Climate Services for the Road and Bridges Infrastructure Sector in Costa Rica

Baseline Assessment Report

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In cooperation with:

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Abbreviations

AfDB .... African Development Bank
AYA .... Instituto Costarricense de Acueductos y Alcantarillados
BCCR .... Banco Central de Costa Rica
BMU .... Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit
CACOF .... Central American Climate Outlook Forum
CATIE .... Centro Agronómico Tropical de Investigación y Enseñanza
CBO .... Community-based organization
CC .... Climate Change
CCSCJ .... Constitutional Chamber of the Supreme Court of Justice
CD .... Capacity development
CFIA .... Colegio Federado de Ingenieros y de Arquitectos de Costa Rica
CIEDES .... Centro de Investigación en Estudios para el Desarrollo Sostenible
CIGEFI .... Centro de Investigaciones Geofísicas
CIIFEN .... Centro Internacional para la Investigación del Fenómeno de El Niño
CIMH .... Caribbean Institute for Meteorology & Hydrology
CIVCO .... Centro de Investigaciones en Vivienda y Construcción
CNC .... National Concession Council
CNE .... Comisión Nacional de Prevención de Riesgos y Atención de Emergencias
CONAVI .... Consejo Nacional de Vialidad
CORBANA .... Corporación Bananera Nacional
CORDEX .... Coordinated Regional Climate Downscaling Experiment
CORDEX-LAC ... Coordinated Regional Climate Downscaling Experiment for Latin America and the Caribbean
CPTEC .... Centro de Previsão de Tempo e Estudos Climáticos
CR .... Costa Rica
CRM .... Climate Risk Management
CRRH .... Comité Regional de Recursos Hidráulicos
CSIS .... Climate Service Information System
CSI .... Climate Services for Infrastructure
DCC .... Dirección de Cambio Climático
DWD .... German Meteorological Service (Deutscher Wetterdienst)
ECV .... Essential Climate Variable
EIA .... Environmental impact assessments
ENCC .... National Climate Change Strategy
ENSO .... El Niño-Southern Oscillation
EU .... European Union
FAO .... Food and Agriculture Organization of the United Nations
GEF .... Global Environment Facility
GIZ .... German Development Cooperation
GFCS .... Global Framework of Climate Services
IAI .... International Global Change Institute
ICE .... Instituto Costarricense de Electricidad
IKI .... Germany's International Climate Initiative
IMN .... Instituto Meteorológico Nacional
INDC .... Intended Nationally Determined Contributions
IPCC .... Intergovernmental Panel on Climate Change
IRI .... International Research Institute for Climate and Society
LANAMME .... Laboratorio Nacional de Materiales y Modelos Estructurales
MAG .... Ministerio de Agricultura y Ganadería de Costa Rica
MIDEPLAN .... Ministerio de Planificación Nacional y Política Económica de Costa Rica
MINAE .... Ministerio de Ambiente y Energía de Costa Rica
MOPT .... Ministerio de Obras Públicas y Transportes de la República de Costa Rica
MoU .... Memorandum of Understanding
MPI .... Max Planck Institute
NAP .... National Adaptation Plan
NASA .... National Aeronautics and Space Administration
NBI .... Nile Basin Initiative
NCS .... National Climate Service
NDC .... National Determined Contributions
NFCS .... National Framework for Climate Services
NGO .... Non-Governmental Organization
NMHS .... National Meteorological and Hydrological Service
NOAA .... National Oceanic and Atmospheric Administration
OECD .... Organisation for Economic Co-operation and Development
OM .... Observations and Monitoring
OO .... Ombudsman's Office
PIEVC .... Public Infrastructure and Engineering Vulnerability Committee
RCC .... Regional Climate Centre
RCM .... Regional Climate Model
RCOF .... Regional Climate Outlook Forum
RCP .... Representative Concentration Pathways
RMP .... Research, Modelling and Prediction
SCOT .... Strength, Challenges, Opportunities and Threats
SDG .... Sustainable Development Goals
SENARA .... Servicio Nacional de Aguas Subterráneas, Riego y Avenamiento
SRES .... Special Report on Emissions Scenarios
TEC .... Tecnológico de Costa Rica
ToR .... Terms of References
UCR .... Universidad de Costa Rica
UGM .... Municipal Management Unit of LANAMME
UIP .... User Interface Platform
UK-MET .... United Kingdom Meteorology
UN .... United Nations
UNDP .... United National Development Program
UNEP .... United Nations Environment Programme
UNESCO .... United Nations Educational, Scientific and Cultural Organization
UNFCCC .... United Nations Framework Convention on Climate Change
UNISDR .... United Nations International Strategy for Disaster Reduction
USAID .... U.S. Agency of International Development
USRCC .... United States of America Regional Climate Centre
WB .... World Bank
WCC-3 .... World Climate Conference 3
WFP .... World Food Programme
WHO .... World Health Organization
WMO .... World Meteorology Organisation
WRF .... Weather Research and Forecasting

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A main road in San Jose, Costa Rica.

I Executive Summary

Infrastructures are the fundamental basis for the sustainable development of a society's economic prosperity and social well-being. The road infrastructure system in Costa Rica is especially vulnerable to extreme hydro-meteorological events. In the period from 2005 to 2017 such events caused economic losses of about US$ 2.210 million in the infrastructure sector of which more than half refers to road infrastructure (CNE 2017). In order to guarantee the functionality of the road infrastructure in the future and minimize costs for their preservation and reconstruction, climate proof infrastructure systems are essential. Climate risk management processes require the availability of adequate climate information which can be incorporated into development decisions and policy at relevant scale.

The road infrastructure system in Costa Rica is especially vulnerable to extreme hydro-meteorological events. In the period from 2005 to 2017 such events caused economic losses of about US$ 2.210 million in the infrastructure sector of which more than the half refers to road infrastructure (CNE 2017)

The CSI project (Enhancing Climate Services for Infrastructure investments) aims to empower decision-makers of the road infrastructure sector in Costa Rica to make greater use of Climate Services when planning infrastructure investments and adapt engineering designs in order to raise the resilience of road infrastructure objects and systems in the context of climate change.

In order to enhance the provision and use of climate information the current state of a National Climate Service for the context of the road infrastructure sector needs to be assessed and analysed. The baseline assessment is based on the concept and structure of the Global Framework of Climate Services. The assessment report provides an overview of the Climate Service inventory which encompasses currently available Climate Service capacities and specific products. It furthermore reflects the current use and demands of Climate Services from the road infrastructure sector. And finally analyses the sector-specific climate-value-chain which comprises the interaction of relevant stakeholders for climate information provision and key actors of the road infrastructure sector.

The assessment results are based on question catalogues which address climate information providers and users. The information was collected via surveys, workshops and interviews. Interview partners are representatives of the National Meteorological Service (IMN), the National Road Council of Costa Rica (CONAVI), the Bridge Unit of the National Laboratory of Materials and Structural Models of the University of Costa Rica (LANAMME), the Municipal Management Unit of LANAMME, the School of Construction Engineering of the Centre of Investigations in Housing and Construction of the Technical Institute of Costa Rica (CIVCO/TEC), the department of water resources of CIVCO/TEC and a private consultant for the development of hydraulic design of bridges.

The results from the Climate Service inventory indicate that IMN adopts a central position as major stakeholder within the national network of climate information providers. Additional contributions come mainly from the academic sector as well as from external providers rather than from national providers. Fundamental results can be summarized by the following statements:

- The operation of Costa Rica's observation and monitoring is institutionally divided between meteorological and hydrological institutions with limitations regarding cooperation, a spatially homogeneous and temporally continuous observation and monitoring of climate variables and events as well as free data use.
- Research activities on climate issues in Costa Rica are mainly initiated by IMN often in cooperation with the academic sector and other government departments. IMN is also the official institution for climate model development, climate predictions and climate change projection. However, since capacities regarding these tasks are very limited climate models and tools are often used from external sources.

- Costa Rica's national Climate Service network is able to provide a comprehensive range of climate data services and information products (according to category 3 of WMO classification system). Although some selected sectors are continuously provided with climate information, there is a significant challenge to provide tailored and usable climate information to sectoral users.
- The interaction with users is characterized as a customer relationship rather than a partner relationship. This relationship is reflected in the organizational structure of the prevalent NCS as well as in the process of Climate Service development which impedes the production of useful and usable Climate information products.
- Existent capacity development structures mainly refer to the individual capacity development level. Greatest needs are, however, identified on the organizational and systematic level in order to develop an effective National Climate Service.

General characterizations of use and demand for Climate Services can be summarized by the following statements:

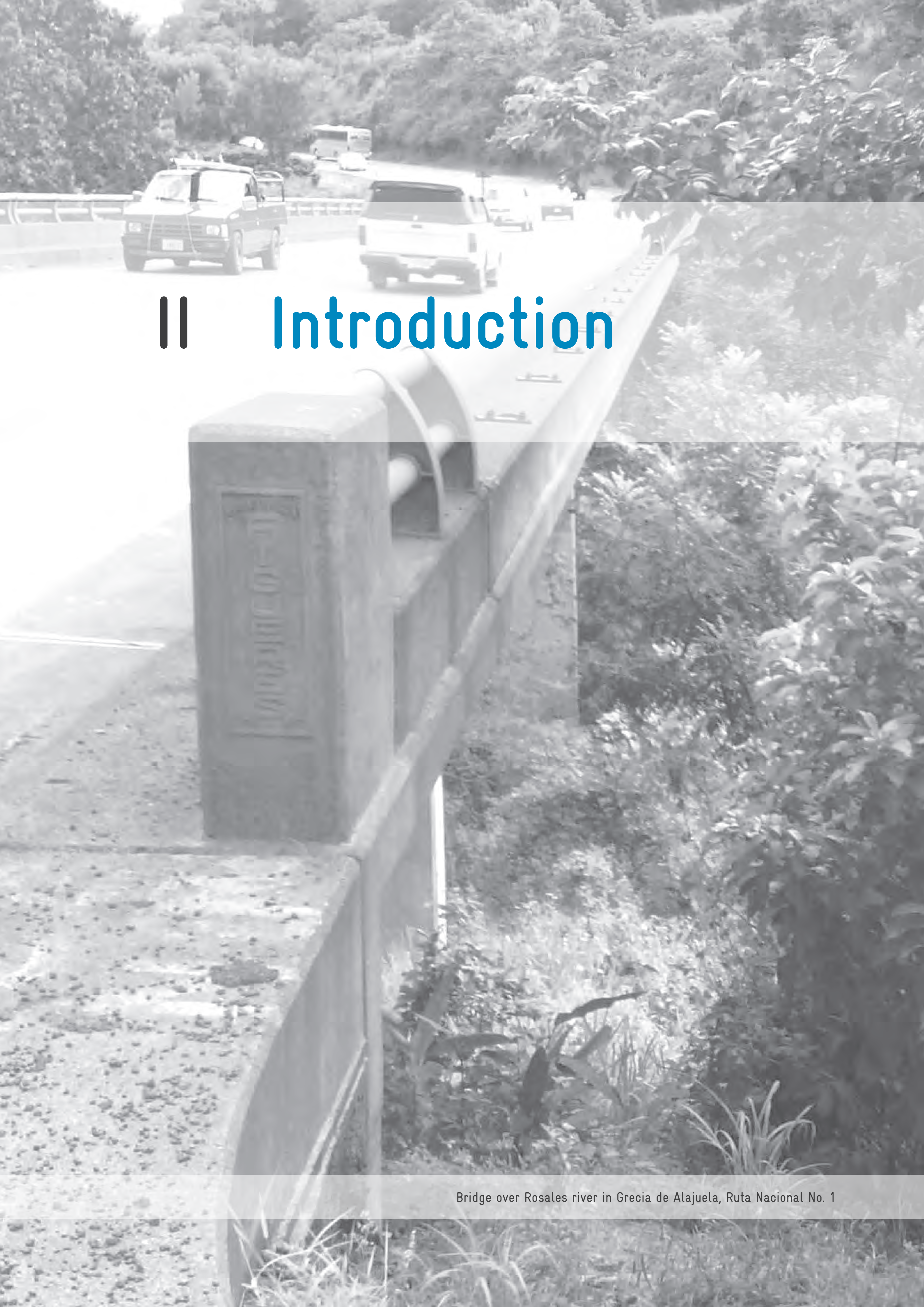
- The consideration of climate information is not explicitly regulated in road infrastructure planning processes.
- The main motivation for using climate information is internal motivation which refers to the organization's vision, objective and policy.
- Climate information is predominantly used for decision-makings processes which refer to infrastructure planning and implementation as well as the development and implementation of risk management plans. Most favourable risk management strategies are risk prevention by protection and risk prevention by transformation.
- Most used climate information products are predominantly data products, both climate data and hydrological data, as well as basic climate statistics. The greatest demand for climate information products refer to climate change impact information, vulnerability and risk information as well as methodical products like trainings, workshops, lectures and information material on climate issues and tools which support decision-making, strategy development and financial planning. Urgent demands for services additional to climate information products refer to support for data processing and application as well as for the assessment of the information value for the specific context.
- The most important reason for not using climate information is the limited access to freely available climate information, the fact that products are not existent (e.g. no available data for a specific region or time period) or the existence of the product is not known as well as the lack of regulations that obligate the use of climate information products.

The results from analysis of the climate value chain can be summarized by the following statements:

- Main sources of climate-related information for users from the road infrastructure sector are the IMN for climate data and ICE for hydrological data.
- CONAVI takes a central position within the climate-value-chain of the road infrastructure sector coordination, both regarding the coordination of sectoral tasks and processes as well as the use of climate information.
- Most of the other sectoral stakeholders take functions of climate service intermediates which imply the provision of value-added climate information products.
- There is a gap in the systematic production and management of such value-added products relevant for the road infrastructure sector. Three possible reasons for this gap are identified: (1) lack of a hydrological service; (2) the lack of a sectoral coordinating partner within the NCS; (3) the lack of cooperation structures with key stakeholders from the road infrastructure sector.

The fundamental recommendation regarding the baseline assessment refers to the establishment of a road infrastructure branch within the prevalent National Climate Service of Costa Rica. This sectoral branch envisages an incorporation of sectoral and political partners which adopt various functions in the development, provision and communication of Climate Service products relevant for the road infrastructure sector. Other recommendations mainly refer to details of the implementation of such a sectoral NCS-branch.

II Introduction



Bridge over Rosales river in Grecia de Alajuela, Ruta Nacional No. 1

Infrastructures are the fundamental basis for the sustainable development of a society's economic prosperity and social well-being. In order to preserve the function of infrastructure, countries all over the world are going to invest public and private resources to preserve and upgrade existing infrastructure and to build new infrastructure networks. Infrastructure of all types is vulnerable to current climatic events. These climatic events do already have an impact on existing infrastructure networks, causing physical damage as well as the disruption of their functionality, which may have knock-on effects on other infrastructures and economic sectors. The infrastructures' vulnerability will increase due to both, neglected management and maintenance of existing infrastructures as well as changing climate conditions in the context of climate change. As climate change may cause a change in magnitude and frequency in extreme weather and climate events as well as gradual changes like sea-level rise and changing eco-systems, design thresholds and management processes of infrastructure networks may not be adopted to future climate conditions and may be breached more often. Operational and organizational processes will have to function within tighter margins between "normal" states and "extreme situations" which will result in decreased efficiency of equipment and production processes and more frequent periods of restricted operation or even failure of the infrastructure's function. Finally, among the negative impacts of climate change will be asset deterioration and reduced asset lifetime, loss of income and increased risks of environmental damage and litigation which will require an adaptation of operational and capital expenditures and thus a change in investment strategies. In order to mitigate additional future costs, such investment strategies need to be adapted to changing climate conditions and changing risks. Climate risk management frameworks for infrastructure investments and respective policies need to be developed and established to support investment strategies for resilient infrastructure. Such frameworks need to support decisions on the design, location and operation of existing and planned infrastructure and help to enhance resilience and avoid locking-in vulnerability (OECD 2016).

