy.

4.1 Project Management

The EER-1 highlighted the need to improve coordination and monitoring processes among the multiple CLIMANDES actors. Compared to Phase 1, the EET acknowledges dramatic improvements in coordination in CLIMANDES-2. To start, the CLIMANDES Proposal for Phase-2 reflects a well-structured organization (Figure 1), designed to overcome the previously experienced coordination difficulties. The project management team for CLIMANDES-2 has made special efforts to enhance information sharing among all concerned at appropriate times and with needed frequency. We also learned about the positive impact of periodic (formal or informal) coordination meetings involving SDC, WMO, SENAMHI and MeteoSwiss, key actors of the project.

Figure 1. Proposed project implementation and management structure for CLIMANDES-2.



Project managers adopted tools that defined clearly the responsibilities of all project participants, and the inputs needed by different tasks. Frequent updates of the status of tasks in progress gave management a detailed picture of advances and allowed early detection of problems. Participants perceived the proactive enhancement of management processes and procedures as helpful: in particular, they viewed the centralized administration of financial resources as an important advantage of this structure. Participants said that Phase 2 management changes reduced the time needed for administrative tasks and paperwork.

On the contrary, the EER-1's recommendation to *include internal evaluation as an important component of project management* has not been implemented, as the present evaluation is happening at the end of CLIMANDES-2, with little or no capacity to influence or revise the project's implementation. The EET acknowledges that there is a Project Steering Committee, but it was unclear to us if they actively evaluated project activities during implementation (e.g., during annual CLIMANDES meetings).

4.2 Outputs Associated with CLIMANDES-2 Proposed Outcome 1

> *Outcome 1. SENAMHI produces and shares user- tailored climate services, mainly for the agricultural sector in the Andean Region. User-tailored climate services for the agricultural sector improve socio-economic benefits for Peru and the Andean Region.*

4.2.1 Data Rescue, Quality Control and Database Management

Reliable climate data and management are the basis for generating good climate services. CLIMANDES-2 made significant progress that built on Phase 1 activities. CLIMANDES-2 (i) developed procedures for historical data rescue, facilitating scanning and storage of paper-based forms, (ii) integrated quality control protocols based on the Swiss experience into the SENAMHI database, and (iii) extended quality control procedures to include automatic weather stations. Station metadata were compiled to comply with the requirements of the OSCAR metadata management system, an international standard.

EET Comments:

Reliable data and derived information are the foundation of decision-relevant, value-added climate information services. Thus, there is active demand for long-term, continuous, well-calibrated observations that are critical for defining the evolving state of the Earth's climate (Karl et al., 2010).

CLIMANDES-1 made solid progress in advancing data rescue efforts and in developing and implementing procedures for the quality control and homogenization of time series of historical climate. The EER-1 strongly recommended that SENAMHI include these procedures into operational workflows. The EET was glad to see that CLIMANDES-2 indeed built on the time and effort invested on data management and stewardship during Phase 1.

The EER-1 had suggested that detected deficiencies be addressed regarding the fast data exchange and transmission required to facilitate nowcasting and hydrometeorological warnings. The EER-2 team is not aware of progress in this area, perhaps due to the shift in focus of CLIMANDES-2 towards the fulfilment of another EER-1 suggestion: the engagement of policy-makers, stakeholders and users of climate information.

The implementation of climate services relies on well-structured data stored in high-performance databases designed with data models adequate to fulfil multiple user requirements (Rosas et al., 2016). CLIMANDES convened a meeting to explore current and evolving needs for data management, and to

consider a possible redesign of SENAMHI's meteorological and climatological database. At the meeting, MeteoSwiss experts proposed data warehouse solutions based on the Swiss experience. To our knowledge, no significant progress was made on this topic. We acknowledge that database migrations are always painful and likely to cause unforeseen operational complications. Nevertheless, we encourage SENAMHI to pursue this avenue, not only because it will enhance the efficiency of data maintenance and access, but also because modern database technology may ultimately result in economic savings for the institution.

Stewardship of climate data (quality control, management and dissemination) often receives little attention by funding organizations, government agencies and the public at large. Despite its apparent "little glory," data-related issues still seem to attract interest throughout South America. Existing interest was clearly illustrated by the strong regional participation (over 100 abstracts submitted, about 80 professionals and students from 18 countries across RA-III and RA-IV, but also from RA-VI) in the first workshop on "Data Management for Climate Services" organized by CLIMANDES in May 2018 in Lima (https://www.senamhi.gob.pe/workshop2018/). The Workshop, which included poster and oral presentations, was inspired by the long-running European Data Management Workshops, but with a focus on the Americas. The workshop bridged, under the umbrella of CLIMANDES, the latest scientific developments with operational climatology and training of participants. The outstanding planning, organization and implementation of this first workshop – that required active coordination among SENAMHI, MeteoSwiss and WMO – contributed to enhancing SENAMHI's role as a key regional player in the management of climate data.

Because of all the positive results described above, we encourage SENAMHI to sustain data stewardship activities after the end of CLIMANDES. There have been multiple previous national and regional efforts to develop and maintain climate databases. Moreover, a regional data set – the Latin American Climate Assessment and Dataset, LACA&D – was implemented by CIIFEN in cooperation with NMHSs from Bolivia, Chile, Colombia, Caribbean Netherlands, Ecuador, Peru, Suriname and Venezuela. Nevertheless, the implementation and maintenance of Climate Data Management Systems, including quality-controlled and homogenized daily time series, and an in-depth assessment of uncertainties in the data, remains unexplored in the region, despite many previous efforts. State-of-the-art climate data management, therefore, perhaps should be considered as one possible focus of post- CLIMANDES efforts – of course, avoiding repetition of earlier work.

4.2.2 Climate services on precipitation and drought monitoring

Assessment of climate reanalysis products. The University of Bern (UniBe), SENAMHI and MeteoSwiss assessed the representation of precipitation in six global reanalysis datasets and also analyzed summer precipitation deficits in Peru during the second half of the 20th century. The exploration of the large-scale drivers of droughts based on reanalyses suggested that upper tropospheric zonal winds in the Central Andes were better correlated with drought occurrence in the *altiplano* than indices related to El Niño/Southern Oscillation (ENSO) phenomenon. A paper discussing UniBe's results is under revision by the *International Journal of Climatology*.

Identification of climate variables and indices relevant for agricultural production. A few indices suitable for describing meteorological phenomena relevant to agricultural production were identified during CLIMANDES-2, as well as the timeframes during which these phenomena influence crop growth and yield. A few indices were selected for subsequent analysis of their climatology and trends, and for inclusion in tailored seasonal forecasts targeting agriculture. Preliminary results on the interannual variability and long-term trends of these climate indices were presented at the 2018 workshop on data management in Lima. The results showed that the mean climatological values of all indices vary greatly within the region due to its complex topography; moreover, all indices had a high interannual variability.

Comparison of indices to monitor agricultural drought. A broad range of drought indices was compared for use in operational monitoring of the beginning, temporal evolution, end, and spatial extent of agricultural droughts. The indices included (i) some derived from *in situ* rainfall and evapotranspiration measurements (e.g., SPI or SPEI), (ii) satellite-derived vegetation indices such as Normalized Difference Vegetation Index (NDVI), Temperature Condition Index (TCI), and Vegetation Condition Index (VCI), and (iii) indices combining multiple inputs and crop models (e.g., the Water Requirements Satisfaction Index or WRSI).

EET Comments:

Reanalysis datasets can provide useful information on climate variables, particularly in regions with sparse observation networks such as the Peruvian Andes. Nevertheless, these datasets have known limitations in reproducing precipitation, further aggravated by unresolved topographical effects in mountain regions. Indeed, the UniBe study found considerable biases tied to topography and thus concluded that reanalyses did not solve the problem of precipitation data scarcity in CLIMANDES pilot locations. However, we also learned that reanalyses could be useful to characterize large-scale atmospheric patterns that influence rainfall, perhaps contributing to the enhancement of precipitation forecasts; this is an interesting topic for future research.

Drought monitoring is a critical component of drought early warning systems and a key instrument in timely risk management and drought planning (Trnka et al., 2018; World Meteorological Organization, 2006; World Meteorological Organization (WMO) and Global Water Partnership (GWP), 2016). Few studies have analyzed the ability of different drought indices to identify impacts in a variety of sectors. The EET was briefed about the CLIMANDES comparison of drought indices during its visit to SENAMHI. Unfortunately, not much detail was available on the results, as this seems to be work in progress. The EET hopes that the comparison can be completed during the no-cost extension so that lessons can be applied to operational drought monitoring.

4.2.3 Prototype seasonal forecast for the Andean region

Verification analyses have been conducted for the ECMWF System 4 seasonal forecast ensemble. The model output was compared to quality-controlled ground measurements and gridded datasets generated within the CLIMANDES project – the Peruvian Interpolated data of the SENAMHI's Climatological and Hydrological Observations (PISCO). MeteoSwiss analyzed a set of hindcasts from the ECMWF System 4 for the period 1981-2015 (35 years). Analysis of the more recent, state-of-the-art ECMWF System 5 products is in progress. Two publications summarizing the results are under advanced preparation: (i) the verification of seasonal mean values against homogenized station data for South America; and (ii) a prototype forecast system of indices including verification against quality controlled ground measurements and gridded PISCO observations. At the same time, SENAMHI used the Climate Predictability Tool (CPT) to produce 1985-2015 hindcasts for stations in the Cusco and Puno regions. These hindcasts were used to compare the performance of the two forecasting approaches (dynamic and statistical). Initial verification results show high skill for temperature and promising skill for crop-related indicators, such as the percentage of days with temperatures within an optimal range for bean growth.

As part of this component, MeteoSwiss designed, programmed, released and maintains the ClimIndVis package, implemented in the free and open-source R language. ClimIndVis includes functions for the calculation of climate indices and their trends for different temporal aggregations, as well as the calculation of categorical forecast probabilities and verification metrics. A set of functions enables the user to visualize the results directly. In the case of seasonal forecast visualizations, forecast uncertainty and skill is included, as well as a reference to the climatological values on which the forecast categories

are based. The vignette provided with the package gives an overview of available visualizations. ClimIndVis is not available yet from the main software repository for R packages (CRAN), but a development version can be downloaded from GitHub. A virtual training on use of the package was offered to SENAMHI's staff and one meteorologist from Argentina's Met Service.

EET Comments:

The availability and quality of observational datasets is a limiting factor for the verification of the forecasts in the Andean region. Unfortunately, global datasets such as reanalyses or satellite-based products show systematic errors. Hence, both monitoring and verification still must rely mainly rely on sparse *in situ* observations.

The focus on dynamical seasonal forecasts is an important line of work to be continued by CLIMANDES and any follow-on projects. First, considerable global investment on the improvement of model-based forecasts may ultimately translate into usable skill for the CLIMANDES region. Second, access to the state-of-the-art ECMWF products until recently involved hefty subscription fees for South American NMHSs. As these products are on the way to becoming freely available through the European Union's Copernicus program, any experience gained on their performance across South America will help decide if their use (feasible due to the free access) can be helpful to regional climate services.

The EET found little evidence that Andean farmers use the seasonal climate forecasts currently provided by CLIMANDES/SENAMHI. Nevertheless, some smallholders encountered during site visits expressed a willingness to use reliable forecasts if they were available from SENAMHI, but no definition of "reliability" was offered. Some government organizations (e.g., the agency managing natural disaster risks in Puno) rely on SENAMHI's seasonal outlooks to guide strategic decisions such as the long-lead purchase of equipment and supplies.

The limited use of seasonal climate forecasts is probably associated with their limited skill. This is a problem not limited to the Peruvian Andes and not likely to improve in the near future, particularly for precipitation. Forecasts of likely temperature conditions apparently have somewhat better skill. In addition to skill limitations, the limited use of seasonal predictions may be tied to the fact that forecasts were not "translated" into likely impacts of expected climate conditions. Moreover, forecasts were generally not tied to understanding of climate vulnerabilities and how to address them. Towards these goals, CLIMANDES initial efforts to achieve local validation of crop simulation models (maize, potato, and quinoa) may be a promising avenue to enhance forecast translation and improve the characterization of climate risks.

In hindsight, perhaps CLIMANDES should have placed a lower initial emphasis on the use of seasonal forecasts with limited skill. As stated by a MeteoSwiss participant, "expectations should have been managed better." The forecasts could have been complemented by climatological and diagnostic information – for instance, to describe better the likelihood of high-impact events, or to document changes in climate perceived by farmers (e.g., a shortening of the September-March rainfall period).

Fortunately, when validation efforts showed that the skill of precipitation forecasts was not as high as expected, CLIMANDES investigators quickly adapted to this limitation in different ways. First, they decided to capitalize on the somewhat better performance of temperature forecasts: they developed indices related to this variable (e.g., the number of days with temperatures within a crop-specific optimal range); some of these indices may be included in prototype forecasts for agriculture. Indeed, surveys conducted by Module 3 suggest that temperature (and associated indices) is a very relevant variable to users. Second, CLIMANDES investigators realized – as suggested above – that historical climate data also were useful and thus had to be fully exploited to understand variability and provide context to forecasts.

This component's focus then shifted towards the analysis of past trends and variability (a paper is in preparation). Finally, another adaptive response involved placing greater emphasis on raising the awareness at SENAMHI about forecast skill, uncertainty, and the limitations of seasonal forecasting (especially for the agrometeorological division of SENAMHI).

In any case, the EET suggests that SENAMHI and its future partners continue to work on the production and communication of seasonal outlooks with the highest possible reliability, including a clearly stated assessment of uncertainty - a fundamental element of a forecast when making informed decisions (Buontempo et al., 2014). Lessons can be learned from other sectors as how to communicate uncertainty to users (e.g., finance or insurance), though care needs to be taken when applying those strategies within a new context (Otto et al., 2016). In the near future, seasonal forecasts' skill may improve at a limited pace, thus reaching a threshold of "usability" can still be a few years away – if ever reached, particularly for variables such as precipitation. In the meantime, a useful alternative is to improve communication and use of the available climate information. Moreover, as pointed out by a MeteoSwiss participant and discussed by Weaver et al. (2013), *seasonal forecasts can be used not only as prediction machines, but also as scenario generators, sources of insight into complex system behavior, and aids to critical thinking within robust decision frameworks.*

The EET saw an exploration of several alternative graphical presentations of probabilistic forecasts, each with different ways of indicating uncertainty. However, we do not know if stakeholders or other test audiences evaluated the various formats proposed. It would be very useful to explore this issue, perhaps with assistance from a specialist in the visualization and perception of graphical information. Alternative formats can be assessed through the SENAMHI web site using the "A/B" tests commonly used in marketing studies. In these tests, people entering the web site are randomly offered one format or the other and then asked a few questions to assess correctness of the message they got from the format viewed; the format that generates better results should be preferred.

An outstanding contribution from MeteoSwiss has been the design, programming, release and maintenance of the ClimIndVis package Similar tools, produced by previous WMO-related efforts (e.g. RClimdex, Climpact) although having a more limited scope, have been very useful as part of training events that combine theory with hands-on-data analysis (e.g., the ETCCDI Workshops). For the post-CLIMANDES era, the RTC Peru and future regional partners in the provision of climate services should capitalize on the effort invested in the development of ClimIndVis by offering training events modelled after the successful ETCCDI/ClimPact Workshops. This could foster a seamless adoption of the tool by numerous NMHSs.

Despite limited use of seasonal forecasts, the review team found clear evidence of active risk management by Andean farmers, including the diversification of crops and cropping locations (various crops, each planted at different heights), inter-planting of different crops, mixed cropping-animal production systems, self-storage of animal feed, non-traditional enterprises (e.g., cuy breeding), and securing off-farm income through employment in nearby towns. These proactive risk management strategies are extremely wise in light of the currently low skill of seasonal forecasts. Moreover, these strategies are excellent examples of alternatives to the "uncertainty fallacy" described by Lemos and Rood (2010) as the questionable assumption that accurate, high-resolution predictions of seasonal climate are a prerequisite for effective risk management. In the future, more attention should be placed on developing decision making protocols that are robust against hard-to-reduce uncertainty in expected climate conditions and their impacts (Weaver et al., 2013).

4.2.4 Product 1.3. Scientific publications on climate services and tools

This output includes publications in peer-reviewed scientific journals, posters or abstracts at scientific meetings, and documents describing scientific results. The list below indicates papers published or submitted to date:

1. "Towards implementing climate services in Peru – The project CLIMANDES", *Climate Services,* December 2016.
2. "The climate challenge for agriculture and the value of climate services: Application to coffee-farming in Peru", *European Economic Review,* February 2017.
3. "Identifying, attributing, and overcoming common data quality issues of manned station observations", *International Journal of Climatology,* March 2017.
4. "The influence of station density on climate data homogenization", *International Journal of Climatology,* June 2017.
5. "Summertime precipitation deficits in the southern Peruvian highlands since 1964," *International Journal of Climatology,* under review.
6. "Designing user-driven climate services. What we can learn from the CLIMANDES project: A checklist for practitioners, scientists and policy makers. Publication of MeteoSwiss and SENAMHI.

Several other publications are currently in preparation:

7. Verification of ECMWF–SEAS5 over Latin America with homogenized station data.
8. User-driven climate services for the agricultural sector in the Peruvian Andes.
9. Valuing meteorological services in resource-poor settings: Application of an integrated economic assessment to quinoa farmers in Peruvian highlands.
10. Using socio-economic vulnerability assessments to guide community-based climate change adaptation: an application to small-scale agriculture in the Peruvian highlands.
11. Analysis of variability and trends in climate indices for the agricultural sector in Peru.
12. A prototype forecast system for user-tailored indices for the agricultural sector in Peru using ECMWF-SEAS5.
13. The R-package ClimIndVis: tools for the easy generation of climate indices products.
14. Skill improvement of indices forecasts through process conditioned bias correction.

In addition, multiple posters and abstracts were presented by CLIMANDES participants in multiple fora, such as the European Geophysical Union meetings (2017 and 2018), the European Meteorological Society (2016, 2017 and 2018), and other meetings. All these posters should be made available at the CLIMANDES web site.

EET Comments:

Although CLIMANDES focused on the creation and operationalization of climate information services, expected project results also include the publication of "articles (reports, papers, notes, etc.) submitted or published in specialized journals, with or without a peer-review process." Peer-reviewed publications provide an independent external quality control of the methods used and findings derived by the project. Publication and dissemination of lessons learned eases the implementation of similar approaches in other parts of the world. Because of all these reasons, the EET encourages CLIMANDES participants to publish their findings, even if it is a time-consuming, often frustrating task. At least eight

papers were reported as being in preparation. We hope they can be completed either during the current no-cost extension or during a possible "CLIMANDES 2.1" stage that we propose to SDC (see Section 6).

In addition, CLIMANDES should attempt to produce general audience publications describing the main results. Recently, some journals have started publishing a "practical Implications" section before the scientific abstract: such texts are good examples of the type of "translation" of findings that should be addressed to an educated but non-specialist audience. It was surprising that no results were published in Peruvian scientific journals (e.g., the *Revista Peruana de Geofísica,* as proposed in the Phase 2 Project Document); a review of project achievements would be a very suitable paper for such a forum. The work of students involved in the project (theses, etc.) should be disseminated through the CLIMANDES web site.

4.2.5 Product 1.4: Systematization of experiences and diffusion of CLIMANDES results

Strong collective and coordinated initiatives among institutions in the region are crucial for countries to benefit from each other's strengths and to achieve positive synergies. WMO Regional Climate Centers (RCCs) can play a central role in producing and disseminating regional-scale climate information and climate services, as well as in strengthening the national capabilities of their member countries. Countries in the Andean Region have agreed to collaborate within the framework of the RCC for western South America (RCC-WSA), operated by the Centro Internacional para la Investigación del Fenómeno de El Niño, CIIFEN, in Guayaquil, Ecuador.

Because of its regional scope and mission and its linkages to WMO, the RCC-WSA was viewed by CLIMANDES participants and funders as a suitable vehicle for the diffusion of the project's experiences and results throughout the Andean region. For this reason, CLIMANDES awarded a contract to CIIFEN to perform the following tasks:

1. Design forms to gather information from Andean NMHSs about climate services.
2. Identify key actors relevant to climate information for agricultural production in the Andean countries.
3. Analyze of the demand for climate sectors within various societal sectors.
4. Survey the technological capabilities of NMHSs from Andean countries.
5. Survey the human capacities of NMHSs from Andean countries.
6. Assess the information gathered in surveys carried out as part of Items 3-5.
7. Develop a plan to enhance climate services in the Andean region.
8. Present preliminary results at the XVIIth Climate Outlook Forum.
9. Conduct a course on agroclimatic risk.
10. Contribute to the "Latin American Data Management Workshop."
11. Submit final report of contracted activities.

EET Comments:

The EET requested a copy of the final report for the CIIFEN contract, but this document was unavailable at the time of the review. From interviews at SENAMHI, however, we understand that tasks 1-9 have been completed (at least partially). A second training course by CIIFEN (on a topic not yet defined) was pending; it is unclear if this course will take place before the end of the no-cost extension. We cannot make comments that are more specific on the interactions with CIIFEN without access to detailed relevant documents. This is unfortunate, as the CIIFEN-developed plan to enhance climate services in

the region (item 7 in list above) would have been extremely useful for the exploration of post- CLIMANDES efforts.

Regional cooperation in the Andean region should be a logical next step after CLIMANDES. The importance of enhanced regional and international cooperation was recently highlighted by the Sendai Framework for Disaster Risk Reduction (SFDRR) that emphasizes the need to "foster collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction, such as for climate change."

4.3 Outputs Associated with CLIMANDES-2 Proposed Outcome 2

> *Outcome 2. Climatology and meteorology-related professionals and students are able to develop high-quality climate services for Peru and the Andean Region.*

Outcome 2 of CLIMANDES Phase 2 was focused on the development of human resources to ensure the production of high-quality climate services. This outcome was structured into three products.

- Product 2.1. Ensure minimum education quality standards for the meteorology study program at the RTC-UNALM, as defined by national educational entities and the WMO.
- Product 2.2. Promotion strategy for the Meteorology Study Program offered by the RTC-UNALM in the Andean region.
- Product 2.3. Implementation of learning tools (e-learning, virtual learning, etc.) about Climate Services.

4.3.1 Product 2.1: Ensure minimum quality standards for meteorology education at the RTC

This outcome is closely associated to the role and evolution of the WMO's Regional Training Center in Peru. In 2011, the 16th World Meteorological Congress (Cg-16) recognized UNALM as a Regional Training Center. Since that time, and as a direct consequence of its participation in CLIMANDES, SENAMHI has accumulated considerable experience on the organization and implementation of short training courses and blended-mode efforts combining virtual and classroom environments. Consequently, Peru's Permanent Representative to the WMO requested that SENAMHI be designated as an additional component of the RTC Peru. After a positive recommendation by WMO's Executive Council Panel of Experts on Education and Training, the Executive Council recognized SENAMHI as a new member of the RTC Peru (resolution 11.1/1 EC-70).

The RTC's mission is to fulfill the training requirements in atmospheric sciences at national and regional levels, following national and international educational standards in line with recent technical and scientific knowledge. One of the tasks for which CLIMANDES agreed to fund the RTC was to pursue accreditation of the meteorology study program proposed by the RTC-UNALM; accreditation needs to satisfy the requirements of Peru's Comisión Nacional de Evaluación y Acreditación Universitaria (CONEAU).

EET Comments:

The management and planning structure adopted by the RTC after the designation of SENAMHI as a full member of the Center was not very clear during the site visit. Based on their performance, RTCs are reappointed every 8 years. *The review of the RTC Peru is coming up soon, most likely in 2019. Accordingly, this is an appropriate opportunity for collective reflexion about the RTC's strengths and*

weaknesses. Ideally, this process should result in an updated Strategic Plan detailing RTC goals and activities for the near future, including actions to ensure the Center's sustainability after the end of CLIMANDES.

Reviewers of Phase 1 had suggested that UNALM's role in formal, degree-granting education had to be strengthened in order to safeguard the future success and sustainability of the RTC. Unfortunately, some difficulties identified during CLIMANDES-1 persisted during Phase 2. The EET acknowledges continued efforts by UNALM to improve the quality of their degree in Meteorology by seeking national certification. At the same time, however, we are aware of ongoing difficulties in the implementation of the academic curriculum designed during CLIMANDES-1. The curriculum delays seem to be associated with the rigid, slow-moving processes for approval of new study plans. These delays are a problem not unique to UNALM, but common to many universities worldwide, but concrete actions to overcome these issues should be proposed.

Another problem reported to the EET is the heavy workload for UNALM faculty who seldom can devote time to activities involved with CLIMANDES or with the implementation/expansion of the RTC program. UNALM authorities should contemplate the opportunities – high international exposure and enhanced chances to attract students – associated with the university's participation in the family of WMO RTCs. If UNALM leaders wish to take advantage of such opportunities, they may consider assigning some faculty specifically to RTC-related tasks, releasing them partially or completely from other university duties. In conclusion, the issues described in this paragraph do not allow us to consider the Product 2.1 as fully completed.

Finally, the EET suggests that UNALM continue its efforts to ensure that their formal education program in Atmospheric Sciences aligns with the goals of both the RTC and CLIMANDES follow-on activities by:

- Going beyond a traditional/theoretical curriculum in meteorology by updating the curricula designed during CLIMANDES-1 to fully meet the professional competency frameworks which are officially recognized by WMO (Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology, WMO-No.1083, and Competencies for the Provision of Climate Services, published as part of the WMO Technical Regulations, WMO-No.49);
- Fully implementing the resulting curriculum in climatology and meteorology for the education of professionals competent in the provision of climate services; and
- Making the necessary arrangements to ensure the availability of sufficient human resources within UNALM to develop, sustain and offer the courses proposed in the new curriculum.

Additionally, in terms of managing future training efforts, we note with distress that the Centro de Capacitación has been eliminated in SENAMHI's new internal organization. The functions and responsibilities of this Center were distributed among various areas and people across SENAMHI. The Centro the Capacitación, with a long tradition and a many successes, has been a key structure to plan, develop and deliver training. As SENAMHI is now a member of the RTC, this institution will have a more active role in planning and managing education and training, therefore a dedicated structure seems necessary.

4.3.2 Product 2.2: Promotion strategy for the RTC Meteorology Study Program

The purpose of this outcome was to position the Peru RTC as a leading institution providing specialized training in atmospheric sciences for the Andean Region. The RTC activities and capabilities were to be promoted throughout countries of WMO's RA III, with the goal of attracting international degree-seeking students and supporting them through scholarships. At the national level, another focus of this outcome was to promote the professional roles of meteorologists within Peru. The development of

strategic partnerships with private- and public-sector institutions was planned as a strategy to enhance the prospects for employment of RTC-trained Peruvian professionals and, at the same time, to contribute to the Center's sustainability.

EET Comments:

The Lima RTC apparently has no problems attracting Peruvian students. The meteorology program at UNALM admits each year the maximum cohort side it can support – about 50 students. Moreover, most Peruvian meteorology students seem to be getting jobs once they graduate (at the rate of about 25 students per year, with comparable proportions of males and females), as demand for these professionals has increased across a range of institutions, both public and private.

In contrast, recruitment of international students has been limited. During CLIMANDES-1, three RTC-UNALM faculty travelled to Ecuador, Bolivia and Colombia, where they met with NMHSs and other meteorology-related institutions to present the RTC Meteorology program and the scholarships offered through CLIMANDES/WMO. As a result, UNALM has signed Memoranda of Understanding with the NMHSs of Ecuador (INAMHI) and Bolivia (SENAMHI). As far as we learned, three students from Ecuador have entered the academic program at the Peru RTC and received scholarships. Three students from Bolivia are seeking admission, but paperwork issues delayed their applications. Finally, one Colombian student entered the program and funded himself.

Even though the overall number of foreign students recruited into the RTC is modest and certainly should be increased, the admissions achieved so far represent a step towards consolidating the key role of UNALM in the education of the next generation of climatologists and meteorologists from the Andean region. Nevertheless, the RTC leadership should carefully reflect on possible reasons behind the low recruitment of foreign students, and should incorporate any insights onto the updated RTC Strategic Plan. We suggest that recruitment of non-Peruvian students may be enhanced by:

- Implementing an ADDIE process (Analyze, Design, Develop, Implement and Evaluate) to identify training gaps at the national and Regional Association levels, adapting RTC programs accordingly;
- Establishing partnerships with public, private and academic institutions (beyond NMHSs) throughout the Andean region to co-develop innovative training efforts to provide the competencies needed to face the multidimensional challenges of climate variability and change;
- Developing a broader portfolio of training offerings, including not only degree programs, but also short courses on a wide range of topics targeting multiple types of participants (e.g., natural resource managers or agricultural extension agents who are crucial intermediaries for the dissemination of climate services);
- Participating actively in WMO's Regional Training Centers Network, thus benefiting from the shared resources for education and training in atmospheric sciences that are rapidly growing around the WMO-Global Campus and WMOLearn (https://public.wmo.int/en/resources/training/wmolearn, in feasibility study).
- Initiating or enhancing the dialog with regional institutions – such as the RCC-WSA or WMO's Regional Office for the Americas – with the goal of embedding RTC-developed training efforts within ongoing and planned projects in the region (e.g., the ENANDES and EUROCLIMA+ projects);
- Enhancing the partnership with SENAMHI to identify new roles for the RTC as part of CLIMANDES follow-on activities; and

- Fostering a dialog between high-level management at both UNALM and SENAMHI to streamline administrative processes that differ between both institutions and cause unnecessary delays in training activities.

4.3.3 Product 2.3: Regionalization of education and training

An important goal of CLIMANDES-2 was the regionalization of training efforts by involving professional staff from SENAMHI and, in particular, from NMHSs in South and Central America in many of the CLIMANDES-developed short-term courses and training activities (internships, workshops, etc.).

The training activities involved virtual-only courses and blended-mode courses (combining virtual and classroom instruction). Capacity building efforts undertaken by SENAMHI and MeteoSwiss during 2016-2018 are listed in Table 1. Classroom-only efforts also are listed for the sake of completeness.The training efforts conducted as part of CLIMANDES (i) addressed several important competencies and (ii) were extremely successful in attracting both Peruvian and regional participants, as evidenced by the numbers and home countries of training participants (Table 1). The personnel from the institutions (SENAMHI, Lima RTC, and MeteoSwiss) who were involved in organizing and implemented all these courses should be praised, as this activity was certainly one of the highlights of CLIMANDES.

Table 1. List of training efforts (virtual-only, classroom-only and blended-mode) conducted by SENAMHI and MeteoSwiss as part of CLIMANDES-2 during the period 2016-2018.