Infrastructure of all types is vulnerable to current climatic events which already have an impact on existing infrastructure networks, causing physical damage as well as the disruption of their functionality, which may have knock-on effects on other infrastructures and economic sectors. The infrastructures' vulnerability will increase due to both, neglected management and maintenance of existing infrastructures as well as changing climate conditions in the context of climate change.

Climate risk management processes require the availability of adequate climate information which can be incorporated into development decisions and policy at relevant scale. This kind of "climate-smart" development necessitates a broad range of Climate Services. However, current gaps in information, communication, policy, practice, and institutional capacity prevent the production and provision of useful and usable climate information at various levels (IRI 2012).

1 The Costa Rica context

Critical infrastructure systems in the Central American region are especially vulnerable to extreme hydro-meteorological events like storms and hurricanes and subsequent events like floods or landslides. According the National Emergency Commission (CNE) of Costa Rica, extreme hydro-meteorological events in the period from 2005 to 2017 caused economic losses of about US$ 2.210 million in the infrastructure sector, of which more than the half refers to road infrastructure like roads, sewer systems and bridges (CNE 2017). The tropical storm Nate in 2017 caused immense impacts on road infrastructure especially in the southern region of Costa Rica. Besides economic losses (around US$ 577 million) overloaded sewer systems caused drinking water shortages and communities were isolated due to collapsed bridges (Tico Times 2017; The Costa Rican News 2017). Total economic losses due to hydro-meteorological events like Nate in 2017 or Otto in 2016 are expected to increase up to 30 Billion US$ until 2050 in the context of climate change (MINAE 2015). In order to guarantee the functionality of the road infrastructure in the future and minimize costs for their preservation and reconstruction, climate proof infrastructure systems are required. The implementation of climate proof road infrastructure requires the existence of appropriate and usable climate information in order to consider current and future climate risks in the planning process of infrastructure objects. This comprises e.g. information on current and future magnitudes, frequencies and inundation areas of flood events but also information on temperature extremes in order to adapt location, height, design and material of bridges, and access roads as well as sewer systems and other protection structures.

Total economic losses due to hydro-meteorological events like Nate in 2017 or Otto in 2016 are expected to increase up to 30 Billion US$ until 2050 in the context of climate change (MINAE 2015)

Furthermore, national policies and regulations need to be developed or reviewed to guarantee the production and availability of climate information for decision-makers and further the use and implementation of this information in infrastructure planning processes. Within their National Adaptation Policy (NAP), the decree for which was passed with Executive Decree 41091 on July 8th 2018, Costa Rica picks up this issue and formulates ambitious goals in order to make their infrastructure climate proof based on an enhanced provision and use of Climate Services.

In the context of the CSI project (see II.2) the road infrastructure was identified by the project partners MINAE, CFIA and IMN as the most vulnerable sector based on a multi criteria analysis. A bridge close to Liberia, Guanacaste, spanning the Tempisque river and providing access to critical economic facilities and Liberia international airport was selected to be the object of investigation for a pilot climate risk assessment. The objective is to get a better idea of what are the most relevant climate threats for bridges in the area in general and how best to adapt the Tempisque Nuevo bridge in particular to the adverse effects of climate change. The information gained by the application of the risk assessment will also be used in order to develop a risk assessment protocol for Costa Rica as part of the implementation of the National Adaptation Policy.

2 Project background

The project Enhancing Climate Services for Infrastructure Investments (CSI) forms part of Germany's International Climate Initiative (IKI). In accordance with a resolution by the German Bundestag the IKI receives backing from the country's Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU).

The BMU has commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH to implement the CSI project from 2017 until 2020 with its partner countries and region Brazil, Costa Rica, Vietnam and the Nile Basin Initiative (NBI). GIZ's main international implementing partners are the German Meteorological Service (DWD) and Engineers Canada.

CSI aims to empower decision-makers to make greater use of Climate Services when planning infrastructure investments and thus helps to raise infrastructure resilience. In this way, CSI also supports achieving the UN Sustainable Development Goal (SDG) 9.

To accomplish its objective, CSI brings together all relevant private and public-sector actors along the Climate Service value chain. This includes climate data providers and the stakeholders, among them decision-makers and engineers, who work with this data. All activities are purposefully integrated into the National Adaptation Plans and Policies (NAP) and (I)NDCs to promote NAP and (I)NDC development and implementation.

CSI prioritises four areas. Specifically, it

i. **supports the provision and use of Climate Services**
Establishing a sustainable interface between users (e.g. infrastructure planners, operators and owners) and Climate Service providers – referred to as a Climate Service User Interface Platform (UIP) – enables potential Climate Service users to participate in the development process. At the same time, it involves providers in the use of the information for infrastructure planning. The German Meteorological Service (DWD) advises Climate Service providers and users on the delivery and use of Climate Services.

ii. **supports the integration of the use of Climate Services into infrastructure planning in line with national plans and strategies**
CSI also focuses on climate-sensitive infrastructure planning methods that take climate risks into account. Together with decision-makers, the project develops recommendations for adapting planning procedures and regulations in line with the climate-proofing approach, e.g. via cost-benefit analyses, the development of building standards or environmental impact assessments (EIA).

Video about CSI the project
www.youtube.com/watch?v=4sTBWQEC2TA

iii. **pilots climate risk assessments for infrastructure**
To identify climate risks, CSI is piloting a climate risk assessment for a specific infrastructure type in each of the partner countries, thereby creating a starting point for prioritising the various adaptation options. Engineers Canada is advising the partner countries on the risk assessment rollout. Based on the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol that Engineers Canada developed to analyse climate risks to infrastructure, the project aims to build local capacity by means of a learning-by-doing approach. At the same time, it is compiling handouts and training materials to disseminate this approach and to operationalise the adapted planning procedures and regulations.

iv. **promotes international knowledge transfer and exchanges**
Furthermore, CSI shares its experience and best practices with national and international forums and posts them on AdaptationCommunity.net, amongst other sites.

CSI project partners in Costa Rica

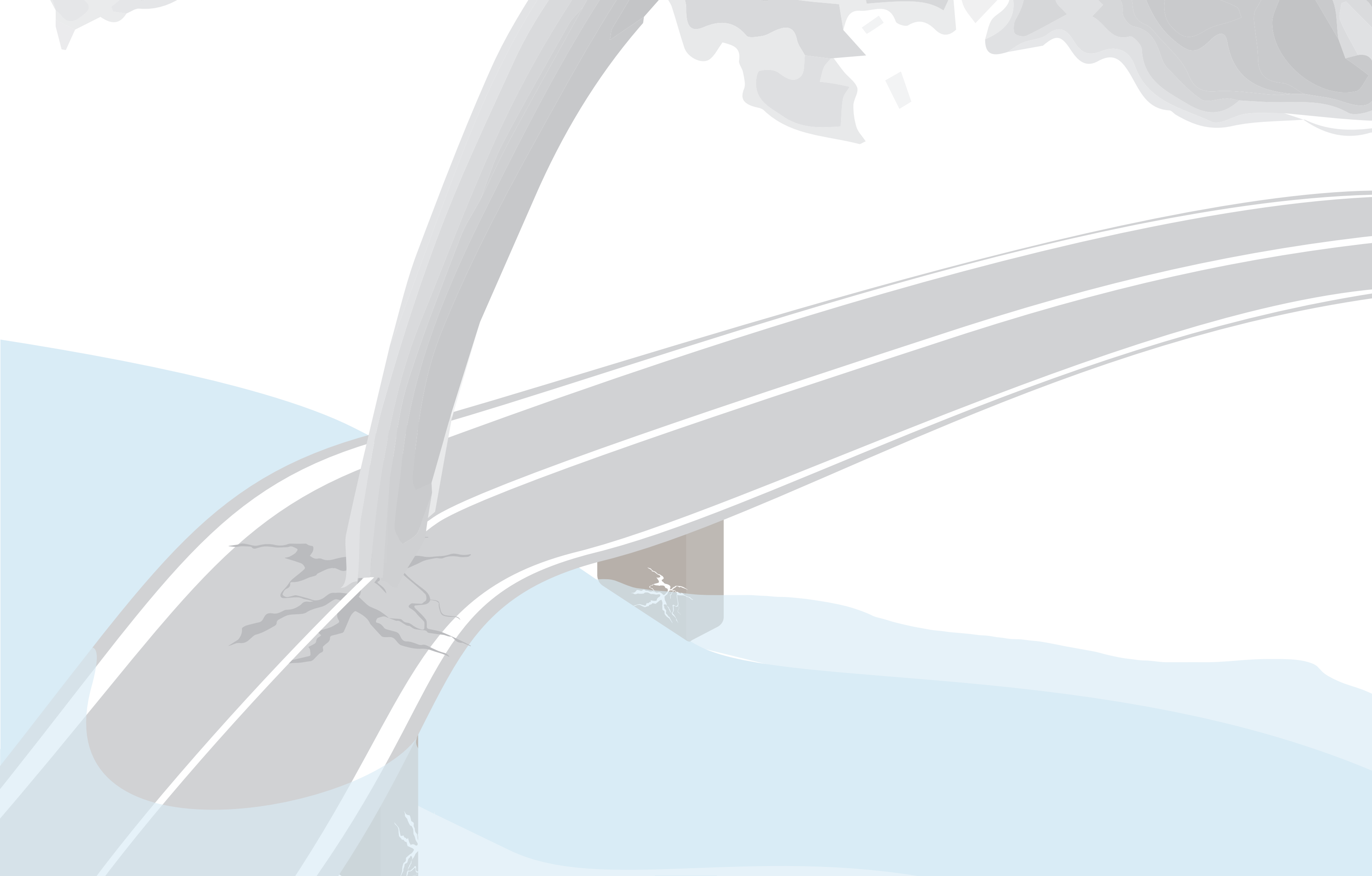
The Ministry for Environment and Energy (MINAE) is the political partner of the CSI project and, regarding its responsibilities in the context of the ENCC and NAP implementation, a key stakeholder (intermediate) of any climate value chain for infrastructures. MINAE has a coordinating and facilitating role in developing and implementing the National Adaptation Policy and Plan.

The National Meteorological Institute (IMN) works in close cooperation with the CSI project. As the major institution which collects and archives climate data and as mandated Climate Service provider in Costa Rica, IMN is a key stakeholder in the climate information provider group of Costa Rica's National Climate Service. IMN has the responsibility of the national observation of meteorological variables and phenomena and is furthermore mandated to provide Climate Services for Costa Rica.

CSI aims to empower decision-makers to make greater use of Climate Services when planning infrastructure investments and thus helps to raise infrastructure resilience. In this way, CSI also supports achieving the UN Sustainable Development Goal (SDG) 9.

CFIA is the National federation of Engineers and Architects in Costa Rica. As national federation they have the responsibility to define, supervise and review engineering standards for infrastructure design, building and operation. Within the CSI project, CFIA is in charge of conducting the climate risk assessment (PIEVC protocol) for the selected bridge in Guardia, Guanacaste and is also a key partner in questions related to the institutionalisation of the use of Climate Services in infrastructure planning in the context of the National Adaptation Policy. CFIA already has fundamental experience in applying the PIEVC protocol.

The CSI project, including all project partners, identified the transportation sector as priority sector for its efforts related to the adaptation of infrastructure to climate change. In the sector, the project works together with the Ministry for Public Works and Transport (MOPT) and the National Road Council (CONAVI) (more detailed descriptions p. 33). The object of choice for the climate risk assessment is a bridge in the province of Guanacaste that spans the river Tempisque. Respectively, the Climate Service baseline assessment will focus on the supply and demand for the road infrastructure sector, with special focus on bridges.



3 Background and structure of the report

3.1 Purpose

In order to enhance the provision and use of climate information the current state of a National Climate Service (see II.5) needs to be assessed and analysed. The state of a NCS is defined as a snap-shot of the current network of climate information stakeholders which constitute and facilitate the basic infrastructure for climate information provision. It furthermore reflects the portfolio of currently provided and used climate information products and services on a national level. Such a baseline highlights actual and specific strengths, challenges, opportunities and threats of the prevalent NCS and constitutes a starting point for the development or enhancement of a National Framework of Climate Services[1] (NFCS) (see II.5).

3.2 Scope

The concept of a NCS applied for this assessment refers to the implementation of the Global Framework for Climate Services (GFCS) (see II.4.2) on the national level. This assessment report provides no comprehensive baseline of the NCS of Costa Rica. Instead, it focuses on the road infrastructure sector as priority sector selected by the national partners of the CSI project (see II.2). Object of the assessment is the inventory of climate information products and services, which are actually or potentially relevant and currently available for the road infrastructure sector. Furthermore, current organizational structures of how climate information is provided for the road infrastructure sector are analysed and discussed.

3.3 Outputs and Objectives

The baseline report provides an abstract of the current state of the NCS in the context of the road infrastructure sector. It provides an overview of relevant stakeholders for climate information provision and key actors of the road infrastructure sector as well as their relationships and interactions. It furthermore lists currently available and used Climate Services for the specific sectoral context and identifies and classifies prevalent gaps and shortcomings in climate information use and provision. Beyond that, strengths and opportunities of the prevalent NCS are highlighted which qualify the report to provide recommendations for short- and long-term measures and strategies to enhance Climate Services for infrastructure investments in the road infrastructure sector in Costa Rica. Finally, recommendations are given on the way a National Framework of Climate Service can be established in Costa Rica for the context of the road infrastructure sector.

3.4 Structure of report

The baseline report is structured as follows: in the following chapter (II.4) the theoretical background for Climate Services is provided. This includes a definition and introduction into the concept of Climate Services and the concept of the Global Framework of Climate Services (GFCS). In chapter III the assessment concept is explicated and applied methods of data collection and analysis are presented as well as processes and procedures of implementation. Chapter IV provides information on the national background which comprises the presentation of project partners and relevant stakeholders as well as the current knowledge on potential climate risks for the region and the sector of concern. In chapter V the results of the assessment of currently available Climate Services are presented and key findings are summarized. Chapter VI presents the current use and demands for Climate Services from the road infrastructure sector. The results are discussed in the context of the climate-value-chain in chapter VII. In chapter VIII an evaluation of the results are formulated. In chapter IX a conclusion and recommendations are given as well as an outlook in chapter X.

[1] An NFCS is an institutional mechanism to coordinate, facilitate and strengthen collaboration among national institutions to improve the co-production, tailoring, delivery and use of science based climate predictions and services by focusing on the five GFCS pillars (WMO 2018).

4 Conceptual basis

The climate vulnerability of infrastructure is a prevalent vulnerability decision-makers like planners and engineers always had to deal with in the past. In the context of climate change, however, knowledge and experiences of past climate conditions and their interrelations with society may not necessarily be valid anymore for the current or future situation. The combined effects of climate change and increase of vulnerability due to, e.g. land-use change, migration and infrastructure development provides unprecedented challenges to today's and future societies. Therefore, there is a growing need to understand climate, the interrelation of climate and socio-economic systems as well as climate predictions and how to better use this information to serve society's needs. This need is recognised by many countries which attempt to develop climate service capabilities. A climate service is considered as the provision of climate information in such a way to assist decision-making by individuals or organizations in a best possible way. Although fundamental infrastructure and capabilities of climate information provision exists in many countries and regions of the world there is limited effective climate impact information for decision-making. In the context of the World Climate Conference-3 in 2009, five key challenges in climate information provision have been identified:

- Access to Climate Services needs to be established and/or improved in all countries;
- The capacity to deal with climate-related risks is lacking in many countries;
- The availability and quality of climate data are inadequate in many parts of the globe;
- Users and providers need to interact better;
- The quality of Climate Services needs improvement to match user requirements better.