Course (Official Name in Spanish as provided by SENAMHI)	**Year**	**Students (virtual / on-site)**	**Countries of origin of the students**
Verificación de pronóstico estacional	2016	48/28	Peru, Chile, Argentina, Ecuador, Bolivia, Venezuela, Panamá
Instrumentos de evaluación cuantitativa para la realización de estudios de beneficios socio-económicos en los SMHNs	2016	-/29	Peru
La plataforma CASSANDRA de simulación de cultivos y escenarios climáticos	2016	-/28	Peru, Bolivia, Chile, Ecuador
Reanálisis: Fundamentos básicos y aplicaciones	2017	50/28	Peru, Belice, Bolivia, Chile, Costa Rica, Ecuador, Guyana, Mexico, Paraguay, Venezuela
Rescate de datos	2017	-/33	Peru
Uso de modelo *substor* para evaluar los impactos del cambio climático en la papa	2017	-/28	Ecuador, Chile, Bolivia
El Sistema OSCAR/Surface para gestión de metadatos	2017	-/25	Ecuador, Chile, Bolivia, Venezuela, Brasil,Argentina, Paraguay, Suriname, Guyana, Perú

Riesgo Agroclimático	2017	-/27	Ecuador, Chile, Peru
Climatología de Mesoescala	2017	-/21	Peru
Predicción Climática Estacional – Módulo 1: Climatología sinóptica de Sudamérica (virtual mode only)	2017	68/-	28 foreign students (virtual) Argentina, Chile, Bolivia, Ecuador, Colombia, Paraguay, Uruguay, Venezuela, el Salvador, República Dominicana, Panamá, Guyana, Guatemala
Predicción Climática Estacional – Módulo 2: Modelos numéricos y pronóstico climático estacional	2017	65/28	24 foreign students (virtual) 12 foreign students (presential) Argentina, Chile, Bolivia, Ecuador, Colombia, Paraguay, Uruguay, Venezuela, El Salvador, República Dominicana
Predicción Climática Estacional – Módulo 3: Aplicaciones prácticas de la información climática para una agricultura resiliente y sustentable	2018	78/28	20 foreign students (virtual) 10 foreign students (presential) Argentina, Chile, Bolivia,Ecuador, Colombia, Paraguay, Venezuela, El Salvador, República Dominicana
Indicadores Climáticos utilizando el paquete de R ClimIndVis (= Climate Indices Visualization) (virtual mode only)	2018	NA	SENAMHI + Argentine Met Service
Modelo Hidrológico MGB	2018	Planned (?)	

4.3.4 Product 2.4: Implementation of learning tools to support training on Climate Services

This product involves the implementation, adaptation, and design of learning tools to support the provision of climate services and facilitate various kinds of training efforts. The well-deserved recognition of SENAMHI as a full member of the RTC-Peru was in part due to the multiple capacity development activities implemented – with MeteoSwiss partners – during CLIMANDES.

The success in blended-mode training (combining virtual and classroom instruction) was not accidental. First, a strategy for implementation of e-learning at SENAMHI and the RTC Peru was designed during a blended workshop facilitated by Sauter GmbH in June/July 2016. Second, CLIMANDES actively fostered the enhancement of e-learning tools at the RTC. For instance, virtual training at SENAMHI was enhanced by the implementation during CLIMANDES-2 of the Moodle open on-line Learning Management System (LMS). The extensive usage of Moodle was part of the evidence offered by SENAMHI to the WMO's Executive Council to justify its appointment as a member of the Lima RTC. The SENAMHI Virtual Campus

Box 1. CLIMANDES - Creating a climate-literate society.

CLIMANDES training and outreach activities are reaching all levels of Peruvian society. CLIMANDES is promoting a climate-resilient society through education. In this Box, we quote some individuals who, during meetings with the Phase 2 evaluation team, expressed in their own words the impacts of CLIMANDES on themselves and their communities.

"CLIMANDES training on seasonal forecasting has improved my competence as a climatologist and meteorologist."

METEOROLOGY STUDENT WHO PARTICIPATED IN THE COURSE "PRONÓSTICO ESTACIONAL"

"On holidays, when SENAMHI does not provide the forecast to our radio station, we look at their website for orange or red warnings and, if any, we broadcast them. Now we can do it, because the SENAMHI website is much improved, and because we attended a training event that allowed us to understand and communicate these warnings."

BROADCASTER FROM RADIO ONDA AZUL, PUNO

"I have always observed the clouds and understood how they bring rain or hail to us. Now, thanks to the workshops offered by CLIMANDES, I understand where clouds come from, why they form, and I know what happens when El Niño comes. This is the first time that SENAMHI or any governmental institution comes to this community."

SMALLHOLDER FARMER FROM PUSI COMMUNITY, NEAR PUNO

reached over 100 students from many countries throughout RA-III and RA-IV in 2016-2018 (Table 1). The Moodle platform supports the sharing and transfer of knowledge throughout Peru (e.g., among SENAMHI personnel working in regional offices) and the Andean region. The EET gathered very positive feedback from participants in the course "Pronóstico Estacional, Módulo 3" (Box 1). They praised the didactic approach and usage of the LMS, especially in those lessons when it was used not only as a repository of teaching materials, but also as an active tool.

One lesson learned in CLIMANDES-2 is that the duration of online courses must be longer than two weeks. Some of the earlier courses were designed to have a short duration, but this required a significant time commitment by course participants during the course. Participants cannot dedicate a substantial proportion of their time for two weeks to an online training. Another factor that requires longer training times is the widely variable levels of previous knowledge among participants: some of the participants

need additional time to refresh their knowledge or familiarize themselves with new topics so they can keep up with the pace of the virtual training. On the other hand, a highly focused virtual course requiring 1-2 complete days may be feasible, as it would be analogous to a short, full-time classroom training effort.

This project component also envisioned use of the e-learning courses developed by the UniBe during Phase 1. Apparently, however, use of these courses has been relatively limited during CLIMANDES-2. The EET was told that a few faculty at UNALM complement their lectures with the e-courses, but they are not used by themselves. We learned that the UniBe course materials have been translated into Spanish during CLIMANDES-2, but they have not yet been included within the framework of a Learning Management System. Given the apparently limited usage of these modules to date and the short time remaining until the end of CLIMANDES, perhaps the project should carefully balance the benefits and costs of completing the migration of the e-courses within *this* project.

Given the great success of virtual and blended-mode training at SENAMHI, a next step would be to try to understand and address the reasons behind the apparent reluctance of UNALM – the other partner in the Lima RTC – to adopt these tools. The capacity-building activities developed for CLIMANDES can be incorporated easily into the UNALM curriculum. Finally, SENAMHI and UNALM should consider adaptation of other existing didactic tools such as those provided by COMET, the WMO, and other institutions.

4.3.5 Other training efforts

As part of Outcome 2, CLIMANDES also has conducted activities targeting teachers and students of elementary and secondary schools and, to some degree, college students. The goals were (i) to include meteorological issues in the basic educational curriculum, and (ii) train school teachers in order to help to popularize meteorology. Over 250 school teachers were trained in the basics of meteorology. To guarantee official validity of this training, the activity was developed jointly with Peru's Ministry of Education. These efforts have materialized in the publication of an excellent book series with resource materials for school teachers at initial, primary and secondary levels (see Figure 2), and also the book for small children *"Willay: Midiendo el tiempo sin instrumentos."*

4.4 Outputs Associated with CLIMANDES-2 Proposed Outcome 3

> *Result 3: Stakeholders in the agricultural sector are aware of the socio-economic benefits of climate services and influence public policy.*

4.4.1 Product 3.1: Mapping and Surveys of Stakeholders from the Agricultural Sector

CLIMANDES Module 3 initiated the process to establish a dialog with stakeholders in the pilot regions by conducting a qualitative and quantitative field study to evaluate the needs and expectations of climate information users from the agricultural sector. First, CLIMANDES-2 mapped stakeholders of the agricultural and food security sectors in Cusco and Puno. The map of actors helped to assess the availability of sectoral expertise. For all actors identified as relevant, the project then described their roles and missions, the territorial reach of each actor, and their available resources. In turn, this led to the identification of key potential partners.

Household surveys were then conducted in Cusco (September 2017) and Puno (December 2016) to assess the vulnerability of smallholder farmers (cultivating less than 10 ha) to climate-related hazards. The surveys identified the media through which farmers receive climate information. This task surveyed

Figure 2. Resource books for school teachers, designed to foster the inclusion of meteorological issues into the educational curriculum. The books cover, left to right, initial, primary and secondary school levels.

over 1100 farming households project sites – not a minor accomplishment. With assistance from a consulting firm, survey results were subsequently used to develop a typology of farmers. Another important result from the surveys was the identification of weather and climate events that are relevant to smallholder farmers in the pilot sites, and the lead times required for preparation.

The preceding surveys confirmed that Andean farmers continue to observe the skies, clouds, stars and the Moon to predict how weather/climate might evolve on time spans from days to months. Seasonal rainfall amounts are anticipated through other signs such as flowering of particular plants or the nesting behavior of certain birds. Only in recent years – and as a direct result of CLIMANDES – has weather and climate information from SENAMHI reached the Andean communities surveyed.

EET Comments:

Communication based only on scientific evidence probably will not change people's behavior substantially. Instead, greater uptake of climate and weather information must be fostered through a solid understanding of the contexts in which climate-sensitive decisions are made, stakeholders' household structure and roles, religious systems, social norms, etc. (Brasseur and Gallardo, 2016). Consequently, CLIMANDES activities aimed at "knowing the audience" of climate services were necessary and useful.

The 1100+ CLIMANDES-2 household surveys elicited (i) the characteristics of farmer households that influence their vulnerability to climate impacts, (ii) the main weather and climate events relevant to agricultural production, (iii) an understanding of farmers' decision processes (including those related to mitigation of weather and climate impacts), and (iv) the farmers' needs/desires for weather and climate information. The EET encourages CLIMANDES participants to extract as much information as possible from the household surveys: we suggest that access to results be offered to all project participants interested in performing additional analyses – after provisions are made to guarantee the confidentiality of respondents.

Farmers prefer to receive weather/climate information through radio broadcasts and, increasingly, through cellphone text messaging or email. SENAMHI broadcasts weather advisories for the Puno region through two local radio stations – Onda Azul and La Decana – in Spanish, Quechua and Aymará languages. Weekly text messages with weather information and early warnings are sent to smallholder farmers and other governmental agencies (AGRO RURAL, INIA, SENASA, and ANA). The EET visited the Onda Azul radio station in Puno and heard from the station's manager (Box 1) how the audience demands daily weather advisories from SENAMHI – to the point that the station no longer charges CLIMANDES for airtime, as this information appears to increase their ratings. An active search for similar win-win opportunities should enhance the future sustainability of activities started by CLIMANDES.

CLIMANDES personnel in pilot sites played important roles, both as "champions" for the project – i.e., enhancing awareness and providing leadership – and as trusted providers of actionable information. The EET perceived firsthand how SENAMHI regional directors – and to a lesser degree, CLIMANDES local coordinators – are well known and trusted by many relevant actors. For example, the SENAMHI regional director in Puno personally broadcasts weather advisories every day at 5:00 AM. The importance of identifying and recruiting other enthusiastic champions (in particular, from institutions outside SENAMHI) is one of the issues that need to be considered when designing CLIMANDES follow-on activities.

4.4.2 Product 3.2: Establishment of a User Interface Platform (UIP)

CLIMANDES developed a prototype User Interface Platform (UIP) to enable strong engagement with key stakeholders, from information providers to local communities and smallholder farmers. The UIP is one of the five GFCS pillars necessary for an effective climate service system. This component can involve a set of activities and processes that foster structured interactions among users, researchers and providers of climate information services.

CLIMANDES implemented the pilot UIP through a structured two-stage approach. The first stage provided the evidence necessary to plan subsequent interventions; this stage was discussed in Section 4.4.1. The second stage translated the previously generated evidence into practice. As part of this stage, climate field workshops were designed and implemented to facilitate bidirectional dialog with climate service end-users in two rural communities. These events brought together CLIMANDES personnel and farmers to discuss observations, forecasts and experiences related to the effect of weather and climate over their lives. The workshops had multiple purposes, such as familiarizing smallholder farmers with the characteristics of their local weather/climate (clouds, freezes, etc.), as well as allowing providers to continue to learn (after the first-order assessment achieved during household surveys) about farmers' needs and expectations for weather/climate information. The workshops combined scientific and traditional knowledge with the intention to build trust and credibility. After each climate workshop, information was collected to assess the intervention's performance and impact.

EET Comments:

The GFCS introduced the User Interface Platform (UIP), an innovative concept that is possibly the most important, yet least understood component of the Global Framework design (Gerlak et al., 2017). Unlike what its name suggests, the UIP *is not* a computational program, web application or smartphone application. Instead, a UIP involves a diverse set of processes and activities that facilitate structured interactions among users, researchers and climate service providers. These interactions can seem daunting at first (Buontempo et al., 2014), therefore the CLIMANDES pilot UIP was designed to help bridge the user-provider gap and to effectively build social capital.

Development of the CLIMANDES pilot UIP clearly has been a major achievement of Phase 2. The UIP included multiple activities designed to facilitate and enhance user engagement. Project participants

from Cusco described the UIP as "a diverse set of tools and activities" including, for instance, SENAMHI's web site, radio broadcasts of weather forecasts and advisories, and messages sent to stakeholders through SMSs and WhatsApp. Moreover, the UIP was further described as including also the *processes* necessary for the production and communication of weather and climate information, as well as the coordination needed among multiple levels of institutions to ensure that the CLIMANDES/SENAMHI information traverses "the last mile," and reaches intended users. The pilot UIP developed during CLIMANDES engaged multiple kinds of actors (governmental and non-governmental institutions, academia, and the private sector). This factor will be key to the future continuity of climate service production and dissemination.

An important component of the UIP was the series of climate field workshops held in Cusco and Puno. Although many objectives were pursued during the workshops, one important goal was to overcome an identified barrier to the uptake of CLIMANDES/SENAMHI weather/climate information: this information was perceived as confusing and hard to understand. Correctly, this barrier was not addressed by placing the blame on farmers (i.e., "they do not understand"), but from both ends of the problem. On one hand, the workshops sought to increase farmers' climate literacy, i.e., their capacity to absorb, understand, and use the weather/climate information provided. On the other hand, the workshops offered "mutual learning" opportunities for information providers to refine the design and contents of weather/climate products.

Household surveys and early interviews confirmed that some Andean farmers continue to observe the skies, clouds, stars, the Moon and other signs in the environment (e.g., nesting patterns of birds, plant phenology) to predict how weather/climate might evolve on time spans from days to months. Awareness of this ancestral knowledge about weather and climate and the present-day use of predictions issued by holders of this knowledge *("yachachiqs")* to inform farming decisions was one interesting aspect of CLIMANDES. Moreover, the climate workshops involved the discussion of weather/climate outlooks from both SENAMHI forecasts and the *yachachiqs'* observations. Although the EET was not present and did not see any recordings or transcripts, we were fairly concerned by statements from participants (both farmers and CLIMANDES personnel) suggesting that traditional and SENAMHI forecasts were being "compared" during the workshops. Open discussion and respectful acknowledgement of ancestral knowledge can be helpful as an "entry point" or "boundary object" to foster intercultural dialog about weather/climate and build trust among farmers. The review team was worried about CLIMANDES/SENAMHI being perceived as endorsing long-term (lead times of months) predictions of climate conditions based on traditional approaches. Reviewers were less concerned about the use of traditional knowledge to anticipate conditions a few days ahead, as probably there are sound physical reasons behind the empirical associations involved. In any case, the issue of outlooks based on traditional knowledge should be handled very carefully in the future, with respect for ancestral beliefs and using detailed observations to supplement diagnostics of present conditions, but without validating use of predictions without any foundation.