A Global Framework of Climate Services was established during the World Climate Conference-3 in order to meet these challenges and strengthen and coordinate existing initiatives and to develop new infrastructures where needed (WMO 2014a).

This chapter provides basic background information on the matter of Climate Services. This comprises definitions of Climate Services as well as the organizational framework for producing, disseminating and applying Climate Services on a national level. The content of this chapter provides a conceptual framing for the baseline assessment as well as for the provided recommendations.

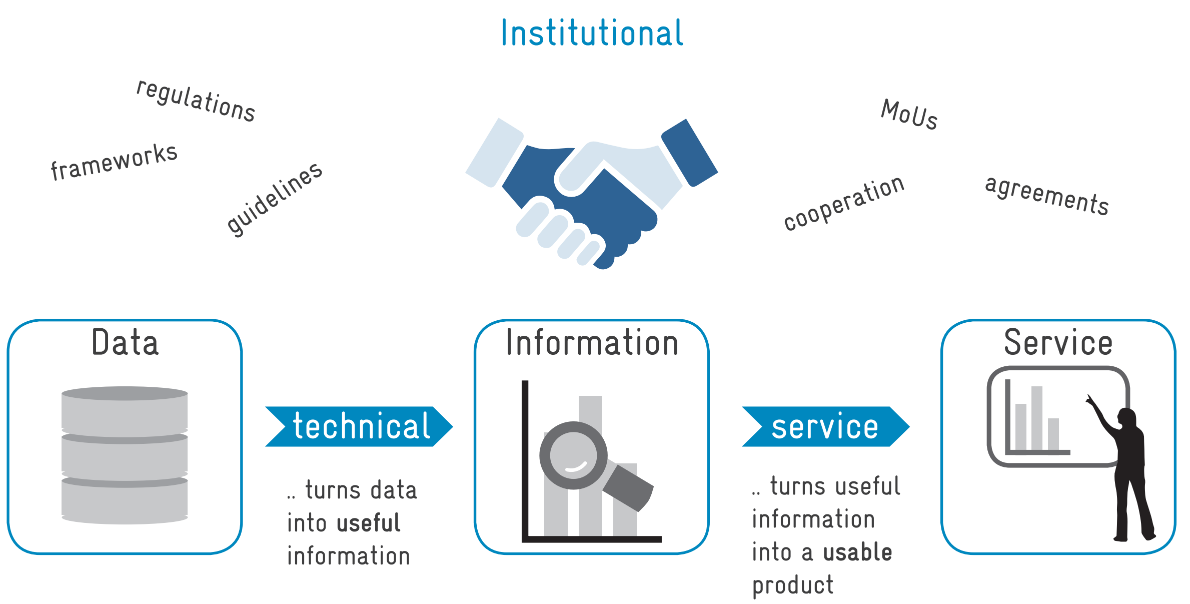


Figure 1 The three dimensions of Climate Services. The technical dimension turns data into useful information by tailoring of the data. The service dimension turns useful information into a usable climate information product by tailoring the presentation and format of the information as well as providing user-specific support and advice. The institutional dimension provides the institutional framework within a co-production of Climate Services can be realized by the cooperation of climate information providers and users.

4.1 Definition and scope of Climate Services

Since the concept of Climate Services is relatively new, various definitions and interpretations exist. The CSI project agreed on the definition provided by the World Meteorological Organization (WMO) in the context of the Global Framework of Climate Services (GFCS). The WMO defines Climate Services as follows:

"Providing climate information in a way that assists decision making by individuals and organizations. A service requires appropriate engagement along with an effective access mechanism and must respond to user needs" (WMO 2014a).

The general WMO definition provides a rather loose delineation of the scope of Climate Services and gives thus room for interpretation. To get a better idea about the scope of Climate Services, the definition of the European Commission provides a more detailed characterization, which can be considered as supplement:

"Transformation of climate-related data — together with other relevant information — into customized products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management" (EU 2015).

The definitions in Box 1 imply three fundamental characteristics of Climate Services which also distinguish Climate Services from climate data and climate information (Box 1). These characteristics are here defined as the three dimensions of Climate Services and refer to and merge the Climate Service elements defined by WMO (2014a) [products; support; feedback] and International Research Institute for Climate and Society (2012) [information; collaboration; policy & practice]. The Climate Service dimensions are defined as follows:

- **The technical dimension defines the usefulness of a climate information product.** It refers to the content of climate information and its relevance for a specific user, user-group or sector (e.g. parameters, indices, etc.). It also refers to the contextualization of climate information with respect to scale and resolution (temporal and spatial) but also format and style of presentation of climate information (e.g. maps, graphs, diagrams, etc.). And furthermore it comprises the quality of climate information and the provision and communication of meta-data and information on uncertainty along with the climate information.
- **The service dimension defines the usability of a climate information product.** It refers to dissemination and utilization of climate information. Dissemination comprises the provision of physical access to climate information (e.g. data platforms, filter systems, etc.) but also promotion of climate information to enhance visibility and perception of the added value for the user. A critical aspect of dis-

Box 1 basic definitions, as used in GFCS Implementation Plan (WMO 2014a)

Climate data: Historical and real-time climate observations along with direct model outputs covering historical and future periods. Information about how these observations and model outputs were generated ("metadata") should accompany all climate data.

Climate product: A derived synthesis of climate data. A product combines climate data with climate knowledge to add value.

Climate information: Climate data, climate products and/or climate knowledge.

Climate Service: Providing climate information in a way that assists decision making by individuals and organizations. A service requires appropriate engagement along with an effective access mechanism and must respond to user needs semination is the timing of delivery and update frequency of climate information. Utilization refers to the support of the user in using climate information for his decision-context. This may comprise assistance for data interpretation, decision-support tools and advice for the implementation in decision-making processes as well as training and educational material on these issues.

- **The institutional dimension constitutes a framework for the formation of technical and service dimension.** It refers the cooperation of relevant stakeholders which are involved in the production of a Climate Service. This implies the cooperation between various (climate) data and information providers as well as the relationship to users to guarantee usefulness and usability of climate information. But also cooperation to political stakeholders to ensure appropriate data policies (data access and availability) mandates and guidelines for the use of climate information.

The Climate Service dimensions suggest that a Climate Service product goes beyond the purely technical level but also includes the provision, communication and advice on climate information, the interaction with users and other stakeholders as well as the governance of climate information production and provision. Furthermore, a Climate Service product often has to be considered as a joint product, which involves the cooperation of several stakeholders. Such a cooperation may be characterized either by a concurrent and/or subsequent coproduction of a Climate Service product. In any way, coproduction in the context of Climate Services comprises a circular (iterative and continuous) process of interaction which implies an exchange of information in both directions: from provider via intermediates to users and back. A Climate Service product cycle is an end-to-end process which comprises the consideration of all required processing steps from data to decision-making as well as all involved stakeholders. Such an end-to-end production cycle is characterized by one or several steps of value-adding which might be tailoring of data or provision of information and services, etc. to make climate information usable. This process is here described as climate value-chain, which is required to produce and provide a Climate Service (Figure 2). The basic stakeholders of a Climate Service value chain can be classified as follows:

- **Providers:** providers of climate information collect, manage, archive and provide climate data and also basic climate diagnostic- and monitoring products as well as climate predictions and projections. Key providers on the national level are mainly National Meteorological and Hydrological Services (NMHS). Also important are academia (e.g. universities, research institutes) for model and product development as well as external data providers which provide data from the regional or global level. In many contexts the private sector may also collect relevant climate data for own interests which is, however, not systematically provided to a central database of a NCS.
- **Intermediates:** intermediates have the function of value-adding and can be differentiated in two types: (1) technical intermediates refine basic climate data or information by tailoring and/or adding external data. Important stakeholders may be impact modelers, risk managers or authorities (line ministries) who can often be found at the sectoral level; (2) institutional intermediates or boundary organizations have the function of communicators of climate information as well as advisors for decision-making. Private companies, None Governmental Organizations (NGOs), Community-based Organizations (CBOs) and media are important stakeholders. Another group of intermediates are “enablers” who provide basic resources like global and regional data, knowledge and capabilities (e.g. UN organizations) and funding (e.g. development banks). Intermediates are also users of climate information but with the main function as a value-adder, communicator or purveyor of climate information.
- **End-Users:** the term end-user predominantly targets stakeholders who use climate information for decision-making in a practical context from the national to the community level. In this concern they can be distinguished from intermediates. Important stakeholders for infrastructure sectors are managers, planners, engineers or politicians.

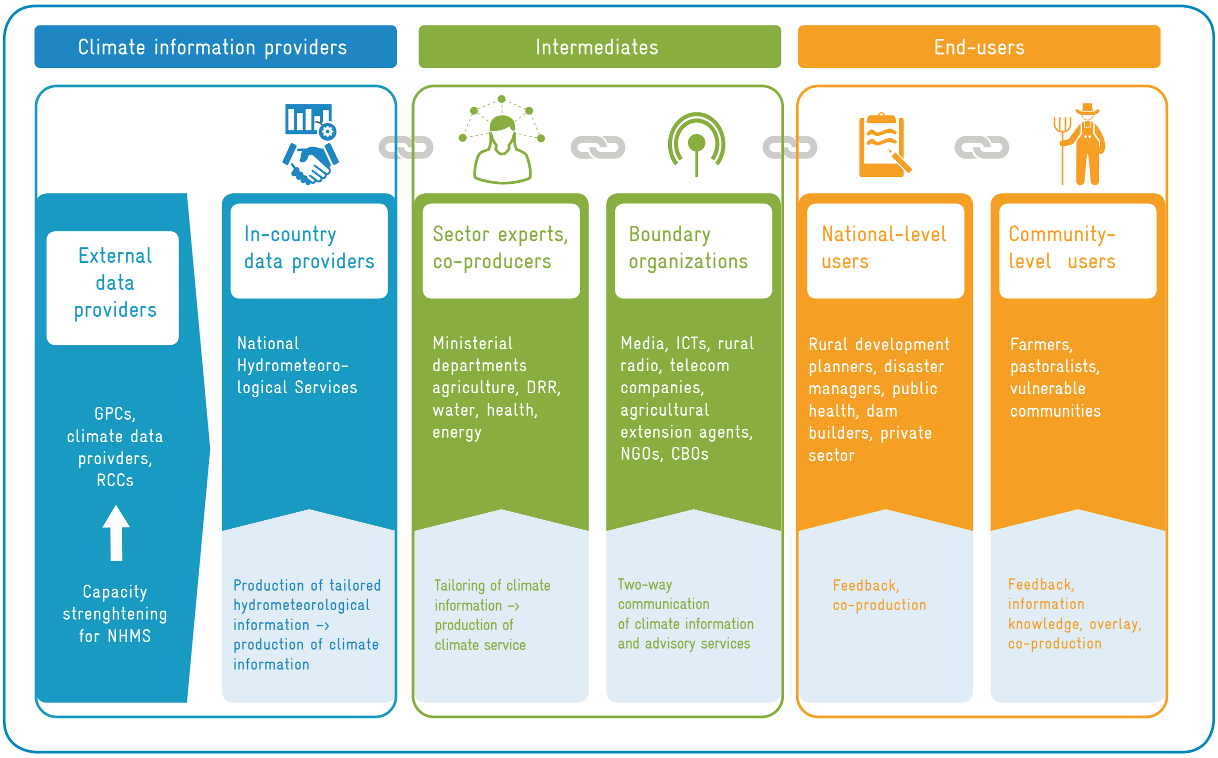


Figure 2 Concept of the climate value chain including the three major stakeholder types: climate information providers (blue box), intermediates (green box) and end-users (yellow box). The stakeholder types are subdivided by sub-types. For each sub-type examples for specific stakeholders are given (blue area) as well as their functions regarding Climate Service development and provision (grey area) (modified from WMO 2018)

Climate value chain characteristics are in general context specific which often refers to individual sectors or even users or user-groups. A climate value chain is always defined by at least one provider and one user. However, the number of intermediates may vary significantly depending on the complexity of purpose and context of a Climate Service application, and furthermore, on the type of end-user and his demands for Climate Services which reflects his capabilities and capacities to process, interpret and digest climate data and information. Besides the amount of stakeholders, the type of stakeholders may also vary or change regarding the context of the Climate Service application. Intermediates and the users often also appear in a very sector-specific context, whereas providers take a rather consistent role for Climate Service provision.

4.2 Global Framework for Climate Services (GFCS)

Decision-makers in many socio-economic sectors including water, agriculture, fisheries, health, forestry, transport, tourism and energy are increasingly concerned by the adverse impacts and consequences of climate variability and change. Thus, there is a growing need for climate information in infrastructure planning and operational decision-making processes. However, the impact of climate information on decision-making is inhibited for various reasons, like limited access to adequate and high-quality climate information, limited capabilities of users to implement climate information in decision-making processes as well as limited capacities of users to deal with climate-related risks and existing climate information.

The World Climate Conference-3 in 2009 in Geneva agreed that in the past 30 years considerable progress was achieved in increasing the quality, coverage and accessibility of climate-related data and the research, modelling and prediction of climate and its impacts. This information enabled the IPCC to provide comprehensive and user-friendly assessments on the current state of knowledge on climate change and its impacts and consequences for society. However, the conference also agreed that less progress has been made in transferring this information into useful and usable Climate Services which help decision-makers to incorporate current knowledge into decision-making processes in order to effectively adapt to climate variability and change. It was realized that "present capabilities to provide effective Climate Services fall far short of meeting present and future needs and of delivering the full potential benefits, particularly in developing countries" (WCC-3 2009, p.2). Based on these findings the Global Framework of Climate Services (GFCS) was established. The GFCS bridges the gap between Climate Service providers and users so that outputs become better assimilated by decision-makers. Thus, the vision of the GFCS is "to enable society to manage better the risks and opportunities arising from climate variability and change, especially as they concern those who are most vulnerable to climate-related hazards" (WMO 2014a, p.4).

The goals of GFCS in support of this vision are:

1. Reducing the vulnerability of society to climate-related hazards through better provision of climate information;
2. Advancing the key global development goals through better provision of climate information;
3. Mainstreaming the use of climate information in decision-making;
4. Strengthening the engagement of providers and users of Climate Services;
5. Maximizing the utility of existing climate service infrastructure.