The GFCS encourages the development of UIP models that are not overly sector-specific, but instead are sufficiently flexible to meet the needs of a wide range of climate-sensitive sectors. A major challenge to be explicitly addressed during the CLIMANDES synthesis stage is to find a satisfactory balance between a generalizable, widely applicable UIP (as suggested by the GFCS), and the context-specific UIP components required, for example, to deal with impediments or barriers, information needs, and decision protocols and constraints that are unique to Andean agriculture.

An even more formidable challenge will be to sustain and continue to enhance the UIP once CLIMANDES officially ends. Scaling up or even sustaining the current interactions in the pilot UIP will be difficult for various reasons. First, the pilot UIP experience highlighted the crucial role of SENAMHI regional offices

and, in particular, dedicated coordinators: these personnel will require resources that may not be available from SENAMHI after CLIMANDES ends. Second, the UIP experience exposed the need for sectoral expertise to support essential activities such as the translation of expected climate into likely impacts on different sectors or activities. Sectoral experts also are necessary to help identify – in collaboration with societal actors – viable actions to prevent or reduce damages from weather/climate events, or to capitalize on favorable conditions. To address both of these issues, an active effort will be needed to establish or strengthen strategic partnerships with relevant institutions and programs (INIA, SENASA, ANA, Programa País). There seems to be more progress on this issue at pilot sites (Cusco and Puno) than at SENAMHI Headquarters – where, perhaps, federal institutions such as Ministries are less nimble. Nevertheless, this process should be accelerated during the no-cost extension or a CLIMANDES synthesis stage.

4.4.3 Product 3.3: Estimates of the potential value of climate services for agriculture.

National governments, NMHSs and development agencies need to understand the value of the socioeconomic benefits (SEB) provided by climate services, so that adequate financing can be mobilized and invested strategically to support the production and dissemination of those services (World Meteorological Organization, 2015). Consequently, CLIMANDES conducted a series of activities to provide initial estimates of the SEB of climate services.

SEB analyses sometimes do not aim to provide an exhaustive account of *all* the benefits that a climate service brings to society, as these benefits are, in general, numerous, of different kinds, and not always measurable. Instead, a more realistic goal of SEB assessment in some situations is to focus on a few services for which there is evidence of benefits, and to establish an initial estimate of the potential of those services to change key decisions. Such efforts establish at least a bottom line for the benefits (recognizing that many more benefits exist that are not measurable at the current stage. This seems to be the case for the CLIMANDES SEB evaluation, as the evaluation has focused in some case studies more than a general evaluation of benefits. Although various SEB studies have been performed by CLIMANDES – see, for example, the work by Lechthaler and Vinogradova (2017) – we focus here on the study of a frost warning for quinoa in the Puno region, as it has been recently used to illustrate the main aspects of the pilot UIP (MeteoSwiss/SENAMHI).

A well-defined model was used to estimate the economic benefits of a frost forecast in Puno. The availability of the forecast was considered as a mechanism for enhancing rural households' welfare through optimal mitigation actions. Therefore, estimated results should be viewed as potential benefits, in the case that farmers optimize their response to climate. Model results showed that the availability of a frost forecast might improve annual welfare by around 4%, which implies an increase in consumption of 24%. Based on an average household consumption (76 kg of quinoa per year) and a fixed average price (2 USD kg^{-1}) the computed gain is around 36 USD per year per household or 76 USD per hectare (based on an average area farmed by a household of about 0.5 ha). Given the area planted with quinoa in Puno (35,694 ha in the 2015-16 campaign), the estimated annual value of the frost forecast for the entire region was about 2.7 million USD.

EET Comments:

One factor that appears to have limited investment in climate services is the relative lack of information on the economic impact of these services (Vaughan et al., 2017). Studies aimed at understanding the value and benefits of using weather and climate information can (i) justify investment in the provision of climate services; (ii) improve the existing provision of climate services to maximize use and value to users; and (iii) justify pricing if users are expected to pay for information (Bruno Soares et al., 2018). CLIMANDES has begun to address the demand for valuation studies through a handful of studies of the

socio-economic benefits of weather and climate services. As stated above, we focus here on the study of the potential value of a frost warning for quinoa grown in the Puno region

The main limitation in the case study discussed comes from the lack of actual monitoring of the change in farmers' decisions involving real management processes, as instead, the evaluation was based on decisions optimized through a theoretical model. A monitoring process based on real decisions would require a balanced panel of the same farmers, who would need to be evaluated throughout the entire study. Unfortunately, this was not the case because it was impossible to have the same participants in all workshops. A greater effort to engage a stable group of stakeholders would be necessary to be able to do this type of follow-up.

It was important that CLIMANDES paid attention to the nexus of poverty and vulnerability by evaluating the smallholders' ability to cope with climate-induced crop failures and the impact on their incomes and wellbeing. One of the main results associated to this SEB analysis is that CLIMANDES served to make climate services more inclusive in the area, as the workshops targeted the more vulnerable populations living under subsistence conditions. Nevertheless, poorer households whose dependence on homegrown food often is higher have shown significant problems of food insecurity that peak in January, shortly before the harvest starts. Although information about food shortages was not gathered by gender (Section 5.6), in smallholder systems elsewhere women were found to skip more meals than men when food was scarce, therefore they typically bear the brunt of shortages (Loboguerrero et al., 2018).

Based on the information derived from the SEB analysis, the EET performed a Cost-Benefit Analysis (CBA) to assess the efficiency of the frost warning. As mentioned before, it is difficult to attribute a specific portion of SEB values to the climate service intervention. We assume that the change in the proportion of adoption of weather/climate information is about 39% (i.e., the difference between the percentages of adoption during the first and last climate workshops, as stated in CLIMANDES project reports). In order to be conservative, we assume an implementation degree of 60% over the potential benefits. This number reflects the fact that achieving the potential benefits assessed in the SEB analysis may require that other efforts be simultaneously implemented, so we cannot attribute the whole implementation to the frost forecast. For example, the Programa País investment in the *tambos* may provide support that helps to attain the benefits of climate services, so we cannot assign benefits entirely to the climate intervention. Moreover, we assume operation and maintenance costs of 15% when the project is finished. We chose a 15-year span to develop the aggregated CBA estimates. With a higher discount rate (e.g., 12 percent), benefits more than a couple of decades out have minimal present value; thus truncating the analysis at 15 years is not likely to have a big impact on project decisions, and also allows a relatively short-run horizon, that is more informative when a high level of uncertainty is present.

Table 2 summarizes the key variables for the CBA analysis, including project timing, benefits, and the discount rate. For all calculations, real values were applied that do not factor in inflation or potential changes in exchange rates. A range of discount rates from 3 to 12 percent was explored. Using the 3 percent and 12 percent discount rates as lower and upper bounds and with the estimated annual benefits and costs as baselines, ex ante CBA estimates were calculated for the intervention explored. Table 3 shows the results of the baseline CBA calculations for a 15-year horizon. The present value of benefits ranges from 3.67 M USD to 0.75 M USD, assuming discount rates of 12 and 3 percent, respectively. These values are based on conservative assumptions, so we can conclude that the project is efficient even if we only consider the contribution of the intervention explored. That is, even though we recognize that additional effort is required for a general estimation of the socio-economic benefits,

the results for the intervention explored allow us to say that the project can have a positive economic return.

Table 2. Key variables for CBA calculations on the bases of the CLIMANDES case studies considered for the SEB analysis.

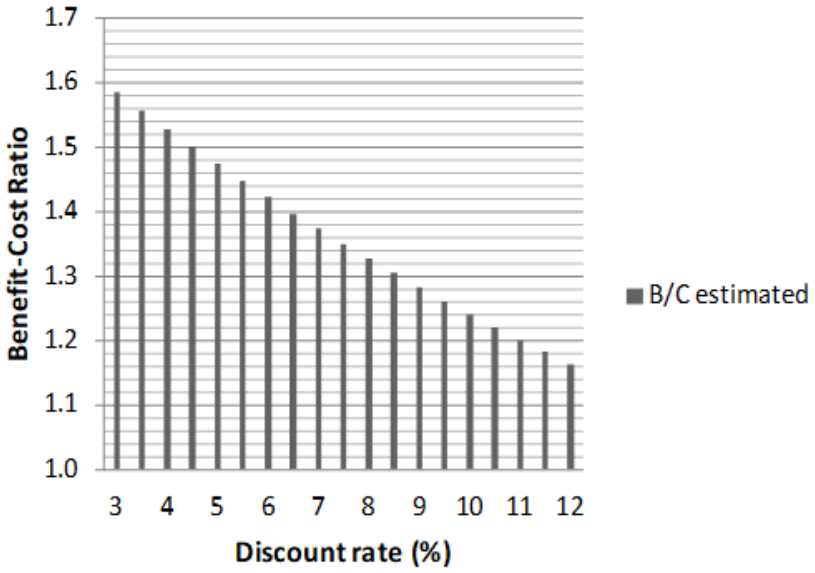
Key variables	Value
Project timing	
Total CBA analysis period	15 years
Benefit estimates (Millions of USD per year)	
Case Study 1 (Coffee production in Cusco)	1.24
Case Study 2 (Quinoa production in Puno)	2.60
Discount rate	
Base case	12%
Lower value for sensitivity analysis	3%

Table 3. Baseline CBA calculations for CLIMANDES-2 case studies.

CLIMANDES Cost and Benefit estimates (Million USD)		
Discount rate	**3%**	**12%**
Case Study: Coffee production in Cusco	3.13	1.68
Case Study: Quinoa production in Puno	6.83	3.66
Total NPV benefits	3.67	0.75

The Benefit to Cost ratio (BCR) has been computed for the baseline and the results are shown in Figure 3. There is an important source of uncertainty in the discount rate considered and for that reason, a range of interest rates between 3 and 12 per cent was considered for the sensitivity analyses. In all cases, the climate service intervention shows benefits that exceed costs, as the cost-benefit ratio is greater than one for the estimates considered. For this reason, and because the assumptions in this report are conservative, we conclude that the expected benefits of the hypothetical climate intervention are robust to possible sources of uncertainty.

Figure 3. Benefit-Cost Ratio for CLIMANDES-2 SEB case studies (Coffee and Quinoa production).



5 Summary Findings and Conclusions

5.1 Was CLIMANDES Relevant?

Climate is increasingly becoming an important element of public and private decision-making processes. Peru is among the countries most vulnerable to climate variability and change due to its extremely varied geography and topography. For instance, *Peru is South America's most water stressed nation.* The growing realization of the impacts of climate variability and change on Peru, together with the need to reinforce the human and infrastructural capabilities of SENAMHI to produce and disseminate authoritative, timely, and useful climate information to support public and private decisions motivated the development of project CLIMANDES.

Understanding how to provide effective decision support for adaptation to climate variability and change is now, and likely will continue to be in the near future, an important challenge to sustainable development in both the developed and developing world. Consequently, because the main question addressed by CLIMANDES was the production and dissemination of weather and climate information to support decisions*, the project's subject was extremely timely, relevant and important.*

The focus on smallholder agriculture was appropriate from the twin perspectives of development interventions and provision of climate services. Because most Andean farmers rely on rainfed crops and pastures for their livelihoods, agriculture in this region is especially susceptible to weather and climate conditions. Socially or economically marginalized people and regions – such as the Andean region and its inhabitants – are particularly at risk from climate-related hazards that place additional stresses on already constrained livelihoods. The results achieved by CLIMANDES, therefore, are highly relevant to

subsistence farmers in the Andes. This relevance was enhanced by CLIMANDES' careful elicitation of the needs, expectations, constraints, and sources of climate-related shocks to livelihoods of smallholders. *We stress, however, that weather and climate are only two drivers in a complex social and ecological context, therefore additional interventions that enhance livelihoods should have a broader scope than climate.*

On a larger scale, understanding how to provide effective decision support to adapt to climate-related shocks remains a challenge worldwide. The lessons and insights from CLIMANDES will contribute much-needed empirical understanding of the processes necessary to produce useful lessons to inform the design of decision support for adaptation to climate stresses elsewhere. Signs of the widespread interest in lessons from CLIMANDES were (a) its designation as one of only eight GFCS pilot projects worldwide, and (b) the 2018 SFIAR Team Award received by the project.

The concept of climate services in Peru will have to evolve rapidly in response to global agendas for climate adaptation and disaster risk reduction, and considering new, emerging approaches to development interventions. CLIMANDES has not focused significantly on variability tied to climate change (on multi-decadal temporal scales) and its likely impacts. Understanding how to cope with present-day climate stresses – a central focus of CLIMANDES – clearly has important implications for climate change adaptation. Nevertheless, in subsequent efforts the scope will have to be expanded to address longer time scales. We stress that uncertainty in projections of future climate will be greater than for seasonal forecasts. Lessons learned in dealing with the present low skill of seasonal predictions should be capitalized when working on climate change. That is, *policy-makers and other stakeholders should not await better projections of future conditions before making decisions. Irreducible uncertainty should be accepted and, consequently, robust decision approaches must be considered* (Lempert and Collins, 2007; Weaver et al., 2013). Robust approaches identify actions that minimize regret about outcomes (i.e., are "good enough"), regardless of the climate conditions that are experienced.

5.2 Was CLIMANDES Effective?

Without question, CLIMANDES has played a transformational role for SENAMHI, helping this institution to leap forward in achieving the human and infrastructural capacities needed to provide climate information services – initially, targeting agricultural production in the Andean region of Peru. CLIMANDES has effectively established SENAMHI's role as the clear leader in the provision of climate services in Peru.

As discussed in Section 2.1, this evaluation is in part a *summative* review, as it examines and discusses the project outcomes. Detailed discussions of each CLIMANDES activity are available in Sections 3 and, in more detail for Phase 2, in Section 4. These discussions show that the EET was satisfied with progress on most project tasks, and did not find serious issues or outstanding problems – although suggestions were made to improve the weaker aspects of the project. The EET also acknowledges that most recommendations from the external review of Phase 1 were addressed (to the project's advantage) during CLIMANDES-2. *Consequently, we can confidently state that Climandes was very effective in achieving its proposed goals.*

The monitoring and evaluation component of CLIMANDES had limitations that restricted the EET's ability to assess the project's effectiveness other than through the expert judgment of reviewers. These limitations have made it challenging to evaluate the impact and value of the CLIMANDES intervention relative to a baseline. For future efforts, we suggest that designing for evaluation from the beginning of a project is a key requirement for enabling the assessment of climate services and, in particular, their economic valuation – information often required by policy makers to justify investment. *Monitoring and*

evaluation should be embedded into the project's design, not an afterthought. Another important aspect to be considered is the need for methods that test the efficacy of communication strategies to ensure that appropriate and accurate uncertainty information is provided and that this is interpreted correctly (Otto et al., 2016).

5.3 Did CLIMANDES Have an Impact?

As stated above, CLIMANDES has had a most significant impact on SENAMHI, which gained much visibility at national, regional, and global levels. Through CLIMANDES, SENAMHI gained first-hand experience on the provision and dissemination of climate services. At the same time, the project really "opened SENAMHI's eyes" (as stated by a participant) about the multiple challenges involved in producing and communicating usable climate services. Because of the CLIMANDES experience, SENAMHI has realized that such task requires truly transdisciplinary teams (i.e., the expertise needed goes beyond what SENAMHI's staff alone can provide), as well as sustained, time- and resource-intensive interactions with a wide variety of stakeholders, from individual smallholder farmers to governmental institutions. Nevertheless, we feel that stronger benefits could have been derived from the CLIMANDES designation as a GFCS pilot project.

One major lesson learned by SENAMHI is that sustaining and scaling the role of climate service provider will be hard. A strong institutional commitment (and a commensurate budget that includes the "Direcciones Zonales") will be required for SENAMHI to sustain the role played in CLIMANDES. The EET learned that SENAMHI plans to create a General Directorate for Climate Services (Dirección General de Servicios Climáticos, DGSSCC) within its organizational structure. As stressed throughout this report, sustainability is THE major challenge at this time. Another clear lesson is that – regardless of available budget – SENAMHI cannot (and should not!) tackle by itself *all* aspects of the production and dissemination of climate services in Peru. CLIMANDES started to knit the necessary "knowledge network" with other institutions, but the need remains for the involvement of agencies/institutions from climate-sensitive sectors.

CLIMANDES has raised awareness among Peruvian governmental organizations at multiple jurisdictions, NGOs, and individuals about the potential of climate information services as an important contribution to improving societal capacity to manage climate-related risks and opportunities. The EET has seen considerable evidence of positive efforts to align CLIMANDES activities with national Peruvian policies and institutional processes at different governmental levels, from municipalities to regional and national levels. At the local level, for example, the government of Pusi is trying to include CLIMANDES-like training into their budget. Regional structures such as the Centro de Operaciones de Emergencia Regional in Puno developed an active interaction with CLIMANDES, now formalized through institutional agreements. Finally, an example of interactions at national level is the cooperation with MINAM and MINEDU in the Plan Nacional de Educación Ambiental.

One of the regional outcomes anticipated was a very active role of the RCC-WSA in producing and disseminating regional-scale climate information and climate services emerging from the CLIMANDES experience. In turn, the RCC-WSA was expected to use the experiences from CLIMANDES to help strengthen the national capabilities of its member countries (Peru included). The report discussed above the RCC's involvement (see Section 4.2.5): the specific activities agreed upon in a subcontract between CLIMANDES and the RCC-WSA appear to have been mostly completed (although documentation was unavailable to the EET). Nevertheless, we did not get the sense of fluid and frequent interaction between CLIMANDES partners and the RCC. We continue to acknowledge the key role that RCCs might play in brokering and facilitating the exchange of information, experiences and tools to/from national entities, and therefore we would envision active participation of the RCC-WSA in a post-CLIMANDES effort

with a regional (supra-national) scope. Nevertheless, we suggest that clear consensus be reached among possible post-CLIMANDES partners (e.g., NMHSs and the RCC-WSA) on their expected roles and responsibilities.

The "twinning approach" in CLIMANDES accomplished effectively its purpose of enhancing institutional capacities through mutual learning. The "twinned" NMHSs acknowledged an evolution in the nature of collaborative relations throughout the project. Whereas MeteoSwiss had to "hold SENAMHI's hand" (according to Peruvian participants) during most of Phase 1, both institutions felt they had comparable roles and responsibilities during Phase 2.

5.4 Was CLIMANDES Efficient?

This evaluation of the CLIMANDES project suggests that overall the project has made an efficient use of allocated funds, and of human resources' time and expertise to achieve the proposed objectives. The EET's assessment of efficiency is based on the comparison of the effectiveness of each task (i.e., whether proposed outputs were achieved and goals were met) and the funds invested in each component.

Due to the predominantly meteorological/climatological information and expertise required for provision of climate services, the two lead institutions (MeteoSwiss and SENAMHI) were the most adequate partners to implement CLIMANDES efficiently. External partners bring additional expertise on particular topics (e.g., agricultural impacts and mitigation practices), but the ownership and liaison with the Peruvian society should remain closely attached to the local institution, i.e. SENAMHI. The appropriateness of the intervention strategy in terms of topics, partners and geographical focus was discussed above (Section 5.2).

We recognize that the management structure of CLIMANDES-2 has been reasonably efficient in coordinating an implementing the different activities. Clear improvements took place in relation to Phase 1. The monitoring of the project has been steered by periodic management meetings (on-line) and frequent, timely reporting. Even though CLIMANDES-2 will need an extension to complete all the products (quite common is large-scale projects) the management has been reasonably effective.

Based on the CLIMANDES SEB analyses and the financial CBA analysis calculated from these estimations, we can state that CLIMANDES is also efficient in economic terms. Even when considering the SEBs for only two interventions – impacts of weather/climate information on coffee production in Cusco and on quinoa production in Puno – the BCR is higher than 1 (i.e., the expected benefits for these two interventions more than cover the total costs of the project) for a range of discount rates and under conservative assumptions. The project has shown it can provide a range of socio-economic benefits that have not been computed, so still there is room for improvement in future SEB analyses.

Table 4 presents a detailed product-by-product list of the budget allocated to each task, the task's share of the total CLIMANDES-2 budget, and the EET's subjective assessment of the effectiveness and efficiency of a task. To assess effectiveness, we follow an approach similar to that used in the first external evaluation (see Table 5 and Table 6 in Annexes): a difference is that we use four effectiveness levels (Low, Medium/Low, Medium, High). In most cases, the EET's assessment of effectiveness is "High," as the objectives of most tasks were achieved. "Low" or "Medium/Low" effectiveness scores were assigned only in three cases: (i) use of seasonal forecasts, (ii) formal education at UNALM and (iii) recruitment of regional students by the RTC. These cases have been previously discussed; the deficiencies can be attributed in the first case to the absence of skillful forecasts (although quick adaptation to the program activities avoided a "Low" score). Low effectiveness in RTC-related activities can be tied to institutional problems that could not be solved within the scope of CLIMANDES.

Fortunately, the RTC activities that were assigned low or medium/low effectiveness did not involve significant portions of the project's budget, therefore their efficiency was assessed as "Medium." Activities related to production and use of seasonal forecasts involved a substantial portion of the budget, thus their efficiency was assessed as "Low". This score should not be interpreted as a reflection of the bad quality of the work performed. As stated above, the EET appreciates the alternative actions taken in response to the realization of limitations in seasonal forecasts. Nevertheless, we assign the "Low" efficiency to suggest that in future activities, expectations about the role of seasonal forecasts in the climate service enterprise should be adequately managed. That is, forecasts should be used carefully, perhaps as mechanisms to produce interesting scenarios for which their implications can be explored/discussed with stakeholders.

Table 4. Assessment of the effectiveness and efficiency of CLIMANDES results and products.

Expected results	*Implemented actions*	*Budget (k CHF)*	*Share of total budget (%)*	*Effectiveness*	*Efficiency*
Result 1. SENAMHI produces and shares user-tailored climate services, mainly for the agricultural sector in the Andean Region, and therefore improve socio-economic benefits.	Product 1.1. Climate services on precipitation and drought monitoring.	380	8.4	High for short-term forecasts.	High
				Medium/Low for seasonal forecasts.	Low
	Product 1.2. Seasonal forecast prototype (Climate Service).	365	8.1	Medium	Medium/Low
	Product 1.3. Scientific publications on climate services and tools.	135	3.0	Medium	High
	Product 1.4. Systematization of experiences and diffusion of results from CLIMANDES.	220	4.9	High	Medium
Result 2. Climatology and meteorology-related professionals and students are able to develop high-quality climate	Product 2.1. Ensure minimum education quality standards for the meteorology study program at the CFRM-UNALM, as defined by national educational entities and the WMO.	24	0.5	Low	Medium/Low
	Product 2.2. Promotion strategy for the	21	0.5	Medium/Low	Medium

Expected results	*Implemented actions*	*Budget (k CHF)*	*Share of total budget (%)*	*Effectiveness*	*Efficiency*
services for the region.	Meteorology Study Program offered by the CFRM-UNALM in the Andean region.				
	Product 2.3. Implementation of learning tools (e-learning, virtual learning, etc.) about Climate Services.	570	12.7	High	High
	Product 2.4. Other training efforts	235	5.2	High	High
Result 3. Stakeholders in the agricultural sector are aware of the SEB of climate services and influence public policy.	Product 3.1. Stakeholder mapping of the agricultural and food security sector	250	5.6	High	High
	Product 3.2. Establishment of a User Interface Platform	360	8	High	High
	Product 3.3. Case study to estimate the potential value of climate services for the agricultural sector	460	10.2	High	High

5.5 Will CLIMANDES Activities be Sustainable?

The sustainability within Peru of efforts initiated by CLIMANDES is probably the major challenge faced at this stage of the project. The external evaluation of CLIMANDES-1 suggested that its planned continuation (what would become Phase 2) should be more proactive in ensuring the sustainability of the results by seeking national (Peru) and external funding, possibly making more intensive use of the opportunities offered by WMO's RA III. The EET recognizes that during Phase 2, active development of strategic partnerships and collaboration agreements between SENAMHI and relevant national institutions was initiated. To date, there seems to be more progress at pilot project sites (Cusco and Puno) than at SENAMHI Headquarters – where, perhaps, federal institutions such as Ministries are less nimble and move more slowly.

SENAMHI, according to the interviews held with the EET, will undergo an internal reform to ensure the sustainability of CLIMANDES. A General Directorate for Climate Services (Dirección General de Servicios Climáticos, DGSSCC) will be created within SENAMHI's organizational structure. According to SENAMHI this internal adaptation will not require additional funding. The establishment of the DGSSCC will need

to enhance coordination with the regional actors and institutions identified during previous CLIMANDES activities.

Preliminary successes in the quest for additional support have been achieved: for example, SENAMHI has been able to successfully apply for funding through two regional projects supported by the European Union's EUROCLIMA+ program (one with Bolivia, one with the RCC-WSA). Moreover, CLIMANDES partners are part of the planning for large regional projects, e.g., the ENANDES program; these projects may offer the opportunity (and the funds) to scale up CLIMANDES' approach. Coordination with WMO's Regional Office for the Americas should be sustained and intensified, and CLIMANDES or follow-on activities should continue to be involved in RA III activities.

The EET suggests the actions listed below as a contribution towards the sustainability of the project's results. Probably, many of these actions already have been started or considered, but we list them here so they can provide a checklist.

- Support continuation of many CLIMANDES-like activities through the regular budgets of local, regional, and national governments. This action requires that the socio-economic benefits and usefulness to institutions and communities of the activities be clearly and convincingly articulated. Also, champions of climate services resulting from CLIMANDES should be identified within governmental institutions.
- Persuade relevant institutions (strategic partners) to allocate human resources to sustain CLIMANDES-like activities. These personnel could form an ad hoc task force.
- Engage partners and supporters from the private sector. CLIMANDES services benefit not only local communities, but also private sector entities (e.g., the radio stations that broadcast weather forecasts and advisories see an increase in their audience). The CLIMANDES mapping of relevant actors should be reviewed to search for potential sponsors or supporters from the private sector. In particular, appeals to Social Corporate Responsibility should be considered, particularly if they can be tied to potential tax benefits (the EET does not know if such mechanisms exist in Peru).
- Actively search for international funding opportunities. CLIMANDES actors such as academic institutions, governmental offices and SMNHs have access to a large number of international funding programs and agencies (ERASMUS+; H2020; World Bank, IDB, WMO's Voluntary Cooperation Program, USAID, and obviously, SDC, to mention just a few). CLIMANDES results can be sustained, and expanded by actively working to build consortia and apply to these funding opportunities.
- Continue communicating the value of climate services. SEB studies demonstrate the value of climate services and thus might facilitate mobilization of additional human and economic resources.

5.6 Did CLIMANDES Address Gender Issues?

The Project Document for CLIMANDES-2 acknowledged that the effects of weather and climate are not gender neutral, and that information about weather and climate is accessed and used differently by female and male user groups. According to Peruvian statistics, 30-40 per cent of women in the Cusco and Puno pilot areas are involved in agricultural activities. *Nevertheless, the project did not propose specific actions among its objectives, nor allocated funding specifically aimed at the inclusion of women or the reduction of the gender gap.* Despite the lack of explicitly proposed gender-relevant actions, during project implementation CLIMANDES actively encouraged the equitable involvement of men and women in project activities, not only as investigators, project managers and communication/outreach specialists, but also as stakeholders.

The EET did not have a chance to meet beforehand with a local social scientist to gain a deeper understanding of the role of women in Andean communities. We were told that the Andean cosmovision perceives males and females as "equal but different," meaning that they have different roles but not implying a hierarchy. When males are present, they typically perform farm chores that require physical strength. Increasingly, though, men seek temporary employment in nearby towns to supplement the household income: in this case, women take on the full range of farming decisions and activities. As mentioned elsewhere in the report, women typically bear the brunt of food shortages in smallholder systems, because they tend to skip more meals than men when food is scarce (Loboguerrero et al., 2018).

To get insights on the impact of CLIMANDES among female stakeholders, the EET had requested that a comparable proportion of men and women be invited to the meetings with local communities. This was the case in Cusco. Additionally, the manager of the Huaccaytaqui tambo near Cusco – where the meeting took place – was a highly enthusiastic and proactive woman who clearly brought rural communities together. The female farmers interviewed in Huaccaytaqui seemed to play an active role in the community: one of them had been designated a *yachachiq*, a high honor. Nevertheless, the women generally participated less in the discussions, and mostly spoke when we addressed direct questions or comments to them. In Pusi (near Puno), local stakeholders did not include women (who apparently were in another meeting taking place at the same time), but we were briefed on the important role they played in the community, especially when men take jobs in the cities and farms are run by women. The aggregated numbers of males and females in household surveys and climate workshops suggest balanced gender participation.

Currently, there is a drive to improve access for women to technology, information, science education and technical training and to strengthen the position of women scientists and technologists – for example, WMO's efforts to achieve gender equality, empower women and build climate resilient societies. Participation by gender, therefore, was assessed among the professionals participating in CLIMANDES. The CLIMANDES-2 management structure (Figure 1) shows a balanced proportion between men and women. Women are present in all project components and at all levels. In particular, the three CLIMANDES coordinators at WMO, MeteoSwiss and SENAMHI are female. In SENAMHI headquarters in Lima, there is a very high proportion of women in the staff; this pattern is common among NMHSs in the region. Unfortunately, in many cases the larger proportion of women in NMHSs is related to the low salaries of government jobs. In addition to sheer numbers, we should note that many of the project women in SENAMHI are well known in the climate community; these people are a valuable asset to SENAMHI and to CLIMANDES. Similarly, CLIMANDES personnel at MeteoSwiss involved comparable numbers of men and women. In the pilot regions, the personnel hired by CLIMANDES (at least those whom the EET met) were almost all men. We do not know if the proportion of female graduates in climate and/or agriculture is lower outside Lima. Our interviews with local and regional authorities and mid-range representatives of governmental bodies also involved a low proportion of women; this proportion was higher in collaborating NGOs (for example, in Cusco). Finally, participants in training courses offered by SENAMHI and the RTC included comparable numbers of males and females.

There is one specific gender-related issue to consider in follow-on efforts: we met female farmers who could not converse in Spanish, whereas this did not happen with men. The language/gender interaction may have strong implications for the design of future communication and training activities. Participants in pilot sites repeatedly stated their wish for more Quechua- or Aymara-speaking personnel; follow-on work should plan for this need.

Greater inclusiveness might be achieved in future efforts if proactive gender-related activities are addressed explicitly during the planning and project development stages. That is, post-CLIMANDES efforts

should explicitly aim to mainstream gender in their governance, working structures, activities and service delivery. Another goal of post-CLIMANDES initiatives should be to attract more women into the fields of science and engineering in general, but in particular climate science and its applications. The WMO policy on gender mainstreaming lists useful indicators that might be monitored in future efforts.