The structure of GFCS is based on five essential components, which are required to enable the production and dissemination of effective Climate Services (Figure 3). The characteristics of the five components of GFCS are briefly described:

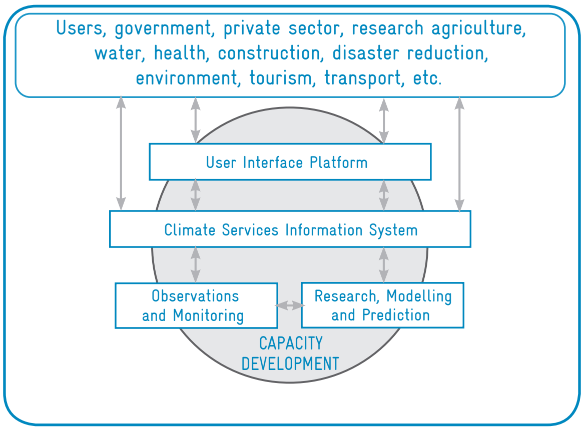


Figure 3 The five functional components of GFCS (WMO 2018)

- **Observations and Monitoring (OM):** the observation and monitoring of the Essential Climate Variables (ECV's[2]) as well as relevant climate phenomena and weather events are the basis for climate analysis and predictions. "High-quality historical and real-time observations and data are required not only across the entire climate system but also relevant biological, environmental, and socio-economic variables so that the impacts of climate variability and change can be evaluated and addressed. Monitoring products such as extreme value statistics derived from high-quality climate observations are of prime importance to planning decisions, for instance regarding reducing disaster risk by developing appropriately resilient infrastructure" (WMO 2014a, p. 9).
- **Research, Modelling and Prediction (RMP):** "RMP fosters research towards continually improving the scientific quality of climate information, providing an evidence base for determining the impacts of climate change and variability and for evaluating the cost-effectiveness of using climate

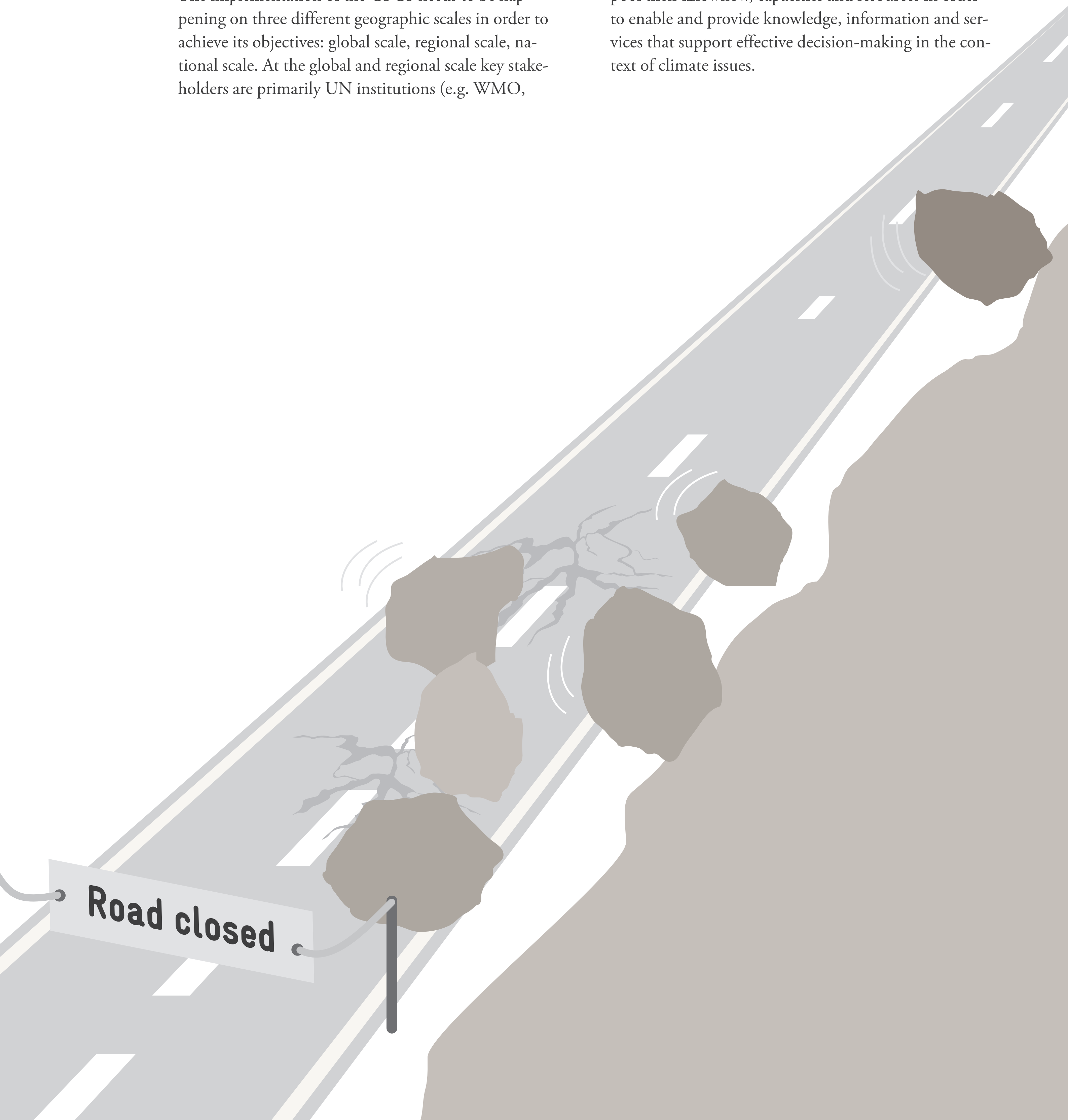
[2] ECV – Essential Climate Variable. An ECV is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth' s climate.

information. It supports the development and improvement of tools and methods that will facilitate the transition of research to operational climate service provision and engender practical applications of climate information. High-quality, reliable observation data and targeted dynamical model outputs will be developed to support the activities of the other pillars" (WMO 2014a, p. 10).

- **Climate Services Information System (CSIS):** "the CSIS is the principal mechanism through which information about climate (past, present and future) is routinely archived, analysed, modelled, exchanged and processed. The CSIS is the 'operational core' of the GFCS; it comprises a physical infrastructure of institutes, centres and computer capabilities that, together with professional human resources, develops, generates and distributes a wide range of climate information products and services to inform complex decision-making processes across a wide range of climate-sensitive activities and enterprises. Its functions include climate analysis and monitoring, assessment and attribution, prediction (monthly, seasonal, decadal) and projection (centennial scale). These functions comprise processes of data retrieval, analysis and assessment, re-analysis, diagnostics, interpretation, assessment, attribution, generation and verification of predictions and projections and communication (including exchange and dissemination of data and products). Knowing user requirements and understanding how users apply climate information will be essential for designing, disseminating and encouraging the uptake of CSIS products and services" (WMO 2014c, p. iii-iv). An essential feature of disseminating and communicating climate information is the pro-active support, training and advice on climate information. This comprises the understanding of climate information content, the application of climate information for the specific user or sectoral contexts and the integration in decision-making processes.
- **User Interface Platform (UIP):** "the UIP provides a structured means for users, climate researchers and climate data and information providers to interact at all levels. The objective of the UIP is to promote effective decision-making with respect to climate considerations by making sure that the right information, at the right time and in the right amount, is delivered, understood, and used. It can be defined further as a managed methodology, or a collection of methods, means, approaches, and processes of systematic and mutually beneficial collaboration. It enables interactions that help define user needs and provider capabilities, tries to reconcile the needs with those capabilities, and eventually promotes effective decisions based on climate information. To achieve its objective, the UIP is aiming for four outcomes: feedback, dialogue, outreach and evaluation. In considering the scope of the UIP it must be borne in mind that the Framework is not a centrally managed system. The methods for developing interactions between climate service users and providers will be determined on a case-by-case basis using available technologies and capabilities" (WMO 2014d, p.1-2).
- **Capacity Development (CD):** "CD tackles two separate but related activity areas: (i) the particular capacity development requirements identified in the other four pillars; and (ii) more broadly the basic requirements (national policies/legislation, institutions, infrastructure and personnel) to enable any GFCS related activities to occur. In the context of both activity areas capacity development actions under the Framework will facilitate and strengthen, not duplicate existing activities. They will also address needs from both the demand side and the supply side of Climate Services" (WMO 2014b, p. iv-1). The CD component is key for the enhancement of developing and using Climate Services. A well developed and implemented CD component enables an effective and efficient development of useful and usable climate information products as well as a sustainable strengthening of users in the formulation of their demands of Climate Services, their application as well as integration in decision-making processes.

The five components do not function as stand-alone entities but they need to interact in order to make the production, delivery and application of Climate Services effective. Furthermore, they need to be considered as conceptual models which cannot be delineated clearly in practice and will cause some overlapping of functions and responsibilities. The functions and responsibilities of each element do not necessarily need to be covered by one institution (e.g. NMHS) but are rather distributed among various stakeholders within a National Climate Service.

The implementation of the GFCS needs to be happening on three different geographic scales in order to achieve its objectives: global scale, regional scale, national scale. At the global and regional scale key stakeholders are primarily UN institutions (e.g. WMO, FAO, UNDP, WFP, WHO, UNISDR, etc.) and other international active organizations like development agencies and development banks (e.g. GIZ, USAID, World Bank, etc.). These international stakeholders pool their knowhow, capacities and resources in order to enable and provide knowledge, information and services that support effective decision-making in the context of climate issues.



5 National Climate Service

For the implementation of the GFCS at the national level each country requires a respective National Framework for Climate Services (NFCS). "An NFCS is an institutional mechanism to coordinate, facilitate and strengthen collaboration among national institutions to improve the co-production, tailoring, delivery and use of science based climate predictions and services by focusing on the five GFCS pillars" (WMO 2018, p. 8). The implementation of a NFCS can be respectively called National Climate Service. A well-organized National Climate Service has the capacities and capabilities to provide core climate products for all relevant sectors and for various demands. Furthermore, it is able to facilitate end-to-end Climate Service provision due to a well-developed User Interface Platform with a wide interlinked network of stakeholders from various sectors and close continuous relationships to a wide range of users, user-groups and other relevant sectoral stakeholders.

The term National Climate Service (NCS) will be used throughout the entire report referring to the collaborative network of stakeholders which are involved in the development production and dissemination of Climate Services on a national level.

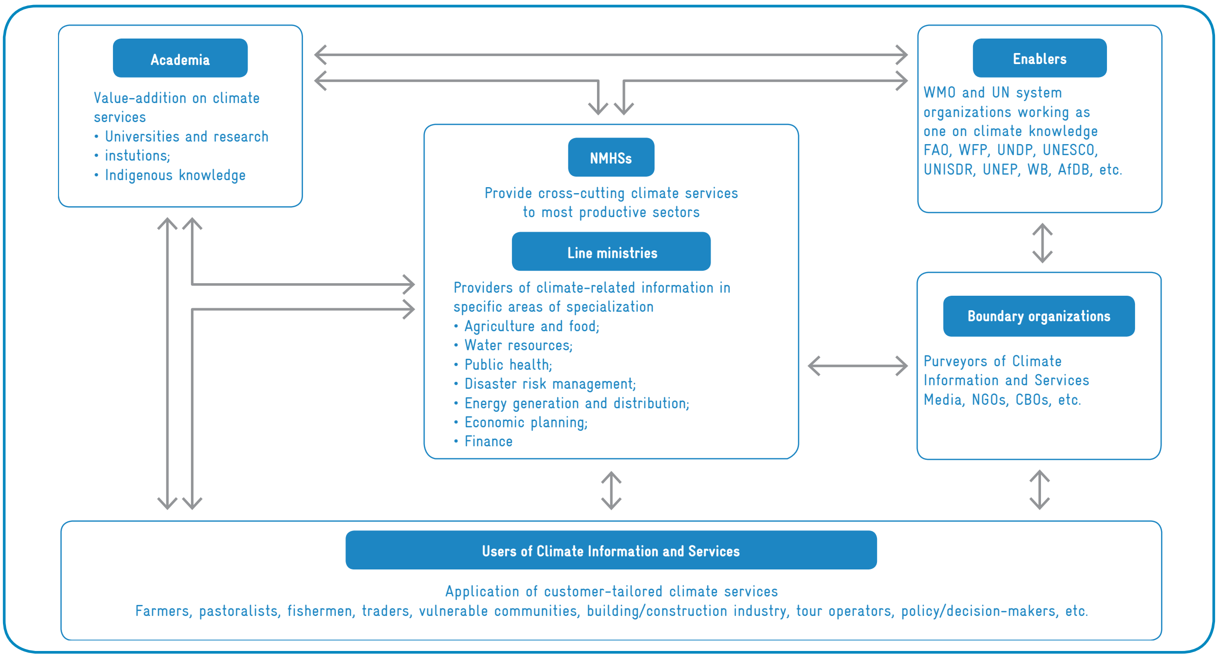
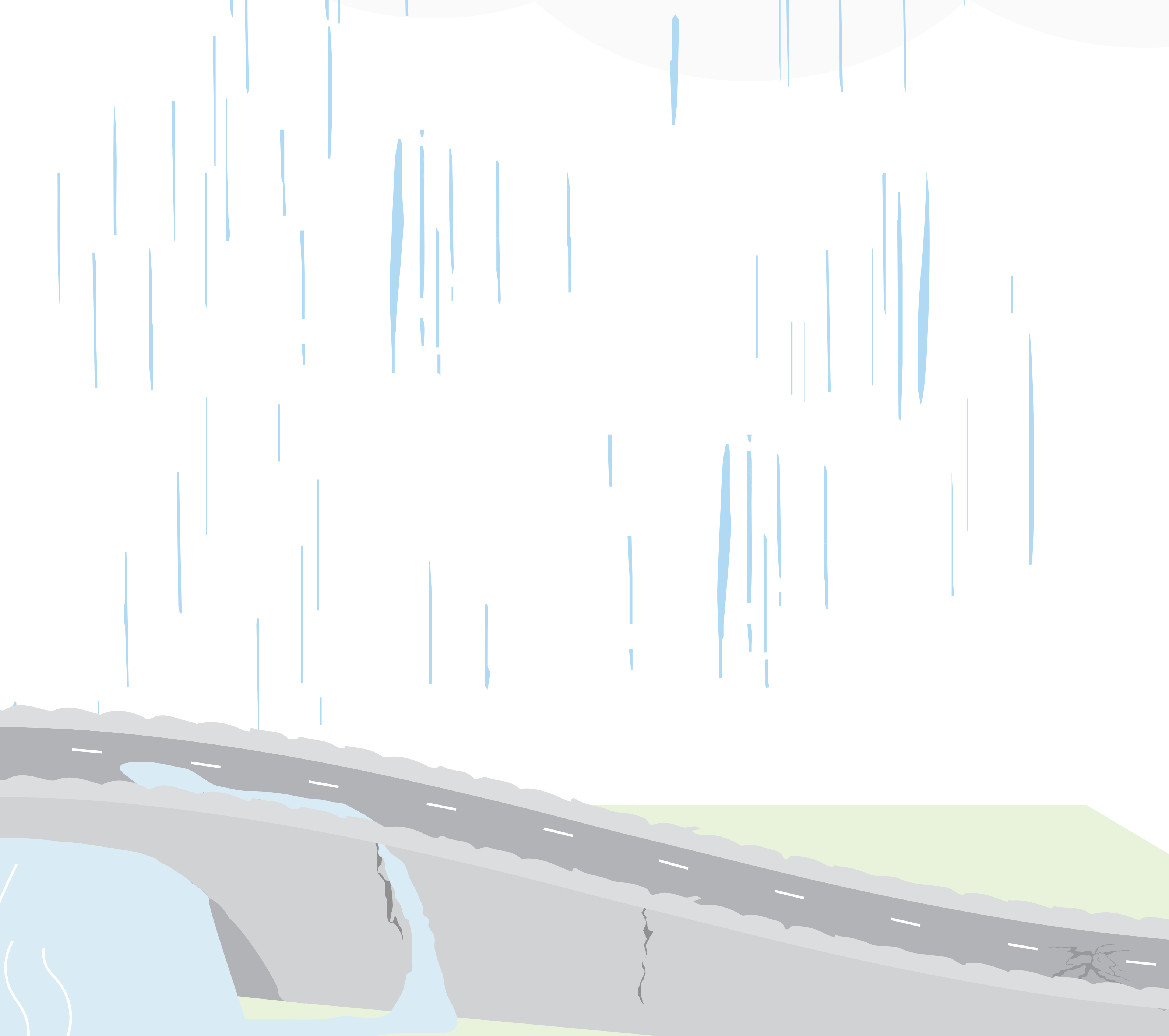


Figure 4 Example for an institutional arrangement of an NCS with key partner institutions and their interlinkages (WMO 2018). (AfDB = African Development Bank; CBO = community-based organization; FAO = Food and Agriculture Organization of the United Nations; NGO = non-governmental organization; UN = United Nations; UNDP = United Nations Development Programme; UNEP = United Nations Environment Programme; UNESCO = United Nations Educational, Scientific and Cultural Organization; UNISDR = United Nations International Strategy for Disaster Reduction; WB = World Bank; WFP = World Food Programme)

The institutional arrangement of a National Climate Service comprises all stakeholder groups that are relevant for the production and dissemination of Climate Services (climate-value-chain) (II.4.1). Figure 4 provides an overview on a sample institutional arrangement for an NCS. The role of NMHS within a NCS is envisaged as key since the fundamental components of the GFCS (i.e. OM, CSIS) are usually adopted by the NMHS as mandated and thus established and enduring institution. Furthermore, NMHS are a point of contact to WMO institutions as well as users of various sectors and thus constitute an important interlinkage of various stakeholders within a NCS. Therefore, NMHSs are considered to be more than just a climate data provider: NMHS are envisaged to take a coordinating role of climate data and climate information as well as their dissemination and communication. And furthermore, the NMHS is expected to coordinate the tasks transferred to the NCS-partners, which refer to value-adding, support, training and advice, in order to guarantee the adherence to standards and thus quality and reliability of climate information.



Landslide caused by tropical storm Nate on Ruta Nacional No. 2,
at the height of the “de la Muerte” masif in El Guarco de Cartago.

III Methodology

1 Assessment concept

The objective of the assessment is to provide an abstract of the current state of the National Climate Service (NCS) in the context of the road infrastructure sector in Costa Rica. The NCS will be characterized and described in this study by basically two products:

1. **the climate value chain** identifies and depicts all relevant stakeholders for climate information provision in the context of the road infrastructure sector and elaborates the state of their tasks as well as their relationships; and
2. the **baseline** which comprises a **Climate Service inventory** of currently available Climate Service products which are actually or potentially useful for the road infrastructure sector as well as a synopsis of Climate Service needs which list all Climate Services which are currently being used by users of the road infrastructure sector.

The output will be an analysis of the completeness of the climate value chain in terms of lacking interlinkages of stakeholders as well as the identification of discrepancies between climate service offer and demand. According to this analysis, entry points for specific measures to enhance the provision of Climate Services for infrastructure investments will be identified.

1. **Climate value chain:** the climate value chain will be analysed with focus on the case-study which is selected for the climate risk assessment in the context of the CSI project. The entry points for the stakeholder analysis of the climate value chain will be the CSI project partners and stakeholders affiliated to the CSI project. For the provider group this will be the National Meteorological Institute of Costa Rica (IMN) which is the main responsible institution for climate information provision. The user-group will be represented by key stakeholders of the road infrastructure sector. By interviewing these stakeholders the climate value chain will be (re-) constructed starting simultaneously at different positions within the value chain and in different directions along the value chain. Additional stakeholders might be identified successively as a result of the interviews conducted in the context of the baseline assessment.

   The benefit of this approach is a potential double-check of interlinkages of stakeholders and how climate information is provided or used. Furthermore, a more comprehensive picture of the Climate Service inventory can be achieved since stakeholders are identified throughout the entire spectrum of the value chain, including data providers, intermediates and applied users from different sectors.

2. **Climate Service inventory:** the inventory of Climate Services within a NCS is assessed on the basis of the GFCS components. The state of each component within the NCS is analysed by considering the fulfilment of the required functions regarding the definitions of the GFCS (II.4.2) and the involved stakeholders which feed back into the climate value chain. Fundamental shortcomings and development needs are identified. The currently available Climate Service products relevant for the road infrastructure sector are assessed considering all three dimensions of Climate Services. This means that besides the listing of products a special emphasis is put on the tailoring and dissemination characteristics for each product type as well as provided complementary services to make it usable for the specific user of the road infrastructure sector. Furthermore, stakeholders are identified which are involved in the production and provision of each product type. A preliminary classification of the availability of climate information products is evaluated according the categories of WMO (2012) (Appendix 2). Concurrently, Climate Service products which are currently used by stakeholders of the road infrastructure sector as well as their needs for not yet available Climate Services are assessed, again considering all three dimensions of Climate Services.

Main findings from the baseline will be summarized within a graphical visualization of the climate value chain for the specific sectoral context as well as in a SCOT differentiating strengths, challenges, opportunities and threats of the current state of a National Climate Service from both perspectives: providers and users.

2 Assessment methods and tools

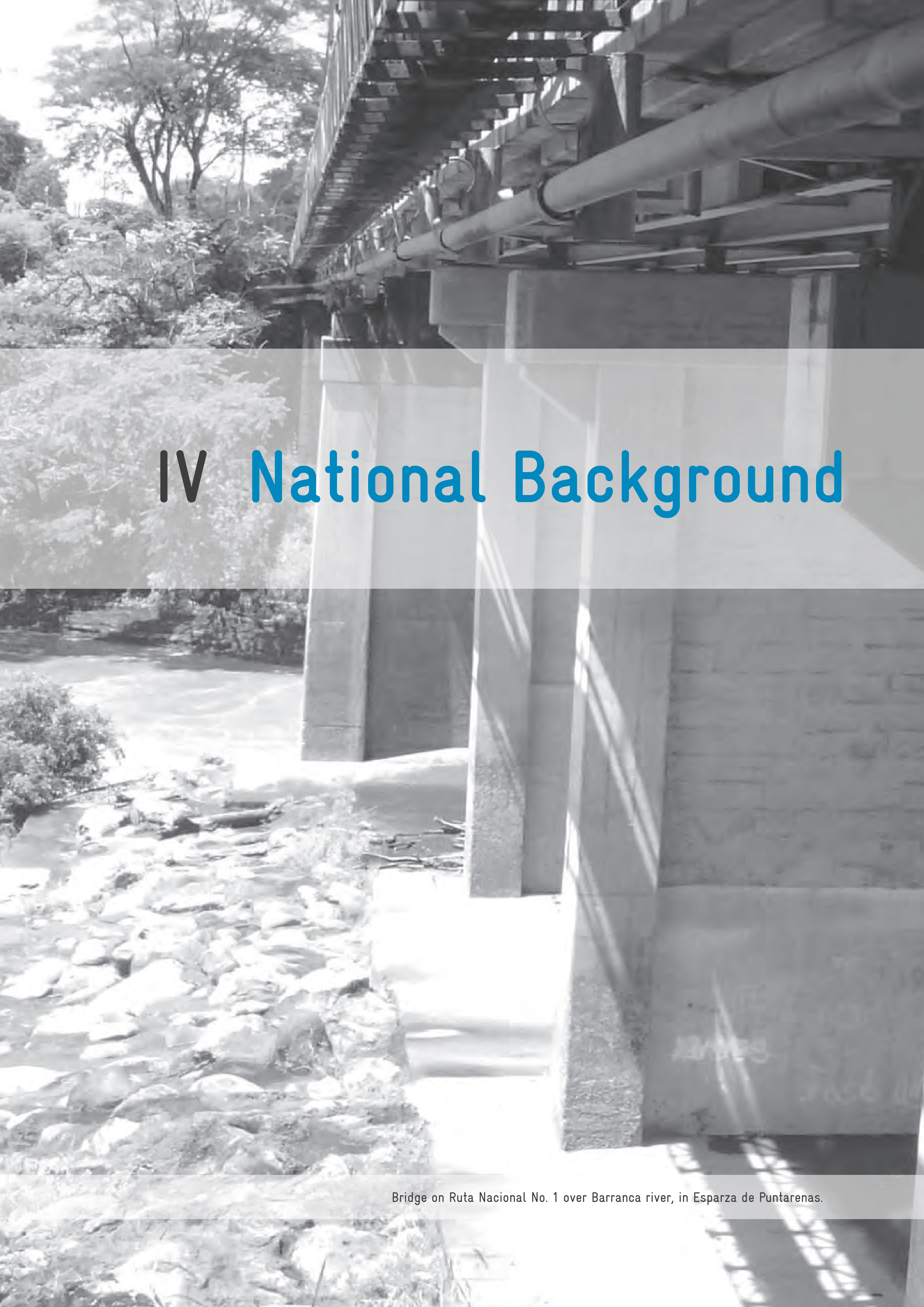
The basic methods for data collection are questionnaires. Altogether two questionnaires were developed: one for providers and one for the users. There is no extra questionnaire for intermediates, since the classification to a stakeholder type is often not that clear and causes discussion and confusion. The user-questionnaire is also suitable for intermediates since it asks for the purpose and output of the use of climate information, which can refer to a decision-making process as well as to a product or service which will be used by another stakeholder. Although, the catalogue of questions is provided in the format of a questionnaire, the required information could also be collected via other methods like interviews or workshop notes and minutes depending on the local situation.

Provider questionnaire: the structure and content of the provider questionnaire mainly addresses NMHSs since these are normally key stakeholder of the Climate Service provider group covering fundamental tasks of a National Climate Service. However, the questionnaire is also suitable for other Climate Service providers when skipping some of the questions. The provider questionnaire is compiled from several WMO questionnaires. This comprises a standard questionnaire from WMO which is used to observe the development of its members as well as three draft versions which also address the current status of Climate Services provided by NMHSs in the context of the NFCS implementation.

User questionnaire: the user questionnaire was developed within the CSI project. However, ideas and experiences from other projects and programs addressing users and their need for Climate Services were considered (e.g. Bessembinder et al. 2012; Daly et al. 2016; BELSPO 2014). The scope and structure of the user questionnaire addresses a range of user types. This comprises experienced users who regularly use climate data and are able to process climate data for their context as well as users who have no experience with climate data. Less experienced users often require tailored products and help with interpretation of climate information as well as decision support. They are often not able to formulate their needs for specific climate information products. The questionnaire is structured in a way that a user is guided to identify his needs for climate information for his specific context.

Product matrix: the product matrix is a tool which is attached to or integrated in the questionnaires. The product matrix reflects the three dimensions of Climate Services on the level of product types. This is because Climate Service dimensions (i.e. the tailoring of products for a specific sector, the services provided along with products, user-interaction as well as cooperation with other stakeholders to develop Climate Service products) may vary between product types (for the product matrix see Appendix 4). The matrix was completed by providers and users and can be directly compared. Discrepancies in offer and demand can directly be identified and also the reason for this discrepancy which might be found within any of the three dimensions of Climate Services (II.4). This approach potentially provides concrete entry points for measures to enhance the use of Climate Services.

IV National Background



Bridge on Ruta Nacional No. 1 over Barranca river, in Esparza de Puntarenas.

1 Climate change risks in Costa Rica

The road infrastructure in Costa Rica is very vulnerable to extreme hydro-climatological events and climate change. One important factor for this vulnerability are the geographic conditions: the most populated areas are located in mountainous regions with jagged topography and many rivers and gorges as well as floodplain regions with changing courses of river channels. Both landscape types are furthermore prone to high annual rates of rainfall and simultaneously exposed to an increase of urbanization which implies an enhanced sealing of surfaces and thus an increase of runoff. Building roads in such an environment requires the construction of many bridges and culverts as well as road cuts and fills which exposes the road infrastructure to landslides and flooding. Furthermore, insufficient and ineffective investments in the road infrastructure result in poorly stabilized road cuts, insufficient sewers in flood-dams as well as bridges which are often designed too low and too short to withstand flooding events which intensifies the physical vulnerability. Other important factors are settlement and land use structures, maintenance of infrastructure objects and landscapes (especially referring to garbage disposal in river beds sewer systems) as well as the organization of the road network which cause a systemic vulnerability. In general, the road network is organized in a radial structure with national and regional centres dominated by Costa Rica's capital San José with almost all major roads passing through these centres. Furthermore, many settlements are widely dispersed in remote regions with very low population density but which require access roads. The combinations of both factors provide little redundancies in case of obstruction or destruction due to flood or landslide events since often no alternative access exist even for functionally highly relevant roads (Mesalles et al. 2014).

The road network is organized in a radial structure with national and regional centres dominated by Costa Rica's capital San José with almost all major roads passing through these centres.

Hydro-meteorological events relevant for the occurrence of floods and landslides are normally storms and indirect effects of hurricanes mainly in the Caribbean Sea which are linked to cold fronts, low pressure systems, tropical depression and of course El Niño and La Niña events as dominant climatic phenomena for the region (MINAET 2009). According the National Emergency Commission (CNE) of Costa Rica, extreme hydro-meteorological events in the period from 2005 to 2017 caused economic losses of about US$ 2.210 million in the infrastructure sector, of which more than the half refers to road infrastructure like roads, sewer systems and bridges (CNE 2017).

In the context of climate change (A2 scenario[3]), precipitation patterns are supposed to change in dependence of the geographical region. The major climatic divide is the mountain range reaching from the north-west to the south-east. For the time period 2071–2100 annual rainfall will probably increase by up to 50% on the Caribbean Slope with an annual peak of up to 100% increase during the period from June to August (rainy season) and an accompanied decrease of around 50% during the period from December to February (dry season). This scenario would imply a marked transformation of the annual rainfall cycle of the Caribbean regime which implies a substantial change of the intensity and frequency of hydro-meteorological phenomena. These are climate conditions which are similar to the consequences of El Niño events which are responsible for 93% of extreme rain events in the Caribbean (IMN and CRRH 2008).

In contrast, the pacific slope will probably have less rainfall with up to 65% in the basins of the North Pacific (Guanacaste). One exception is the very south of the Pacific slope which will probably have an increase of about 30% of rainfall. This general decrease of rainfall for the Pacific Slope (were around 90% of the inhabitants of Costa Rica live) will be throughout the year but most significant in the rainy season (June-August) which would cause an increase of the magnitude as well as persistence of droughts and heat-spells. The precipitation peak will probably be relocated to the first rainy period May/June which means a loss of rele-

[3] The A2 scenario is one of six possible scenarios from 2000 describing future greenhouse gas emissions (SRES) which are the basis for a specific degree of global warming (IPCC, 2000).

vance for the second rainy season in September/October as major contributor to the annual rainfall and thus a fundamental change of the annual cycle of the Pacific rains (Alvarado et al. 2012). Projections for hydro-meteorological extreme events are not available. However, regarding the rainfall projections the increase of probability of droughts in the Pacific North Region as well as high magnitude rainfall events in the Caribbean Region should be anticipated.

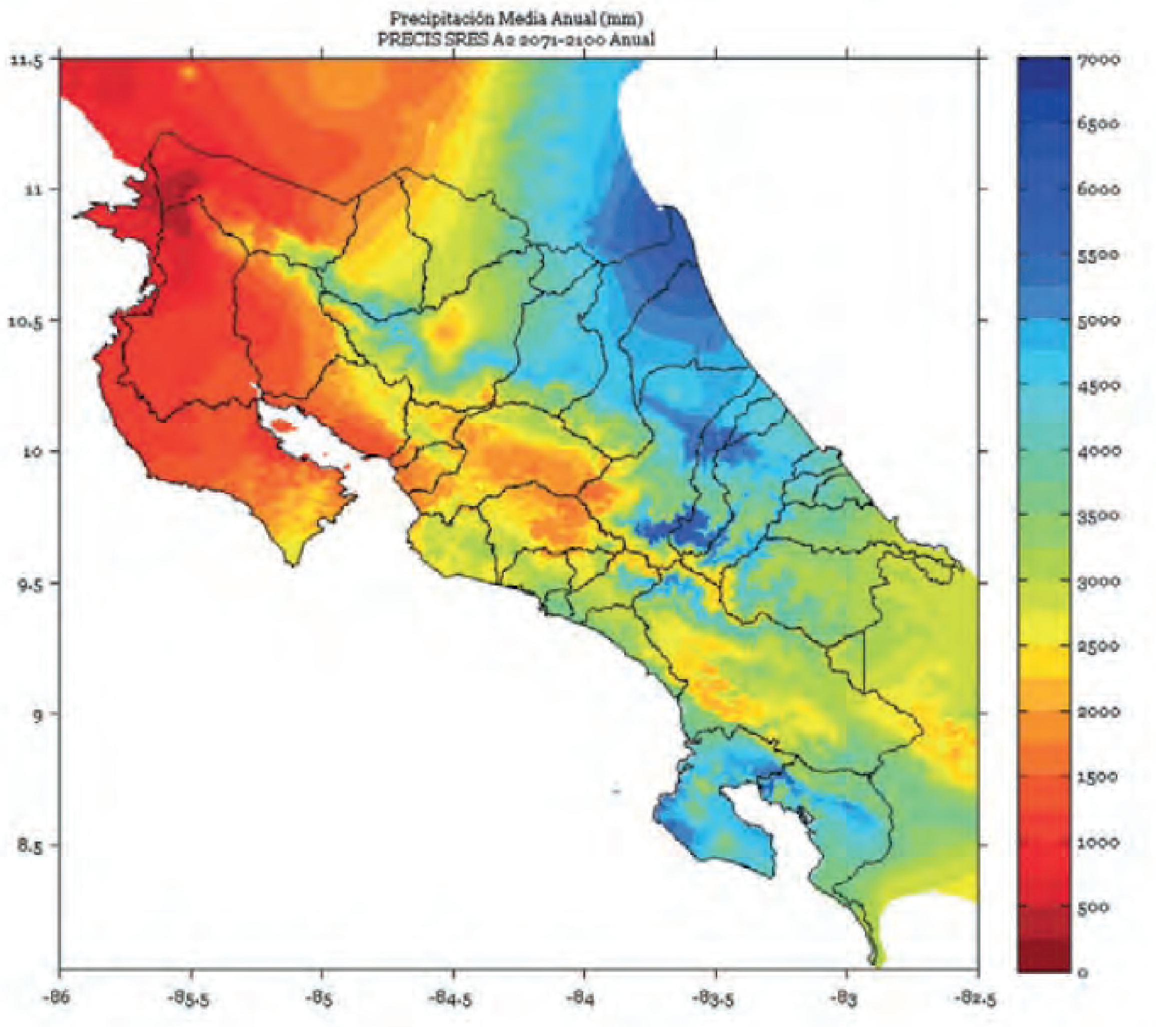


Figure 5 Projected mean annual precipitation for Costa Rica for the period 2071–2100 based on the regional model PRECIS and global model HadCM3 and the scenario A2 (Alvarado et al. 2012).