6 Recommendations for a Post-CLIMANDES Initiative

In addition to the assessment of completed CLIMANDES activities, SDC asked the EET to provide strategic orientation and recommendations for the design of a future initiative on climate services for sustainable development. This effort, subsequently referred to as the "Post-CLIMANDES Initiative" or PCI, should build on the accomplishments of CLIMANDES, promoting and enabling regional climate services that increase resilience to the impacts of climate variability and change in South America. To that effect, in this section the EET will discuss possible objectives, geographic and thematic scope, intervention strategy and design, relevant actors, and the partnerships and institutional arrangements needed for a PCI.

6.1 General Design Considerations for a Post-CLIMANDES Initiative

Sustained focus on climate services. Climate has become an important element of public and private decision-making processes. In particular, scientific knowledge will be essential to enhance the capacity of sectors and governments to respond to the challenges posed by climate variability and change. Understanding how to provide effective decision support for adaptation to climate variability and change is now, and likely will continue to be in the near future, an important challenge to sustainable development in both the developed and developing world. A common response to growing demands for useful climate information often involves increasing research funding and producing more information (McNie, 2012). Nevertheless, increasing societal resilience to climate is not just about enhancing information; it is also about building necessary capacity, developing two-way communications and overcoming institutional, technological and cultural barriers. Because CLIMANDES explicitly addressed many of these issues, there is a timely opportunity to build on the achievements of this project through follow-on efforts. For this reason, *we recommend that a PCI should continue to promote and enable the production and dissemination of climate information and services to support policy- and decision-making in climate-sensitive sectors and to increase resilience to the impacts of climate variability and change.*

Continued contributions to GFCS implementation. The past few decades have witnessed considerable progress in climate science. Nevertheless, there is a general concern that stakeholders are not yet fully benefiting from scientific progress because the uptake of climate services in support of decision-making still is relatively limited. Such concerns motivated the establishment of the GFCS (Freires Lúcio and Grasso, 2016). At the global level, the GFCS focuses on defining global goals, needs, and large-scale activities required for successful implementation of the Framework. At the regional level, however, there is ample scope to support and strengthen the GFCS activities, for example, through facilitation of knowledge and data exchange, infrastructure development, and support for research and training. *A post-CLIMANDES effort should continue to contribute to the implementation of the GFCS at regional (supra-national) and national scales.*

Coherence with global policy agendas. In 2015, the international climate policy agenda underwent a complete overhaul (Dilley and Grasso, 2016). On that year, the international community set global goals for 2015-2030, aiming towards sustainable development (2030 Agenda for Sustainable Development), adaptation and mitigation of climate change (UNFCC, Paris Agreement), and reduction of risks

associated to natural disasters (Sendai Framework). These agreements have had a profound influence on cooperation and development policies in Switzerland and throughout the European Union. The ultimate success of international agreements, however, depends on the appropriate translation of global goals into specific national policies and actions. *The combination of CLIMANDES' experience on climate services, together with SDC's capacity building and institutional strengthening expertise, can make a significant contribution towards the necessary translation of scientific evidence on climate into policies and practices in climate-sensitive sectors of South America.*

Contributions to development challenges. In the face of the multi-dimensional challenges created by global climate variability and change, climate service interventions like CLIMANDES are critical to enhance the resilience of marginalized groups and thus contribute to the pursuit of global development agendas. Throughout the world, there are clear linkages between poverty and vulnerability, and climate-related stresses. On one hand, climate impacts are an obstacle to the sustained eradication of poverty. On the other hand, if poverty can be reduced before climate change becomes even more severe, populations will become less vulnerable to climate impacts. In other words, the provision of relevant climate information can help to reduce societal vulnerability to climate – particularly among the poor –by informing planning and preparedness actions. Consequently, the *production and dissemination of climate information and services as part of a PCI can play an important role in advancing development interventions and poverty reduction. Nevertheless, future provision of climate services aimed at reducing poverty should not be pursued in isolation from equally important and complementary development actions, such as improving access to markets and credit, and strengthening social protection systems and safety nets.*

Diverse institutional participation. Decision makers at many levels–households, communities, regions and countries–increasingly will need usable information that combines state-of-the-art climate science with an integrative understanding of the dynamics of affected social-ecological systems. Research and practice on climate science, therefore, must be complemented by improvements in the way in which climate information and knowledge is analyzed, assessed, synthesized, communicated and merged with the needs, procedures and decision protocols of climate-sensitive sectors of society. A PCI in South America should seek to engage a diverse set of actors. Academic experts from the social sciences can help to understand decision processes and information uptake. Engagement of governmental agencies, NGOs and the private sector can ensure the relevance of the proposed agenda of activities. Other UN agencies beyond the WMO and multilateral institutions (World Bank, Inter American Development Bank, Corporación Andina de Fomento) can leverage SDC funds and facilitate a path towards the operationalization of PCI efforts. *The potential roster of PCI participants should be sufficiently broad and balanced to provide an integrative understanding of the dynamics of climate-sensitive sectors and of the economic, social, and cultural contexts in which climate adaptation decisions are embedded.*

Support of an active research program. *The sustainable provision of operational climate services must be supported by an active, user-centric research program.* Because climate services depend critically on diagnostics of recent conditions and predictions/projections of regional climate, climate science clearly must be an important research focus of any climate service. Nevertheless, as the information produced by a PCI will likely be aimed at assisting decision making in climate-sensitive sectors (e.g., agriculture, water resources, human health), progress in climate knowledge must be matched by a commensurate understanding of how natural and social sciences can inform climate-resilient decisions and policy (Harrison et al., 2008; Stainforth et al., 2007).

6.2 Geographic Scope of a Post-CLIMANDES Initiative

After the previous generic design considerations, the next logical question about a PCI is "what should the geographic scope of a PCI be?" We assume that SDC wants to continue its work in South America. Many countries in South America are highly vulnerable to climate variability and change due to their socioeconomic, geographic and institutional characteristics. The region faces important potential losses in biodiversity and human lives due to extreme climate events. If SDC wishes to sustain its focus on mountainous regions, the geographic scope of a regional PCI in South America could potentially encompass the Andean portions of six countries: Colombia, Ecuador, Peru, Chile, Bolivia and Argentina.

Most of the regional economies involve an important agricultural sector and a broad range of crops (see ccafs.cgiar.org/regions/latin-america). The importance of the agricultural sector in South America is illustrated by the fact that, according to FAO statistics for 2016, *five of the top eleven global producers of soybeans are in this region* (Brazil, Argentina, Paraguay, Bolivia and Uruguay). The agricultural sector presents a high sensitivity to climate variations: South America relies mostly on rainfall to sustain a huge crop and cattle production that contributes to global food security and trade, and to transport agricultural goods along its waterways.

The GFCS leaves implementation of climate services to the individual countries. Even GFCS-related entities such as RCCs receive little to no support from the WMO, which at most helps to broker assistance from donor countries. For example, the two active RCCs in the region (for western and southern South America) must support their activities through contributions from their member countries (mostly in-kind, such as staff time) or through external funding. In light of this situation, fostering effective regional cooperation towards the provision of climate information and services in South America – a region where the gap between climate science and policy remains wide open – should be a logical follow-on step for SDC after CLIMANDES.

The South American institutional context for the production, dissemination and use of climate information services shows considerable asymmetries in the capabilities (infrastructure, human capital) of NMHSs throughout the region. A PCI with a regional (supra-national) scope would encourage and support regional cooperation, and thus contribute to address disparities in national capabilities. Unfortunately, most NMHSs (even those with more capacities) have chronic personnel shortages, low budgets, limited incentives for staff development, and operational missions that take priority over other tasks (especially, recent and still unfamiliar activities such as climate service provision). However advantageous the collaboration may be, NMHSs have limited budgets to engage actively in regional interactions. *Support from a PCI would be instrumental in fostering active interactions among NMHSs and other institutions from climate-sensitive sectors, facilitate sharing of experiences, and draw on the respective strengths of each country in the region.*

6.3 Other Ongoing or Planned Efforts in South America

Efficient use of scarce resources requires that the design of a PCI must seek to complement and leverage other ongoing or planned climate-related efforts in South America. This report has previously listed some of these efforts, but it may be worthwhile to recapitulate and discuss some of them in this section.

In the Andean region of South America, two climate-related projects have been funded by the European Union through its EUROCLIMA+ 2018 announcement of opportunity. These two projects, scheduled for an early 2019 start, are respectively led by CIIFEN – a project focusing on extreme events such as droughts and floods – and by SENAMHI Peru in partnership with SENAMHI Bolivia. Additionally, countries in the Regional Climate Center for Southern South America (which includes three potential PCI partners with mountain regions: Chile, Bolivia and Argentina) have applied for another EUROCLIMA+

project focusing on the development of a drought information system for southern South America. This proposal is still under review and a decision on funding should be forthcoming in the near future.

Another relevant effort currently under development is the proposal being developed for funding from the UN Adaptation Fund. This project, called ENANDES, seeks to reduce vulnerability and increase resilience of the Andean communities in Colombia, Peru and Chile to climate variability and change by implementing climate-smart decision-making networks for better disaster risk, hydropower generation and agriculture management. Some of the activities proposed for ENANDES are consistent with the goals of a PCI. If funded, the implementing agency for ENANDES will be the WMO, therefore SDC should approach the WMO to explore potential synergies between ENANDES and a PCI. We note, however, that ENANDES partner countries include only Colombia, Peru and Chile, plus the RCC-WSA.

6.4 Drawing on Swiss Expertise for a PCI

A PCI should draw as much as possible on the strengths, experience and expertise of Swiss institutions. Throughout this report, we have highlighted aspects in which Switzerland can offer significant expertise that will add considerable value to a PCI. A major contribution to the design and implementation of a PCI would be based on the experience gained by Switzerland in the design and implementation of the Swiss National Center for Climate Services (NCCS). The NCCS provides a national coordination and innovation mechanism to support climate-sensitive decision-making. The NCCS coordinates the development and dissemination of climate services. Acting as an interface between producers and users, the NCCS encourages dialogue and fosters the collaborative development of climate services. In this way, the NCCS ensures that its work is focused on the needs of the users. During the inception stage of the CLIMANDES review, the EET considered that the NCCS could provide a useful model for climate services as part of a PCI. Consequently, we requested a briefing on the Center's design and functions during our visit to MeteoSwiss; the briefing was kindly provided by Ms. Cornelia Schwierz.

A key feature of the NCCS model is one that, so far, seems to be missing in many of the WMO-related institutions in South America: the active participation of institutions from climate-sensitive sectors. For instance, the Regional Climate Centers list as members the NMHSs of countries involved, and a few associated institutions that are mainly from the climate sector (e.g., academic departments of climate science). To date, however, there seems to have been limited involvement and participation in the RCCs' strategic decisions of other actors. In contrast, the Swiss NCCS included several institutions from climate-sensitive sectors *from the beginning* of the Center's activities in late 2015. For example, institutions involved in the NCCS include the Federal Office of Meteorology and Climatology (MeteoSwiss), the Federal Office for the Environment (FOEN), the Swiss Federal Office for Civil Protection (FOCP), the Federal Office for Agriculture (FOAG), the Federal Office of Public Health (FOPH), the Federal Food Safety and Veterinary Office FSVO, the Swiss Federal Institute of Technology in Zurich (ETH Zurich), and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL).

Another area in which Swiss expertise would be clearly helpful to a PCI is the strong expertise of MeteoSwiss on climate data management. Some of the Swiss experience on data stewardship was transferred to Peru as part of the CLIMANDES "twinning," but the entire region also would benefit significantly from this experience. We discuss below state-of-the-art climate data management as one possible focus of post-CLIMANDES efforts – of course, avoiding repetition of earlier work. A Swiss contribution to the enhancement of regional Climate Data Management Systems (CDMSs) would also leverage efforts planned as part of the ENANDES project being proposed to the UN Adaptation Fund.

6.5 Developing Strategic Partnerships

Over the past few decades, two important factors have contributed to a dramatic increase in society's awareness of the usefulness of considering climate information in public and private decision-making. First, decision-makers in governments, private sector organizations and academia understand better the linkages between present and future climate, and equitable and sustainable economic growth and development. Second, climate observations and predictions/projections are becoming increasingly available and accessible to decision-makers. Despite advances in our ability to monitor and predict variations in climate, use of climate information in decision-making still lags the availability of new knowledge (Baethgen et al., 2009). Moreover, the mere availability of climate information does not necessarily guarantee its use in decision-making processes (Dilling and Lemos, 2011).

The information needed for climate-related decisions goes well beyond data about the physical climate, and must also include evidence on impacts, adaptation, vulnerability, and a host of socioeconomic factors (Hewitson et al., 2017). That is, progress in climate knowledge must be matched by a better understanding of how science can inform climate-resilient decisions and policy (Harrison et al., 2008; Stainforth et al., 2007). In turn, this will require the active involvement of a broad disciplinary spectrum of scientists, policy makers, resource managers and practitioners able to work effectively at the interface between research and decisions, "coproducing" actionable knowledge with social actors. The seasonal forecasting experience clearly shows that early, iterative communication and partnerships among scientists and stakeholders are the most effective paradigm for increasing the usability of climate information (Dilling and Lemos, 2011). *Innovative partnerships with a range of academic, research, governmental and non-governmental organizations, and private firms from multiple sectors of society will be necessary to enhance the provision of climate services as part of a PCI.*

6.6 Options for a post-CLIMANDES Initiative

This section discusses various alternatives for a PCI. Some of the options discussed below are not mutually exclusive – aside from budgetary considerations – and could be regarded as complementary.

6.6.1 Option 0: A CLIMANDES 2.1?

Before we go into discussing PCI options we propose an alternative that, for the sake of this discussion, we call "CLIMANDES 2.1." Because this option is not rigorously associated with a PCI, we label it as "Option 0." Nevertheless, SDC could pursue this option regardless of other decisions about a PCI. In fact, adopting this alternative may even contribute to enhance the design of other follow-on activities. *Briefly, we envision CLIMANDES 2.1 as a short (6 to 9 months) effort during which no new activities would be started. Instead, this stage would focus on reflexion, synthesis and communication of CLIMANDES lessons.*

We can suggest three simultaneous foci for CLIMANDES 2.1. First, this stage should seek to complete important components of CLIMANDES-2, for instance, publications in preparation (both scientific and for general audiences) or the design of a drought monitoring system for Peru. The activities to address should be chosen carefully to maximize the achievable benefits: for example, given the lengthy and complicated institutional processes required, probably no effort should be invested during CLIMANDES 2.1 to seek approval of academic programs at UNALM. Second, strong efforts should be made by SENAMHI to consolidate institutional partnerships and agreements aimed at sustaining, and possibly scaling up, CLIMANDES interactions with stakeholders and the dissemination of weather/climate information. Third, and most importantly, a rigorous process (including professional facilitation/guidance, if needed) should foster collective reflexion on the lessons from CLIMANDES, including how these lessons can help to

improve the future production, dissemination and use of climate information throughout Peru and other countries of the region, or in other climate-sensitive socioeconomic sectors or activities.

The EET is fully aware that SDC wants to lower the curtain on CLIMANDES (an intention illustrated by SDC's choice of the "post-CLIMANDES" term). Nevertheless, we put forward the CLIMANDES 2.1 option because we saw firsthand how participants in both Peru and Switzerland are rushing to complete multiple pending activities that, in the EET's opinion, are unlikely to be finished by March 2019. Does this "unfinished business" indicate poor project execution that should not be rewarded by additional funding? Not necessarily. In a long, complex program (particularly Phase 2, in which the different modules and activities were highly interdependent), delays may be due to the discovery of unexpected opportunities, or to smart, adaptive adjustment of previous goals and activities. More importantly, the current rush to complete pending work by March 2019 does not afford participants the luxury of slowing down and reflect on what CLIMANDES achieved (or did not), or to synthesize the project's findings to inform future efforts in the region and elsewhere.