2 Context of CSI-project

2.1 Political background

In the context of climate change Costa Rica faces fundamental challenges. Especially the infrastructure sector has been affected by extreme weather events in the recent past. In reply, Costa Rica adopted a National Climate Change Strategy (ENCC) in 2006. A focus highlighted in the Intended National Determined Contribution (INDC) is the adaptation of public infrastructure to climate change. One objective until 2020 will be the utilization of methods for the identification and prevention of infrastructure's vulnerabilities as well as the development of a respective monitoring system. The National Adaptation Policy[4] has already been decreed as of July 2018. Within the policy Costa Rica picks up this issue within two axes and formulates ambitious goals to make their infrastructure climate proof by the enhanced use of Climate Services:

Axis 1: Knowledge Management for Climate Change Impacts, Climate Services and Capacity Development

- Enabling information platforms and climate services, […], in order to collect data and generate and disseminate climate scenarios at the necessary scales that facilitate a better decision-making and guide adaptation actions within the framework of public and universal access information systems.
- Promotion of scientific research, systematic data collection and current and prospective analysis of information on impacts, losses and damages due to hydro-meteorological threats, as well as quantifying and analyzing costs, opportunities and social benefits associated with Climate Change adaptation measures in different sectors for decision-making.

Axis 4: Adapted Public Services and Resilient Infrastructure

- Strengthening of norms and guidelines for public investment with criteria of adaptation to Climate Change that guarantee the design of infrastructures and adapted services and ensure their utility and continuity of services.
- Protection of public infrastructure, through appropriate risk assessment and the adoption of protection mechanisms ensuring the robustness of infrastructure works.
- Implementation an open climate data policy by 2020.

The Climate Change Department of Costa Rica's Ministry of Environment and Energy (MINAE-DCC) is in charge of coordinating the implementation of the ENCC. Furthermore, they are supervising the definition of technical standards in close coordination with other sectoral stakeholders (e.g. Ministry of Public Works and Transport (MOPT)) and institutions related to MINAE, such as the National Meteorological Institute (IMN) (MINAE 2015).

2.2 National Climate Service for the road infrastructure sector

In the context of the baseline assessment relevant stakeholders for the provision and use of Climate Services for the road infrastructure sector were identified. Regarding the tasks and functions of the individual stakeholders a preliminary institutional arrangement (stakeholder map) of a NCS for the road infrastructure sector in Costa Rica can be drafted. Such an arrangement is provided in Figure 6. It is important to note that this NCS is hypothetical. The stakeholders do exist and may be allocated to the respective roles within the NCS due to their current tasks and mandates. However, actual roles and interrelations may not (yet) be existent. This stakeholder map shall provide a starting point for the baseline assessment and basis for the discussion of the results.

Further sectoral key stakeholders of a potential NCS are (besides project partners (II.2)):

MIDEPLAN is the Ministry of National Planning and Economic Politics. MIDEPLAN is responsible for formulating, coordinating, monitoring and evaluating the Government's strategies and priorities. Main functions (among others) are the definition of a country development strategy that includes medium and long-term goals and the preparation of the National Development Plan, which should translate the Government's strate-

[4] Decreto Ejecutivo 41091-MINAE sobre la Política Nacional de Adaptación. www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=86580&nValor3=112448&strTipM=TC

gy into priorities, policies, programs and actions as well as coordination, evaluation and follow up on those actions, programs and policies for all sectors.

CONAVI is the National Road Council of Costa Rica and is subordinated to the Ministry of Public Works and Transportation (MOPT). The main tasks and responsibilities of CONAVI are planning, financing and operational management of the national road network in accordance with the programs prepared among others by MIDEPLAN in order to guarantee the functionality, operation and safety of the national road network.

CNE: the National Commission for Risk Prevention and Emergency Response is the leading institution of the State policy on Risk Management, promotes, organizes, directs and coordinates the operation of the National Risk Management System and the execution of its National Plan. It contributes to reducing vulnerability, safeguarding human life and the well-being of the country's inhabitants.

UCR is the University of Costa Rica. Most relevant institutes for climate change studies is the Center for Research and Studies for Sustainable Development (CIEDES) which is a multidisciplinary unit dedicated to the investigation and study of the structure, processes and results of the interaction between societies and the environment. And the Geophysical Research Center (CIGEFI) which does research on i.a. climate variability, climate change projections, hydro-meteorological modelling and disaster prevention.

LANAMME is the National Laboratory of Materials and Structural Models of the University of Costa Rica (UCR) which is attached to the School of Civil Engineering.

CIVCO the Center of Investigations in Housing and Construction of the Technical Institute of Costa Rica (TEC). CIVCO is mandated by the government via the research and extension plans to support the integral development of the country's infrastructure.

CRRH, RCCs are regional climate centres for hydrological (CRRH - Comité Regional de Recursos Hidráulicos) and climatological issues (Regional Climate Centre: CIMH (RCC-Caribbean); USRCC (RCC North America)). They provide regional information like seasonal forecasts and support for prediction, water resource management, data exchange, research etc.

More detailed information on these stakeholders is given in V and VI.1.

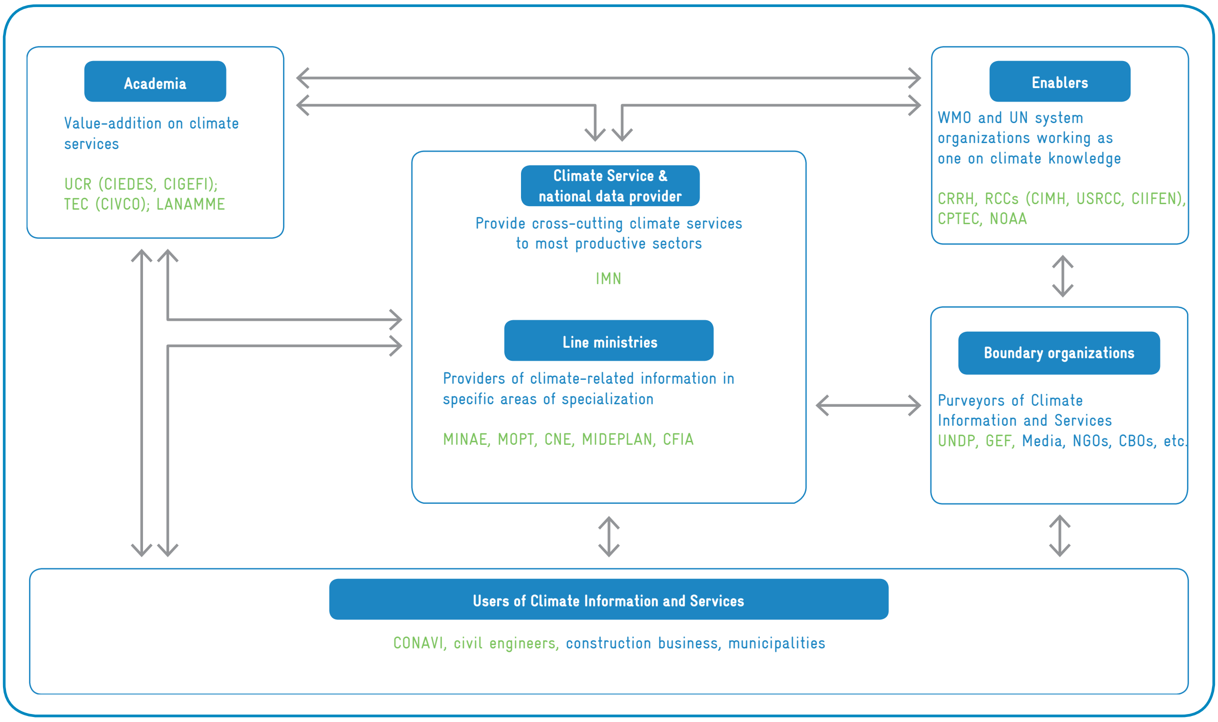


Figure 6 Preliminary institutional arrangement for an NCS of the road infrastructure sector in Costa Rica. Stakeholders in green color are identified organizations and institutions in Costa Rica which already do or potentially might take the allocated role within a NCS for the road infrastructure sector in Costa Rica. (based on WMO 2018). For abbreviations please refer to abbreviations list.

3 Data collection

For the assessment of the Climate Service inventory, IMN was interviewed exclusively. One provider questionnaire was completed by IMN as well as the results from an additional questionnaire which was completed in the context of a standard survey by WMO. The completion of the product-matrix was done in the context of a workshop at IMN in October 2017 with six experts from different sections of IMN. Open and new questions emerging during evaluation were answered subsequently via bi-lateral communication with IMN.

The identification of relevant users of Climate Services in the context of road infrastructure which were available for interviews was the result of various ex ante talks with stakeholders in the road infrastructure sector. For data collection the user questionnaires were used. The questionnaires were completed by the interviewees themselves and sent to the CSI team in Costa Rica or in the context of interviews or in a combination of both. Ex ante talks as well as the execution of the interviews were done by the CSI-GIZ team in Costa Rica. The user data was collected in February/March 2018. Altogether, six questionnaires were completed by nine users from six different organizations (see Table 1: Key users from the road infrastructure sector in Costa Rica which were interviewed for the Climate Service baseline assessment.Table 1).

Table 1 **Key users from the road infrastructure sector in Costa Rica which were interviewed for the Climate Service baseline assessment.**

#	Entity	Department / Unit
1	CONAVI	Direction of Roads and Bridges Design
	CONAVI	Planning
	CONAVI	Hiring
2	LANAMME, UCR	Bridges unit
	LANAMME, UCR	Municipal Management Unit
3	Consultant – freelancer	Hydrologist and lecturer
4	CIVCO, TEC	Water Resources TEC
	CIVCO, TEC	School of Construction Engineering

V Climate Service inventory

Bridge on Ruta Nacional No. 1 over Barranca river, in Esparza de Puntarenas.

The climate service inventory is supposed to be assessed for the National Climate Service (NCS) of Costa Rica for the context of the road infrastructure sector, which comprises Climate Services provided by all partners of the NCS in Costa Rica (see II.5). However, IMN as National Meteorological Service takes a central position within the NCS since it has a mandate from the government that qualifies it as official provider of Climate Services in Costa Rica and is also funded via national budget. There are officially no other entities in Costa Rica that provide Climate Services, and thus IMN also appears as central Climate Service provider in Costa Rica. For that reason the focus of the inventory assessment is put on IMN. Nevertheless, cooperation partners who support IMN in the production and provision of Climate Services are also assessed.

IMN – the Costa Rican National Meteorological Institute

The IMN (for its acronym in Spanish) is an institution founded 130 years ago and affiliated to the Ministry of Environment and Energy (MINAE). It is a scientific body that is in charge of the coordination of all meteorological and climatological activities in the country. It maintains a systematic monitoring of the weather in order to provide support for the safety of air navigation in the country, for the prevention of disasters of hydro-meteorological origin and to prevent adverse effects of variability and climate change. IMN is structured in five administrative and organizational units (Administrative Coordination of the Direction; Administration and Finances; Human resources; Legal Advice; Press Office; Informatics Unit) and four technical departments (Weather Network and Data Processing; Meteorology, Synoptic and Aeronautics; Climatology and Applied Research; Information), which are operated by around 80 people and governed by a director and the National Council of Meteorology. The National Council consists of representatives from Civil Aviation, the Institute of Aqueducts and Sewers (AYA), the Institute of Electricity (ICE) and the Minister from MINAE. It sets the policy for meteorological activities, approves the financial plan and appoints the director (IMN 2018).

The operational core for the National Climate Service in Costa Rica is IMN. IMN is the official Climate Service provider of Costa Rica mandated and funded by the government. However, the collection and provision of climate data is also done by some public and private organisations. Meteorological and Hydrological Services in Costa Rica are separate. A hydrological service as such does not exist. The role of IMN as Climate Service provider is supported by WMO who accompanies IMN in developing a National Plan for Climate Services. However, this process is yet pending. For the integration of climate information provision in sectoral contexts, a Disaster Risk Management Strategy as well as several sectoral policies and strategies are in place to build on. However, no detailed information is available on these strategies for this report. IMN fosters cooperation at the regional and international level with the Regional Climate Centre of North America (US-RCC), Central America and the Caribbean (CIMH - Regional Association IV), the Regional Committee for Water Resources (CRRH) as well as with the Conference of Directors of the Ibero-American Meteorological and Hydrological Services. Furthermore, IMN is the Costa Rican focal point for the International Panel on Climate Change (IPCC), the World Meteorological Organization (WMO) and the International Global Change Institute (IAI).

1 Observations and monitoring

The operation of Costa Rica's observation and monitoring is institutionally divided between meteorological and hydrological institutions with limitations regarding cooperation, a spatially homogeneous and temporally continuous observation and monitoring of climate variables and events as well as free data use.

The monitoring of climate variables and phenomena in Costa Rica is basically incumbent upon the National Meteorological Institute (IMN). IMN operates altogether 293 climate stations all over the country and thus facilitates the observation and archiving of all essential climate variables [ECV's] for atmospheric domain (Precipitation, Temperature, Relative Humidity, Wind, Wind direction, Radiation, Atmospheric Pressure) (Figure 7). Besides the observation network of IMN there is a parallel observation network operated by ICE (Costa Rican Institute of Electricity) as well as several additional climate stations which are operated by other stakeholders like for example, CATIE (Center for Tropical Agricultural Research and Higher Education), SENARA (National Service of Underground Water, Irrigation, and Drainage) and CORBANA (National Banana Corporation). None of these stations, however, do feed into a central climate data base of IMN but need to be purchased and are only available for internal purposes (e.g. research, specific projects, etc.). A further external data source is the National Oceanic and Atmospheric Administration (NOAA) from the United States which provides satellite data that is enhanced by own infrastructure (e.g. own satellite disc). This data is predominantly used for monitoring purposes and forecasts of hydro-meteorological events. Also data from re-analysis is used for the completion of time series. IMN operates no own maritime observations but provides marine forecasts (tides and waves) which are based on observations and services provided by buoyweather.com[5]. Terrestrial ECV's are supposed to be assessed but no details about type and data source is given.

A hydrological observation network (variables: river flow and precipitation), which covers primarily the mountainous regions, is operated by ICE. Further hydrological stations are operated by SENARA and AYA which are related to specific projects and are not part of a central hydrological observation network. Hydrological data from all hydrological data providers is not generally available to IMN for analysis and archiving and thus does not feed into their climate data bases. In contrast, hydrological data needs to be procured anew for each individual project as well as the agreement of the scope of use of the purchased data. However, it is noteworthy that there are activities regarding the consolidation of hydrological data in Costa Rica ongoing. A committee for hydrological data was established which works on a respective decree. However, no details on the committee, the activities and the decree are available for this report.

As a longtime WMO member, IMN adheres to WMO standards like the WMO climate monitoring principles (Appendix 1) concerning observations, monitoring and data management which is adopted in a well-documented strategy ensuring security, integrity, retention policy and technology migration for data archival process and systems. This comprises the standardized collection and archiving of data in adequate data bases with sufficient meta-data as well as the guarantee of appropriate data quality and the implementation of data rescue programs, if required. All climate observations which are done by IMN are integrated in a central observation system and accumulated in time series in appropriate length and resolution for standard climate analysis. However, there are no homogeneity tests implemented for these time series. There is also a long-term strategy in place for managing the observation network and its change which comprises the enhancement of the station density, the relocation of stations, the establishment of automated observations that meet climate observation requirements and standards in order to obtain real time data as well as the protection of long-term observing stations. Furthermore, IMN provides its data to WMO institutions and programs on the regional and global level (via CACOF - Regional Committee of Hydraulic Resources (CRRH)) for operational use and back-up. In contrast, the public use and sharing of meteorological data in Costa Rica is restricted by respective data policies.

[5] Buoyweather is a commercial marine forecast service that provides customized forecasts and data on marine weather, tides and wave all over the world.

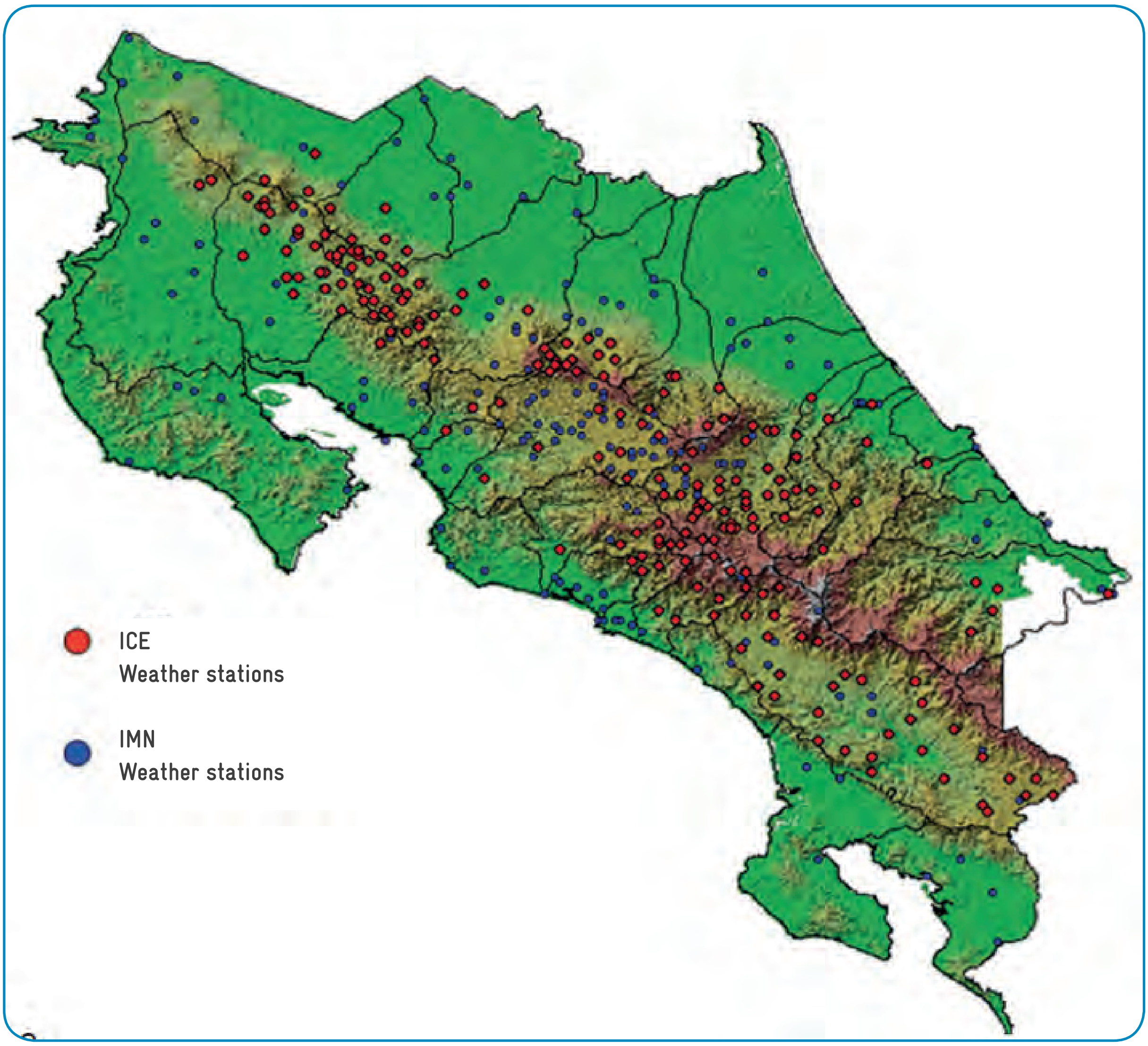


Figure 7 Location of climate stations operated by ICE (red) and IMN (blue) (provided by IMN in Costa Rica 2009).

2 Research, modeling and predictions

Research activities on climate issues in Costa Rica are mainly initiated by IMN often in cooperation with the academic sector and other government departments. IMN is also the official institution for the production of climate model development, climate predictions and climate change projection. However, since capacities regarding these tasks are very limited climate models and tools are often used from external sources.

Research activities at IMN are integrated in the department of "Climatology and Applied Research". IMN's research activities cover a broad range of issues (e.g. agro-meteorology, climatic variability, air pollution, interaction ocean-atmosphere, greenhouse gases inventory, climate change and others). However, there is no budget for research activities at IMN itself. Research on climate issues mainly occurs in the context of specific projects with limited funding according to the project scope and lifetime and in cooperation with project partners from academia (e.g. UCR) or with sectoral stakeholders or authorities. Such projects mostly refer to climate change, climate change impacts and adaptation to climate change as well as research contributions to tasks of the UNFCCC. The cooperation with the academic sector in the context of such projects is very close, especially CIGEFI-UCR. This cooperation comprises the free provision of required climate data by IMN to academic institutions for studies or student thesis but also in the context of academic exchange (e.g. regular internships of students at IMN) or consultancy works by UCR-students for IMN tasks and projects. Sector-specific cooperation agreements exist with the Ministry of Agriculture and Livestock (MAG) for the development and provision of agro-meteorological products and services which mainly refer to weather and seasonal forecasts. Similar cooperation with the road infrastructure sector does not exist but research institutes like LANAMME who research on material and geotechnical issues benefit from the agreement with IMN on free climate data use.

For the context of climate modeling and the provision and communication of climate change projections, IMN is the official institution in Costa Rica to generate these products and services. However, especially staff capacities for these tasks are very limited. There is only one person responsible and capable to handle climate projection models and data. The development of scripts for regional models is partly transferred to the UCR under supervision and funding from IMN. For the production of climate scenarios existing climate models from external providers are mostly being used (more information is given in V.3).

3 Climate Services Information System

Costa Rica's national Climate Service network is able to provide a wide spectrum of climate data, information products and services. Although some selected sectors are continuously provided with climate information, there is a significant challenge to provide tailored and usable climate information to sectoral users.

IMN as official Climate Service provider in Costa Rica operates as climate information hub of the prevalent NCS: available data and model outputs, which are partly generated by other institutions, often at regional and international level, are collected, coordinated and specific information is generated by IMN and then disseminated and provided to national users. However, it must be highlighted here that not all climate observations which are done in Costa Rica feed into the central climate data base and are thus not part of the NCS.

3.1 Dissemination, communication and outreach of climate information by IMN

Climate information products are generally provided by IMN via their web page. These products are freely available for download in the format provided on the website. This applies for all standard products of climate diagnostics and climate monitoring but also for seasonal forecasts, climate projections and climate hazard information. Specific seasonal forecasts and climate warnings as well as expert interviews and press conferences are also proactively presented in TV, radio and newspapers.

Other climate information products, especially data products like time series or specific statistical analysis are only available on request. These products and services need to be requested and are in general not free of charge and not freely accessible. The purchasing process is accompanied by terms on the purpose and scope of use of the data which need to be agreed on. Costs for climate data and information are not incurred by users with special agreements. This refers to academia or for analysis in the context of infrastructure projects of national interest, on condition that confidentiality agreements on the use of data are being signed. However, the purchase process and its timeframe as well as the accounting of costs for products and services are often confusing for users. User-interaction occurs via email or telephone for which an entire section (information department) is ready to provide a helpdesk function. However, there is no protocol or guideline available for the information department which helps to identify user demands in a structured way. Especially users who have no continuous relationship to IMN are often not aware of the climate vulnerabilities of their sector and organization and are thus not able to formulate their specific needs for climate information. Such a guideline or protocol would help to support the communication process between Climate Service provider and user.

Extra attention is dedicated to the issue of climate change and its impacts for Costa Rica. For this issue an extra web page was established which also provides secondary products like climate change scenarios, climate (change) impact analysis, risk and vulnerability studies and research articles as well as a journal[6] edited and published by IMN itself. Beyond that, the dissemination, communication and outreach activity of IMN for climate information is rather passive or restrained. IMN conducts no marketing on Climate Services or other awareness raising of relevant climate information for specific sectors: for the user it is difficult to overview which products and services are generally or potentially available for a specific purpose or contextual use. The webpage provides no structured search function to identify potentially useful products for a specific user. Furthermore, product descriptions that help to identify context and limitations of use as well as technical details on the products are hardly available.

Specialized products for specific sectors are developed in the context of research projects. Project results and related products are in general presented to the public media on press conferences or are the matter of talks and presentations for a selected, also sector-specific, audience. As a consequence, outputs from research projects are primarily designed for the specific context of the project and the specific user (if available). Those specialized products have the potential to provide even larger benefits to users if they were to be transformed into standard products. Standard products are produced and up-dated on a regular basis and provided via the webpage with respective support material and ser-

[6] Topicos Meteorológico y Oceanograficos

vices. Such products provide instant and continuous availability of required information for a wider sectoral community. As of yet, this is not done by IMN.

3.2 Climate Service Inventory

A product inventory provided and disseminated by IMN is presented below. Products and services are categorized according climate product types (Appendix 3). All products mentioned in the following sub-chapters are recapitulated in Table 3.

Climate data sets

Climate data and time series are generally provided by IMN. Data which feeds into these time series originate exclusively from climate stations operated by IMN. Data from other climate data providers has to be purchased anew for each project or study. Continuous and quality controlled time series exist for all basic atmospheric ECV's as well as essential derived variables (temperature, humidity, radiation, precipitation, wind speed, wind direction, atmospheric pressure and dew temperature). The length of time series varies but is long enough for appropriate climatic analysis, i.e. a minimum of 30 years and partly more than 100 years with a monthly, daily and hourly temporal resolution. For precipitation even higher temporal resolutions are available (5, 10, 15, 30 minutes). IMN does not produce and provide any standard data sets which are, e.g., provided and accessible via the website. Specific data sets are always compiled on request.

Climate diagnostics, climate monitoring & climate hazards and events

Climate diagnostic and monitoring products are products which are the result of the statistical analysis and evaluation of observed and monitored climate data. Such products are also provided by IMN and are generally available on the IMN website. The portfolio comprises a Climate Atlas which includes maps on precipitation normals[7], temperature normals and sunshine normals for the period of 1961 – 1990. Furthermore, climatologies for specific provinces, a daily updated national map on rainfall distribution (isohyets[8]), monthly bulletins on the climatology of Costa Rica as well as research publications on climate change, climate variability and implied risks.

The observations of all natural hazards and climate-related hazards (especially floods) are recorded by the National Emergency Commission of Costa Rica (CNE). IMN itself does not operate any observation systems for climate hazards or other phenomena (e.g. hurricanes or ENSO) but uses the data and services from NOAA (e.g. National Hurricane Center) or the Regional Climate Centre of Western South America (CIIFEN). However, IMN supports CNE in its tasks by providing relevant climate information as well as meteorological warnings for specific early warning systems (e.g. flood warning for the Sarapiquí and Nosara river basin (in preparation)). IMN reports regularly on climate hazards and events within the monthly bulletin. Beyond that, IMN provides a series of reports based on project studies on climate vulnerability and risk assessments for Costa Rica. These studies mainly refer to water and agricultural issues but the health and infrastructure sector are also considered (Table 3). These studies are produced in cooperation with MINAE, MIDEPLAN, selected departments of UCR as well as changing consultants and international organizations (e.g. UNDP).

Long-term predictions (monthly, seasonal) and climate projections

Long-term predictions are produced in cooperation with the WMO Climate Outlook Forum of the Central American region (CACOF) which is represented by the Climate Centre of the Regional Committee of Hydraulic Resources (CRRH). CACOF integrates the capacities of the national meteorological and hydrological services (NMHSs) of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panamá to develop consensus seasonal climate outlooks with a 15 km resolution, based on the WRF-model[9], and

7 Climate Normal: A Normal is defined as the arithmetic average of a climate element (e.g. temperature) over a 30-year period (Wikipedia; 2018/06/19).

8 An isohyet or isohyetal line is a line joining points of equal rainfall on a map in a given period (Wikipedia; 2018/06/19).

9 www2.mmm.ucar.edu/wrf/users

forced by GFS-model of NOAA[10]. IMN and UCR-CIGEFI contribute own data to this consensus outlook for validation. IMN has no own regional model but it uses projections (ETA-model[11]) provided by the Weather forecast and Climate Studies Center (CPTEC, Brazil), as supplement and output control for the consensus outlook. Furthermore, IMN also uses the probabilistic forecast tool "CPT software" (by IRI-USA) to make station-based precipitation predictions for Costa Rica. Based on this infrastructure and cooperation network IMN is able to regularly provide monthly and seasonal (3-month) predictions and projections on rainfall on the national and subnational scale[12] with information on quantity and probability. Furthermore, outlooks of 6 months are provided for Central America and annual outlooks for Costa Rica.

The current climate change projections for Costa Rica were calculated by IMN. They are based on the scenarios A2 and B2[13] and are calculated on the basis of four Global Climate Models (freely available) which were also used for the IPCC report as well as one regional dynamic model (PRECIS – by UK-MetOffice[14]). Projections are available for precipitation, average temperature, maximum temperature and minimum temperature, for the period 2011 – 2100. Results are presented in 30-years sub-periods with a monthly, seasonal and annual resolution (overview is provided in IV.1). Currently, further projections with new scenarios are under development (RCP scenarios[15]) in cooperation with the Technological Institute of Costa Rica (TEC).

10 www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs

11 http://etamodel.cptec.inpe.br

12 Costa Rica's subnational levels are divided into provinces, cantons and districts.

13 The A2 and B2 scenarios are two of six possible scenarios from 2000 describing future greenhouse gas emissions (SRES) which are the basis for a specific degree of global warming (IPCC, 2000).

14 More information about PRECIS: www.metoffice.gov.uk/research/applied/international-development/precis

15 RCP (Representative Concentration Pathways) refer to "time-dependent projections of atmospheric greenhouse gas (GHG) concentrations". More details in Moss et al. (2008).