Again, we stress that any activities supported by a hypothetical CLIMANDES 2.1 should be carefully and wisely selected. Nevertheless, we believe that a relatively small additional investment by SDC (in relation to the 7.5+ M CHF already invested) would make it possible to achieve many accomplishments that may not be completed otherwise, and to distill useful experiences and guidelines to inform future provision of climate services.

6.6.2 Option 1: Climate services for one climate-sensitive sector

As discussed above, the geographic scope of a regional PCI in South America could potentially encompass the Andean portions of six countries: Colombia, Ecuador, Peru, Chile, Bolivia and Argentina. It seems clear that SDC cannot fund up to N simultaneous efforts (i.e., in N countries) with the depth and breadth of CLIMANDES – the option we call "CLIMANDES times N". *Therefore, SDC should invest as much time and effort as needed to identify much more narrowly-focused PCI themes – yet societally important and intellectually challenging – to make a regional, multi-national effort economically viable.*

The first option we submit is "N countries, *one* sector." This involves a PCI focused not only on a single climate-sensitive sector, but perhaps even on *one specific problem or question within that sector.* Possible overall themes for such a PCI could involve relevant questions within any of the five GFCS priority areas: (i) agriculture and food security, (ii) disaster risk reduction, (iii) energy, (iv) health, and (v) water. Due to the importance of agriculture in the countries involved and the path already explored by CLIMANDES 1 and 2, Agriculture and Food Security deserves and still needs considerable attention. Other Andean countries have important populations of smallholder farmers – the target of CLIMANDES efforts. A PCI could continue to focus on these stakeholders in light of the obvious links to poverty reduction and development goals. At the same time, a PCI could also focus on market-oriented agriculture, where there may be many more opportunities to adapt agronomic management and marketing strategies in response to diagnostic and prognostic climate information. In any case, continuing with the focus on agriculture would build on earlier efforts, capitalize on previously gained knowledge, and facilitate a natural transition towards other societal sectors through obvious links (e.g., the food, water and energy nexus; health and food insecurity, etc.).

In any case, *a specific problem or question should be identified within the chosen priority area* – that is, selecting "water" or "agriculture" as a theme still would be too broad. We submit that three other conditions should be satisfied. First, *all PCI activities should be problem-driven:* participants from different disciplines or with different roles (scientists, policy-makers, resource managers, individual decision-makers) can organize their activities around the problem targeted. Note that despite the *a priori* selection of a problem or question during the announcement of opportunity, during detailed

planning sufficient time should be invested in shared problem definition, clarifying any ambiguities or misunderstandings before implementation starts. Second, *the early involvement of multiple types of stakeholders must be feasible* (i.e., relevant stakeholders should be identified and engaged very early in the project, ideally even during the planning stage). Third, we recommend that *the chosen theme must be of comparable interest to all participating countries to ensure effective commitment and engagement*; this last requirement may not be as easy to accomplish as it appears.

Another important requirement of a problem-centric PCI is the need for expertise beyond that available within NMHSs. A common element of the current discourse on climate services is the special nature and importance of NMHSs (Harjanne, 2017). Other institutions are welcome, but NMHSs often are the key actors, the central nodes. The main argument is that NMHSs are naturally suited to be the central actors because of their expertise, institutional position and infrastructure. Nevertheless, because the PCI approach should be problem-centric and not focused solely on climate science, expertise will be needed not only on climate, but also about the activity or sector targeted. For example, a PCI will require sector-specific process models that link climate (observed or expected) with likely impacts; such models should allow the exploration of viable actions to mitigate negative impacts or capitalize on favorable conditions.

During a visit to SDC Bern as part of the CLIMANDES review, the topic of involving sectoral actors in a PCI came up. Initial reaction by SCD management was that this involvement would "fall outside the scope of climate services." Nevertheless, at the end of the conversation we agreed that climate services encompass the *full* range of needed components – from producing climate information to supporting decisions in a sector (including assessing likely impacts and providing risk management options). Unavoidably, this implies the need for sectoral or domain knowledge.

The "knowledge network" of institutions to be engaged should include the private sector (e.g., operators of hydropower plants if the theme were related to energy or water). Creative mechanisms to attract private participation should be designed. Special consideration should be given to the involvement of boundary institutions that bridge the divide between information producers (scientists) and information users (policy- and decision-makers) enhancing and sustaining communication, translating technoscientific information into more usable forms, and mediating conflicts that arise in the boundary spanning process (Kirchhoff et al., 2013; Kirchhoff et al., 2015). Interactions between producers and users through boundary organizations (e.g., farmer associations, agricultural cooperatives) facilitate the use of climate information, both by increasing producers and users' understanding of each other's perspectives and expectations and by building trust between producers and potential information users (Flagg and Kirchhoff, 2018).

6.6.3 Option 2: Nurturing development of National Frameworks for Climate Services

At the national level, the GFCS will be developed and coordinated by each national government and by key national organizations. This is to ensure that all participants can express their needs and requirements for successfully implementing climate services. A National Framework for Climate Services (NFCS) will be the coordinating process to enable the development and delivery of climate services at national level. An NFCS facilitates multisectoral coordination to devise measures based on specific national contexts and capabilities, and relevant scientific data. Moreover, an NFCS contributes to the implementation of the Paris Agreement that calls for science-based research and systematic observations. In supporting the implementation of Paris Agreement, NFCSs complement National Adaptation Plans (NAPs) in medium- and long-term adaptation to climate impacts. NAPs elements that require effective and timely climate services include assessment of climate vulnerabilities and identification of adaptation options, development of products that help improve the understanding of climate and its impacts, and enhancement of capacity for planning and implementation of adaptation for climate-sensitive sectors.

Countries can derive many benefits from the NFCS process – many of which are highly consistent with the likely goals of a Post-CLIMANDES effort. The benefit most frequently identified in a survey associated with the mid-term evaluation of the GFCS (Gerlak et al., 2017) was "increased collaboration between national meteorological services, national ministries, and other organizations." Other highly cited benefits included the "increased information sharing among participating organizations" and "elevated the importance of climate services and adaptation in national development agendas."

Colombia is the first country in South America to formally launch (in November 2017) the process to formulate an NFCS. The EET was told by SENAMHI that "a Peruvian NFCS would have been the crowning achievement of CLIMANDES." Although that goal was not reached, Peru is NOW next in line to launch the NFCS process in South America, to a large extent as a result of the CLIMANDES experience. Chile and Argentina also are interested in initiating the process: that is, four of the six Andean countries potentially participating in a PCI are interested in development of an NFCS.

A possible focus for a PCI would be to nurture and assist Andean countries in the process of developing their national frameworks. Given the widespread interest and the fact that some early actions to initiate development of NFCSs are already happening, such a focus appears to be justified. The exact form in which the initiative would be implemented needs to be determined. There are activities involved (e.g., conducting national dialogues, compiling baseline information) that are the responsibility of each nation. Nevertheless, the separate national activities, however, could be nurtured by a PCI by facilitating the fluid exchange of experiences (positive and negative), or through sharing protocols to inform the needed baseline assessments and consultation processes that identify major gaps, user needs, and priorities for national climate services.

The process of establishing strategic partnerships with institutions beyond NMHSs is a key requirement to ensure the smooth flow (in multiple directions) of information and knowledge throughout the climate value chain or knowledge network. However, so far it has proven difficult for NMHSs to move out of their "comfort zone" (generating climate data and products) and reach out to potential partners who are absolutely critical for climate services to spread to all levels of society. During CLIMANDES, SENAMHI has been exposed to the need for partnerships and the difficulties involved in identifying complementary needs and interests to motivate the interactions. The experience gained in this respect could be useful to other countries beginning this complex process.

6.6.4 Option 3: State-of-the-art stewardship of regional climate data

In previous sections of this report, we highlighted the important and necessary data stewardship activities (quality control, management and dissemination) performed by CLIMANDES. We pointed out that reliable data and derived information are the foundation of decision-relevant, value-added climate information services. Consequently, there is active demand for long-term, continuous, well-calibrated observations (Karl et al., 2010). Data-related issues still seem to attract much interest throughout South America: this interest was clearly illustrated by the strong regional participation in the workshop on "Data Management for Climate Services" organized by CLIMANDES. State-of-the-art climate data management, therefore, should be considered as one possible focus of post-CLIMANDES efforts – of course, avoiding repetition of earlier work.

The GFCS considers an NMHS to have "basic capacity" when it maintains a Climate Data Set. Climate Datasets are the foundation of any climate analysis (e.g., seasonal forecasts) and must be quality controlled and homogenized. Despite several previous initiatives, the Andean countries do not have a Climate Regional Dataset, developed with a consistent methodology to avoid edge or border effects and publicly available or, at least, available to the research and operational community. The closest to this is the Latin America Climate Assessment and Dataset (see Section 3.5.1), although it lacks temporal and

spatial coverage. Some countries in the area have high quality datasets, for example, Argentina and Peru – in the case of Peru, with strong support from CLIMANDES. However, even those national datasets could be improved by the sequence of activities proposed below including DARE – Benchmarking – QC – Homogenization - Climate Products - Uncertainty Evaluation. We therefore propose a sequence of collaborative activities including:

- *Phase 1. DARE:* review of not-digitized data, preservation and digitization.
- *Phase 2. Benchmarking:* construction of artificial climate-datasets and datasets derived from parallel data. Quality Control and homogenization of the artificial datasets. Evaluation and identification of the most appropriated approaches for quality control and homogenization at the daily scale.
- *Phase 3. QC and Homogenization:* application of the best performing techniques from phase 3 to quality control and homogenize climate data at the daily scale
- *Phase 4. Climate Products:* quality controlled climate dataset, homogenized climate dataset, climatologies, climate indices, etc.
- *Phase 5. Uncertainty Evaluation:* computation and communication of the uncertainty of the products. Comparison to reanalysis.

This proposed focus for a PCI would draw on the strong expertise of MeteoSwiss on climate data management. Some of the Swiss experience on data stewardship was transferred to Peru as part of the CLIMANDES "twinning," but other countries also would benefit significantly from this experience. This task would require an active cooperation of all the SMNHs, which should be bound by a formal agreement. Moreover, the NMHSs should develop clear data policies, including provisions for data access and sharing both within the PCI and outside.

6.6.5 Option 4: A regional GFCS office or focal point

According to information received during site visits, both the WMO's current structure and its approach to climate information services appear to be in a state of flux. This situation offers opportunities for innovative approaches to post-CLIMANDES efforts. One option identified by the EET is the establishment of an SDC-funded Regional Office or Focal Point of the GFCS in South America (or part of the region). We use these two terms with caution, as it was pointed out that a "Regional Office" may convey the image of an expensive structure with physical offices, staff members, etc.

This option is strongly supported by the results of the GFCS mid-term review (Gerlak et al., 2017). First, the review states that *"investments in regionally located personnel will […] go a long way to bridge global, regional, and national activities and to support the development of national frameworks."* Second, the report emphasized that the GFCS Office *"is attempting to be the engine with inadequate human and financial resources, and in ways that do not maximize the advantages of its contributors."* In other words, the proposed GFCS regional presence would offload some of the duties that currently overwhelm the Central Office staff. More importantly, a regional presence would help to get WMO and the GFCS highly involved in climate service production in South America, an area where the Framework has been somewhat less active.

During the discussion of this review by CLIMANDES participants, a valid point was raised: whether *yet another structure* would be helpful or needed, in light of the existence of other WMO entities such as the RCC-WSA, the RTC Lima, and the Regional Office for the Americas. This issue clearly deserves attention as a PCI is designed. Does SDC and potential PCI partners such as the WMO consider that the existing regional structures are functioning smoothly and interacting effectively? If this were the case, clearly the regional entity proposed would be unnecessary. Nevertheless, as quoted above, *the GFCS*

mid-term review clearly pointed out the need to reinforce regional activities and the GFCS presence. Moreover, in this report, we pointed out issues associated with the RTC, and also stated that the linkage between SENAMHI and the RCC-WSA did not appear to be as fluid and frequent as it should be. The WMO Regional Office has undergone a recent change in leadership and, despite promising early signs of a very proactive role, it is too early to assess the contribution of this Office to regional coordination.

The regional GFCS structure proposed might be useful and used in a variety of ways, some of which cannot be envisioned fully at this time, as WMO's purported redesign is in progress. The overarching goal of the entity would be to help national organizations working in climate services to collaborate more effectively, efficiently, and with a common focus. First, as stated above, a GFCS regional institution could facilitate and nurture the development of NFCSs. Second, the institution could have a major role in fostering the effective, tangible collaboration and complementation between the two (possibly three in the near future) RCCs in South America. Despite frequent statements about the need or desirability of such interactions, they have not occurred to any significant extent. Third, large benefits may derive from enhancing the interaction and collaboration among RTCs in the region to draw on their respective strengths. Again, tangible interactions among RTCs seem to have been very limited so far.

Clearly, this alternative does not exclude the other options listed above, but rather complements them. A regional GFCS entity would serve to coordinate and manage regional collaboration and sharing of expertise, whether focused on a particular climate-sensitive sector or on the development of NFCSs. Moreover, it could actively identify and foster the establishment of appropriate "twinning" or partnering arrangements in response to specific regional needs and availability of expertise throughout the world. If this option is ultimately selected – by itself or combined with another option – the mission and roles of the proposed entity should be carefully defined with strong input from WMO and all countries in the region, and obviously should consider ongoing discussions on future GFCS governance and management.

6.7 Institutional Design of a PCI

In previous sections, we put forward the need for a large spectrum of participants in a PCI coming together as part of a broad knowledge network. Another important need involves the exploration of appropriate organizational and governance models for the PCI-supported provision of climate services. A post-CLIMANDES Initiative with a regional scope would undoubtedly require an appropriate institutional design to achieve the proposed goals and to facilitate project management. *Because a "form follows function" approach is appropriate, the final institutional model of a PCI must be collectively defined once the specific goals, functions and activities of the follow-on project are decided.*

A core challenge for the governance of a PCI will be to combine the interests of the climate science community with the diverse needs of many relevant climate-sensitive sectors. Previous experiences in many places suggest that the notion of a single institution ("the Climate Service") generating products and information seems insufficient or inappropriate; alternative models must be explored and implemented. While meteorological and climate institutions will provide the backbone of climate services, real progress only can occur through the involvement of those who stand to benefit from use of climate information and knowledge. Consequently, one may envision the structure of PCI-supported regional climate services as a broad knowledge network encompassing multiple overlapping sub-networks of institutions or actors targeting different constituencies or sectors. Intermediary or "boundary" organizations (Agrawala et al., 2001; Kirchhoff et al., 2013; Kirchhoff et al., 2015; Parker and Crona, 2012) such as agricultural extension agencies or farmers' associations can help connect to the more distant nodes of the networks. Moreover, they provide a useful alternative to a linear, unidirectional model of transfer of scientific information, facilitating instead the *multi-directional* flow of

information between institutions, scientists, and decision-makers (Cash and Buizer, 2005; Kirchhoff et al., 2013).

This report already discussed some issues related to this topic, such as the current emphasis on the centrality of NMHSs versus the need for broader engagement (e.g., of institutions and practitioners from climate-sensitive sectors). The need to engage relevant institutions and actors to provide the necessary scientific and domain-specific expertise should be balanced against budgetary and governance considerations. The twinning approach, thoroughly successful in CLIMANDES, should be not neglected as a helpful and effective solution, perhaps including multiple "siblings" in a PCI. *A major lesson from CLIMANDES that should be heeded during a PCI is that NMHSs SENAMHI cannot (and should not!) tackle by themselves all aspects of the production and dissemination of climate services in South America.*

Although the institutional setup of CLIMANDES has been successful, this EET suggests a formal participation of other multi-national institutions with a presence in the region, especially those in the WMO family. One logical institution to be considered as part of a PCI is the RCC-WSA, as the facilitation of regional collaboration is central to its mandate. Nevertheless, the EET would like to confirm that RCC member countries perceive the existing interactions with this institution as fluid and mutually beneficial – as stated earlier in the report, such perception was not clear and distinct. Another concern is that, should ENANDES be funded (and we hope so!), the RCC-WSA may find itself overwhelmed with the management and coordination of a large project (6-7 M USD) in addition to its regular functions. Another institution that definitely should be more actively involved than during CLIMANDES is the WMO Regional Office for the Americas. As stated previously, this Office recently underwent a change in leadership, and its current Director, Mr. Julián Báez Benítez, so far has shown to be very dynamic, proactive and willing to invest considerable effort to foster regional collaboration at a time of lean budgets everywhere.

In the same way in which PCI participation should be broadened to include sectoral institutions or actors, there are other well-established regional institutions with experience in the coordination of institutional collaboration in the Americas. For instance, the Inter-American Institute for Global Change Research (IAI, www.iai.int) is a 26-year old regional intergovernmental institution including 19 countries throughout the Americas that promotes scientific research and capacity building to inform decision-makers on the continent and elsewhere. We understand that the IAI has interacted before with SDC on the topics of glacier retreat and biodiversity. The IAI is increasingly focusing on the science-policy nexus, aiming to foster the use of science-based evidence to inform decisions and actions at many levels. Finally, the IAI may issue a call for collaborative proposals (they often require participation by four countries or more) during 2019 and a request for projects designed to inform climate service production and assessment may be co-funded with SDC.

If a continued focus on agriculture is chosen for a PCI, it is important to consider the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), that seeks to address the challenges of global warming and declining food security on agricultural practices, policies and measures. The CGIAR network includes 15 international research centers, including the International Potato Center in Lima. CCAFS focus on climate-smart agriculture aims to foster a smallholder farmers' transition towards climate-smart production systems and climate-resilient livelihood strategies, while protecting them from climatic extremes. CCAFS also has a strong focus on gender and diversity issues, that the program views as critical to achieving desired development outcomes of increased production, improved outcomes for poverty alleviation, increased well-being for all, and a fairer distribution of burdens and benefits in agriculture among women and men. In South America, CCAFS has been very active in Colombia, where it has promoted a system of Local Technical Agro-Climatic Committees (LTACs) to explore means of

creating dialogue between researchers and farmers that would provide farmers with options in the face of both short- and longer-term variations in climate (Loboguerrero et al., In press).

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Annexes

Table 5. Summary assessment of the efficiency and cost-efficiency associated with the outcomes of Climandes Phase 1, Result 1. The table was summarized from the external review report of Phase 1.

Outcomes	Cost (kCHF)	Efficiency	Cost-Efficiency
R.1.1: ***Providing education, specialization and training in Meteorology and Climatology to undergraduate and postgraduate students***	342	HIGH	
R.1.1.A Assessing current and future needs of meteorologists and other stakeholders, with emphasis on the high Andean areas and specialized training related to regional labour demand	104	HIGH	
R.1.1.B Evaluating and restructuring the training curricula of meteorologists at the RTC in the light of regional needs and scientific and technological developments in meteorology	107	HIGH	
R.1.1.C Modular design and implementation of e-learning courses in meteorology	131	MEDIUM	
R.1.1.D Cooperation exchange agreements with other RTCs and Meteorological Services		HIGH	
R.1.2 ***Enhancing institutional training capacities and acquiring skills in meteorology and climatology for students, teachers (RTC) and SENAMHI forecasters.***	347	HIGH	
R.1.2.A A Setting up teaching teams at UNALM and SENAMHI	35	HIGH	
R.1.2.B Training and specialization of UNALM teaching staff and SENAMHI practitioners to improve weatherclimate forecasting capabilities for Andean areas	181	HIGH	
R.1.2.C Formulating Public Investment Projects (PIP) to finance the implementation of laboratories and infrastructure in UNALM and SENAMHI	15	HIGH	
R.1.2.D Producing and disseminating applied research	7	MEDIUM	
R.1.2.E Publishing scientific results in international scientific journals	109	MEDIUM	
R.1.3 ***Facilitating exchanges of teachers and students for transferring knowledge and experience.***	140	HGH	
R1.3.A A Identifying qualified candidates for internships and master's degrees in Switzerland		HIGH	
R1.3.B Courses at UniBe for one doctoral student or two master's degree students from UNALM	140	HIGH	

Outcomes	Cost (kCHF)	Efficiency	Cost-Efficiency
R.1.3.C Attracting foreigner students for RTC/UNALM		HIGH	
R.1.4 ***Meteorology training for schools, including teachers of basic education in rural Andean areas***	584	HIGH	
R1.4.A Designing a training curricula for technical staff	4	HIGH	
R1.4.B Incorporating meteorological issues into the basic educational curriculum and training primary school teachers (helping to popularize meteorology)	310	HIGH	
R1.4.C Assessing current and future needs	68	HIGH	
R1.4.D Enhancing short-term forecasting capabilities	110	HIGH	
R1.4.E Improving high-impact weather event warnings	92	MEDIUM	

	VERY SATISFACTORY
	SATISFACTORY
	LESS SATISFACTORY
	UNSATISFACTORY

Table 6. Summary assessment of the efficiency and cost-efficiency associated with the outcomes of CLIMANDES Phase 1, Result 2. The table was summarized from the external review report of Phase 1.

Outcomes	Cost (kCHF)	Efficiency	Cost-Efficiency
R.2.1: ***Identifying climate services according to demand from the State and private stakeholders***	55	HIGH	
R.2.1.A Qualitative study of demands and needs for climate services in the Andean region of Peru.	35	HIGH	
R.2.1.B Prioritizing key requests and design of climate services in pilot areas based on the demand identified (Cusco and Junín).	20	LOW	
R.2.2: ***Implementing climate services in pilot areas (Cuzco and Junín)***	789	MEDIUM	
R.2.2.A Quality control and implementation of automated data homogenization in the pilot studies.	331	HIGH	
R.2.2.B Calculating climate change indicators in the context of the pilot areas	291	MEDIUM	
R.2.2.C Implementing pilot services in the southern and central Peruvian Andes.	75	LOW	
R.2.2.D Publishing scientific results in international scientific journals.	43	MEDIUM	
R.2.2.E Developing a website for viewing climate indicators.	29	HIGH	

Outcomes	Cost (kCHF)	Efficiency	Cost-Efficiency
R.2.2.F Transferring and exchanging methodologies for climate services.	20	HIGH	
R.2.3: ***Building a communication network between SENAMHI and public and private-sector decision-makers***	12	MEDIUM	
R.2.3.A Diagnosing communication problems on climate services and products for decision-makers.	6	MEDIUM	
R.2.3.B Designing suitable mechanisms and products for communication with decision-making users.	6	MEDIUM	
R.2.3.C Implementing appropriate communication mechanisms and products in the pilot areas for decision-makers		LOW	
R.2.4: ***Developing a system for disseminating climate information to public and private-sector decision-makers***	41	MEDIUM	
R.2.4.A Setting up a climate reporting network with strategic coverage.	5	MEDIUM	
R.2.4.B Incorporate local media for broadcasting climate and environmental information	16	MEDIUM	
R.2.4.C Develop user-friendly information templates for decision-makers and the general public	8	MEDIUM	
R.2.4.D Make informative summaries of technical information of SENAMHI for massive diffusion	4	HIGH	
R.2.4.E Enhance communication mechanisms and products for decision-makers.	8	LOW	
Coordination and project management	825	LOW	

	VERY SATISFACTORY
	SATISFACTORY
	LESS SATISFACTORY
	UNSATISFACTORY

Table 7. Assessment grid for evaluations of SDC projects/programmes.

Assessment grid for evaluations of SDC projects/programmes

Key Aspects based on DAC criteria		Score (choose only one answer for each question)	Justification - compulsory (please write a short explanation with the main points and refer to the chapter(s) where the information that justify your assessment can be found)
Assessment of relevance			
1. The extent to which the objectives of the SDC projects/programmes are consistent with the demands and the needs of the target groups (incl. gender-specific requirements).	☐ ☒ ☐ ☐ ☐	*Very good: Fully consistent* *Good: Largely consistent* *Poor: Only partly consistent* *Bad: Marginally or not at all consistent* *Not assessed / Not applicable* [1]	CLIMANDES has had a demonstrable effect over local communities. No evidence on any plans on gender-issues
2. The extent to which the objectives of the SDC projects/programmes are consistent with the demands and the needs of partner country (institutions respectively society) as well as the sector policies and strategies of the partner country	☒ ☐ ☐ ☐ ☐	*Very good: Obvious consistency with demands and needs of society and in line with relevant sector policies and strategies*[2] *Good: Consistency with demands and needs of society and in line with relevant sector policies and strategies* *Poor: Consistency with demands and needs of society not visible but in line with relevant sector policies and strategies* *Bad: Not consistent* *Not assessed / Not applicable* [1]	We found a number of synergies with sector policies and strategies of Peru, such as “Programa País” and all the actions in the Tambos initiative.
3. The extent to which the design of projects/programmes is adequate to achieve the goal and objectives (definition of target groups; choice of approach and operational elements; articulation of components; choice of partners; consistency with SDC policies and experiences).	☐ ☒ ☐ ☐ ☐	*Very good: Fully adequate* *Good: Largely adequate* *Poor: Only partly adequate* *Bad: Marginally or not at all adequate* *Not assessed / Not applicable* [1]	The CLIMANDES approach is largely adequate. Twinning provides balance between expertise and regional knowledge. Consortium is composed by international body (WMO), Met Services and academic institutions. The target groups are vulnerable to climate and weather. Stronger involvement of local stakeholders would facilitate continuation of activities.
Assessment of effectiveness			
4. The extent to which the planned objectives at outcome level have been achieved taking into account their relative importance. If possible, distinguish the quality and quantity of results achieved.	☐ ☒ ☐ ☐ ☐	*Very good: Fully achieved or overachieved* *Good: Largely achieved* *Poor: Partly achieved* *Bad: Marginally achieved* *Not assessed / Not applicable* [1]	Objectives related to use of seasonal forecasts not fully achieved. Formal education objectives achieved minimally.
	☒ ☐ ☐ ☐	*Very Good: Strong evidence of contribution* *Good: Evidence of contribution* *Poor: Few evidence of contribution* *Bad: No contribution*	We saw evidence in our visits about vulnerability reduction and increase in adaptive capacity in Puno and Cusco communities.

[1] This category applies a. if the ToR of the evaluation explicitly exclude the assessment of the criteria and/or of the key aspect(s) or b. if there is no information available to assess the criteria.
[2] The policies and strategies should not be in opposition to the needs of the society (applies mainly in governance and human rights).

5. The extent to which the projects/programmes contribute to poverty reduction, inclusion and/or reduction of vulnerabilities.[3]	☐	*Not assessed / Not applicable* [1]	

[3] Dimensions for consideration are: a) economic (income and assets); b) human capacities (health, education, nutrition); c) ability to take part in society (status and dignity); d) political capacities (institutions and policies); e) resilience to external shocks.

6. The extent to which the outcomes achieved contribute to improved governance from a system perspective.[4]	☐ ☐ ☒ ☐ ☐	*Very good: Strong evidence of contribution* *Good: Evidence of contribution* *Poor: Few evidence of contribution* *Bad: No contribution* *Not assessed / Not applicable* [1]	The outcomes achieved have a limited impact in improving governance, except perhaps for the formalization of an agreement between SENAMHI and regional authorities in Puno.
7. The extent to which the outcomes achieved contribute to gender-specific results.	☐ ☐ ☒ ☐ ☐	*Very good: Strong evidence of contribution* *Good: Evidence of contribution* *Poor: Few evidence of contribution* *Bad: No contribution* *Not assessed / Not applicable* [1]	Upon our request, we were able to interview women from the local communities in Puno. There was evidence that the governmental institutions and, most prominently SENAMHI and MeteoSwiss had strong participation of women. Nevertheless, we did not find explicitly gender-oriented actions implemented or even planned.
Assessment of efficiency			
8. The extent to which the relation between resources (mainly financial and human resources) and time (e.g. delays compared to planning) required and results achieved is appropriate (Cost-benefit ratio - CBR).	☒ ☐ ☐ ☐ ☐	*Very good: Positive CBR based on a cost-benefit analysis (CBA)* *Good: Positive CBR, based on qualitative justification* *Poor: Poor CBR, based on qualitative justification* *Bad: Bad CBR demonstrated* *Not assessed / Not applicable* [1]	Cost-benefit analysis showed a CBR positive under conservative assumptions and sensitivity analysis, considering only those benefits quantified in a couple of case studies. Therefore, the project returns much more than compensate the resources used.
9. The extent to which the approaches and strategies used by the SDC projects/programmes are considered efficient (Cost-efficiency).	☐ ☒ ☐ ☐ ☐	*Very good: Highly efficient* *Good: Efficient* *Poor: Partly efficient* *Bad: Not efficient* *Not assessed / Not applicable* [1]	Although there have been delays and some of the activities will need some additional time or will not be completed as initially foreseen, none of this is alarming understanding the complexity of the project. Some activities could have been budgeted in a more efficient way. Furthermore, overall coordination and implementation is much improved in comparison to CLIMANDES-1
Assessment of sustainability			
10. The extent to which the positive results (outputs and outcomes) will be continued beyond the end of the external support. Considering also potential risks in the context.	☐ ☒ ☐ ☐ ☐	*Very good: Very likely based on evidence* *Good: Likely based on evidence* *Poor: Little likelihood based on evidence* *Bad: Unlikely based on evidence* *Not assessed / Not applicable* [1]	As the project involved a bottom-up approach, and the communities appear to have a high level of commitment, the sustainability of CLIMANDES results seems high, although some actions will require continuous investment.
	☐	*Very good: Strong capacity (also to further develop without support)*	

[4] Dimensions for consideration are: a) structure (informed policies, laws, corresponding to basic HR obligations; degree of decentralization/multilevel concertation/cooperation); b) good governance in the performance/interaction of responsible actors/institutions (GGov principles: participation, transparency, accountability, equality&non-discrimination, effectiveness & efficiency, rule of law); c) capabilities, behavior, empowerment of actors/institutions for positive change; d) consideration of important global or regional governance dimensions.

11. The extent to which partner organizations are capable to carry on activities. Capacity includes technical, financial capacity, human resources and importance of the activity for the organization.	☐ ☒ ☐ ☐	*Good: Reliable capacity* *Poor: Little capacity (require further support)* *Bad: Still too weak capacity* *Not assessed / Not applicable* [1]	There is need for further support in the local communities and, to a lesser extent in SENAMHI and UNALM. In the two later cases, the capcity is there, but needs investment both in human and economic resources

Additional information (if needed): Click here to enter text.
Project: CLIMANDES
Assessor: Enric Aguilar, Sonia Quiroga, Guillermo Podestá
Date: 16 December 2018