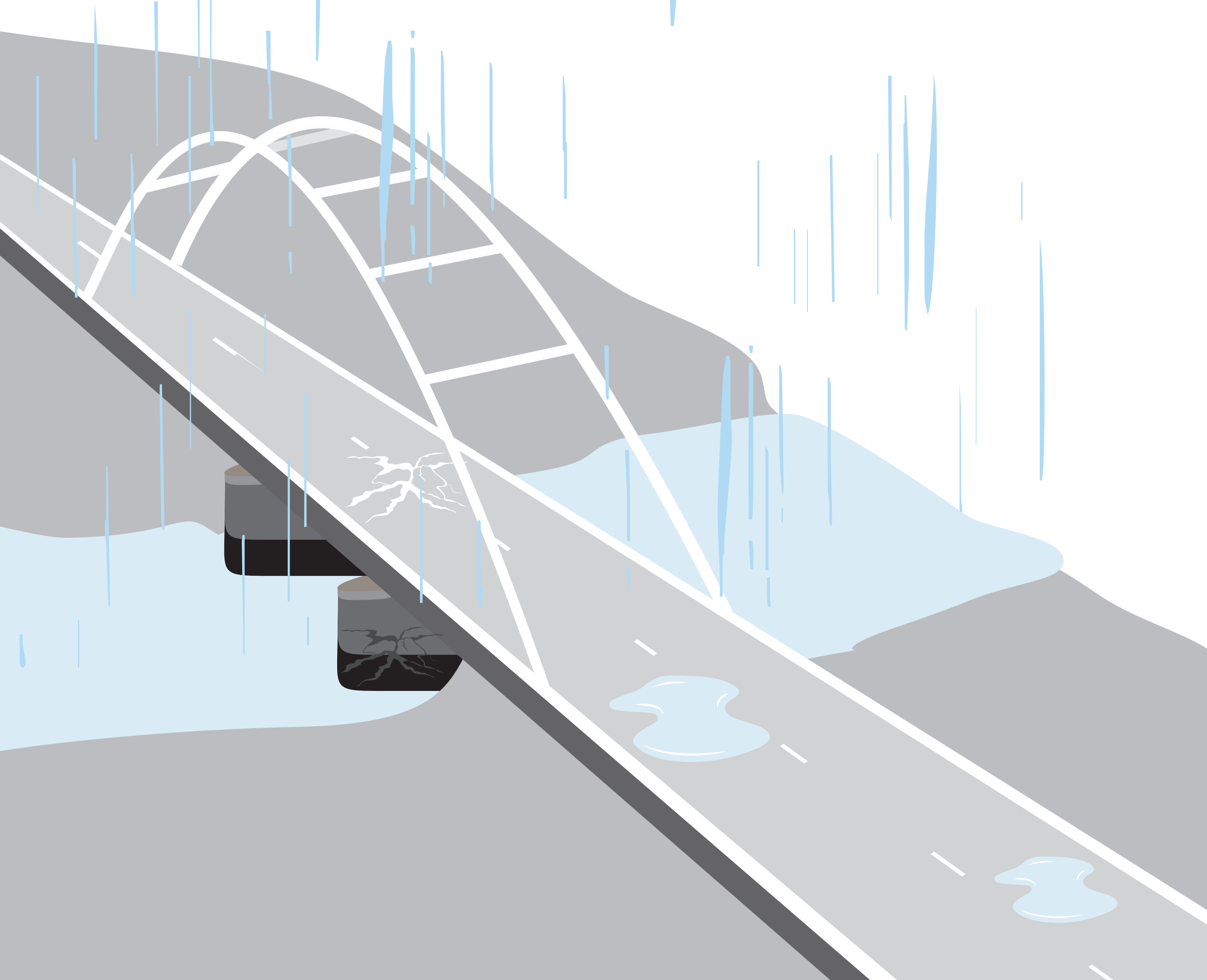
3.3 Climate Services for road infrastructure

According to IMN, there are no sector-specific climate service products generated by default. However, available products are revised and tailored to the user needs upon request (e.g. for an integration in decision support tools) and within the technical capacities of the IMN. Whilst there is a good cooperation on the level of research to develop sector-specific application models (e.g. agriculture sector) user requests do not feed back in product development procedures (i.e. co-production of Climate Services). In general, IMN provides Climate Services to all relevant sectors in Costa Rica. However, not all climate product types are being used equally by the sectors. Most important sectors in Costa Rica which are provided with Climate Services are especially the government[16], aviation and emergency planning and response (very high importance) but also local authorities, science sector, water sector, private economy, agriculture sector and the finance and insurance sector (high importance).

From the IMN perspective the share and effort of Climate Service provision for the transport sector is rather low relative to other sectors. Most important customers of the IMN are the government, aviation and emergency planning. Nevertheless, the entire product portfolio is considered as potentially useful for the road infrastructure sector. And indeed, many climate products, especially historical climate information as well as monitoring products are commonly demanded by the road infrastructure sector from IMN. The purpose of application is mainly for infrastructure design and for juridical issues regarding justifications of work delays due to bad weather. Furthermore, historical climate information is used for research, specifically for studies on material and its application in the transport sector. Monitoring products are also used by inter-institutional committees and for emergency planning and operation (CNE) as well as for policy making. Seasonal forecasts are demanded for the planning of working schedules at existing construction sites with respect to heavy rainfall events. Although there might be some potential usefulness of climate projections for the road infrastructure sector, this has not yet been incor-

16 no details on specific use are provided in the questionnaire

porated in infrastructure planning processes by stakeholders from the road infrastructure sector. Despite the common use and potential usefulness of many climate products, there are no products exclusively produced for the road infrastructure sector. One exception is a vulnerability-assessment for infrastructure in general in the context of climate change (Mesalles et al. 2014). With respect to the road infrastructure this report discloses inherent vulnerabilities (physical, systemic and functional) of the road infrastructure in Costa Rica and analyses how these vulnerabilities may change due to climate change especially with respect to hydro-meteorological events. Nevertheless, some typical product specifications for the transport sector are known by IMN: most of the time precipitation information is required at high temporal resolutions (minutes to hours). Such products are not considered as sector-specific by IMN experts (at least they were not named as sector-specific), since they are being used for other purposes as well (e.g. predictions and projections) or because products are generally compiled case-by-case (e.g. processed data sets). This means that many products may be suitable for sector-specific application but they are not explicitly identified as such. Even though IMN does not produce standardized products for specific sectors or co-developed with specific users, it is eager to revise and adjust climate products and services to user needs and to make them applicable for existing decision-support tools or protocols necessary for e.g. risk assessments.



4 User interaction and interface

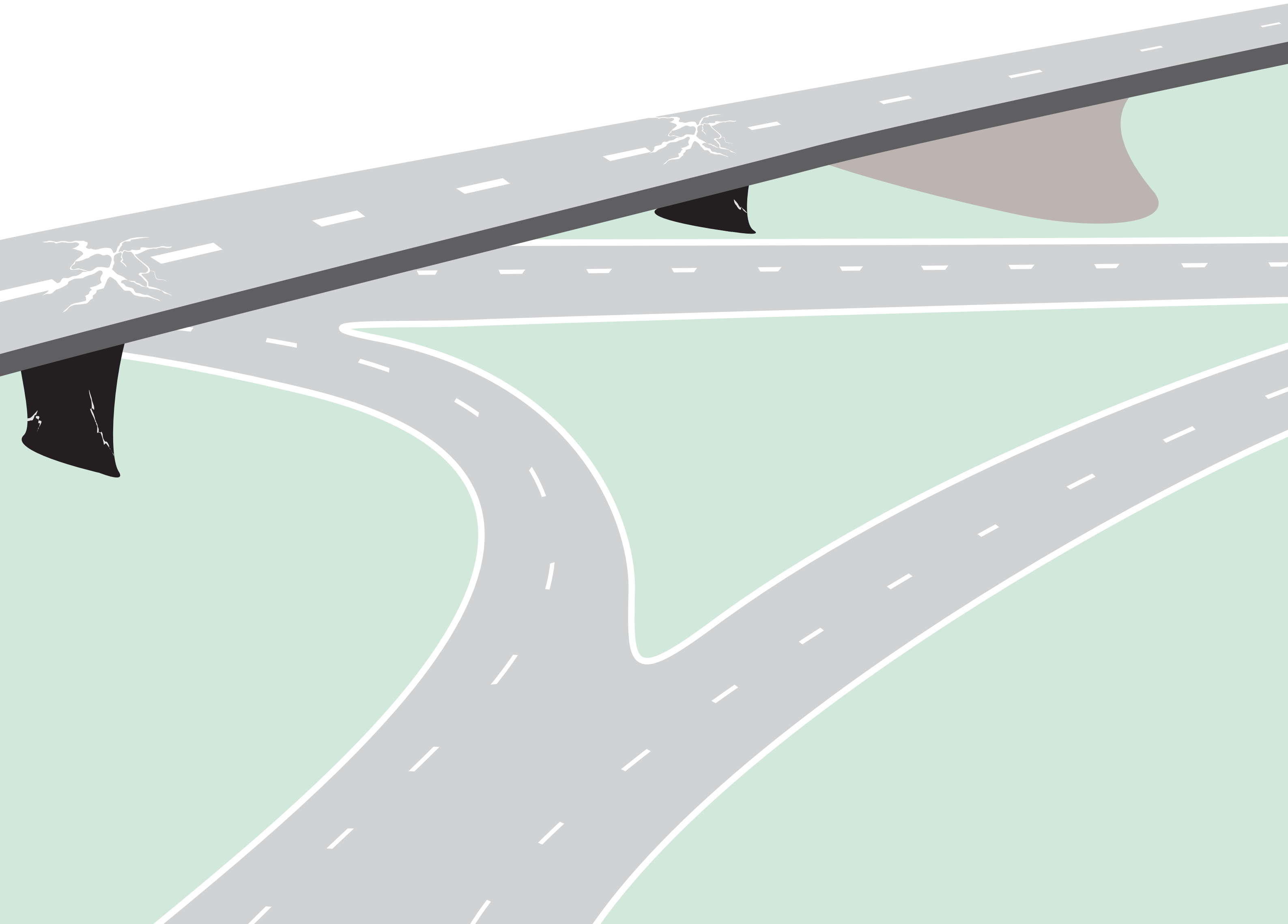
The interaction with users is characterized as customer relationship rather than a partner relationship. This relationship is reflected in the organizational structure of the prevalent NCS as well as in process of Climate Service development which impedes the production of useful and usable Climate information products.

The organizational structure of IMN is geared towards the interaction with users and the production of applicable climate information. This is reflected in the exclusive mandate from the government to interact with users and implemented by the creation of the department of "Climatology and Applied Research" and the department for "Information". The currently active mechanism to enable user interaction on the product level is the direct contact to the respective departments at IMN (e.g. Climatology and Applied Research (12 people) or Synoptic Department (14 people)) or via the Information Department for general needs (4 people). The latter provides something like an uniformalised helpdesk function which enables the user to formulate demands for general and customized climate products, climate information and additional services like support and advice on the use of tools and the understanding of products. However, an appropriate training program for users is lacking which often limits the user's understanding for applying climate information. Beyond the helpdesk, national and regional outlook forums are implemented (e.g. COENOS - National technical commission of the El Nino phenomenon) to proactively approach the user and seek dialogue about utilization habits, to communicate and enhance awareness for specific climate products (e.g. seasonal outlooks) and to provide tailored information for specific user groups. A mechanism which enables regular interaction between the sectoral line ministries and IMN does not yet exist but is in preparation.

IMN tracks the use of climate products in terms of user type and quantity of use. No data is collected on a regular basis regarding user satisfaction, impact or (socio-economic) value of the use of climate products. The latter, however, is not standardly done by other NMHS either. Feedback to IMN on climate products can be provided through social networks or the Information Department. Feedback is mostly gained in the context of specific projects and subsequent project reporting structures. However, due to insufficient staff capacities, such feedback does often not have any follow-up activities at IMN. According to IMN, this refers to the limited number of staff available for user-interaction processes but also the specialized qualification for the interaction and communication with users and their specific sectoral needs. Beyond this, the current organizational structures and processes for collecting and processing user feedback as part of the user interface platform provide potentials for optimisation in order to increase the efficiency of user-interaction processes (e.g. systems for user-needs evaluation). Their underdevelopment may very likely be another factor explaining the limited interaction with users. However, this organizational structure has not been analyzed in-depth within this assessment and thus, no specific shortcomings and opportunities for enhancement can be identified yet for this concern. They should be analysed more deeply to identify potential efficiency gains.

Although users from the transport sector are not the most important customers relative to other sectors, users from the transport sector are well known by IMN. They are key players from different sub-sectors, institutions and authorities related to the transport sector (e.g. MOPT, CONAVI (roads); Aviación Civil (air traffic); ICE (energy); civil engineers, CFIA (engineering association), architects, LANAMME UCR (research)) but also emergency authorities (CNE) and juridical stakeholders as well as hospitals and the general public. In general, there is a customer relationship with the users which means that the users approach IMN and request climate information or purchase it from the web site, if available. This is also valid for the road infrastructure sector for which no cooperation agreement (MoU) or other permanent relationship with IMN exists. Such an agreement would guarantee continuous exchange and communication on Climate-Service-development, design and application. In contrast, other stakeholders from the transport sector do have close relationships with IMN. Examples are CNE and

Aviación Civil, which are also considered as most important users of Climate Services within the transport sector. With CNE there is a special agreement on data provision in order to enable effective risk assessment and monitoring as well as operational risk management with respect to climate related hazards. Aviación Civil also regularly receives data to accomplish their daily tasks.



5 Capacity development

Existent capacity development structures mainly refer to the individual capacity development level. Greatest needs are, however, identified on the organizational and systematic level in order to develop an effective National Climate Service.

The capacity development component is an integral part of the GFCS. The content of this chapter refers to the existent capacity development structures of the NCS in Costa Rica. Identified needs refer to the interviewees, first of all IMN. Recommendations on specific capacity development activities are provided in chapter IX.

Capacity Development is clustered into the three dimensions i) human/ individual, ii) organizational, and iii) systematic or enabling environment.

i. Regarding the individual capacities, IMN has developed internal policies on building human capacities and renewing qualification of the staff. Furthermore, IMN utilizes regional and international training programs of various formats (e.g. training courses, conferences, fellowships, e-learning, curriculums, etc.), offered e.g. through WMO to enhance technical capacities of its staff. IMN also operates a training program for user communities. Despite this engagement in capacity building, there is a general need of individual capacity building in the context of Climate Services. This refers to special training on Climate Services in general, tailoring of climate information for specific sectors and the communication with (sectoral) users as well as general capacities like funding and staff in order to meet these needs.

ii. Organizational: no information is given on capacity development activities, programs or strategies on the organizational level. The organizational structure (e.g. Department for Climatology and Applied Research; Information Department) of IMN indicates a development towards an enhancement of Climate Service provision. However, information obtained during discussions with IMN identifies several problems on the organizational level: this comprises a missing redundancy within the staff pool implying potential loss of knowledge and competency as soon as an expert leaves IMN; and furthermore, strong hierarchical structures which result in an opacity of administrative and organizational processes regarding their characteristics as well as their schedule. Thus, basic resources for thoroughly fulfilling current tasks but also for implementing planned or desired development activities are generally considered as limited. This refers to technical equipment, building space (e.g. for presentations and regular user-interaction) and funding. According to IMN additional staff as well as training of existing staff is required in all aspects and sectors of climate service provision (data management, product development, service provision, user interaction and research). However, as shortly discussed above (V.4) the opportunity of restructuring organizational processes in order to make them more efficient needs to be considered as well.

iii. Enabling Environment: on a political level, IMN demands a higher visibility as Climate Service provider as well as a better understanding for the value of Climate Services by governmental authorities. Consequently, IMN wishes for an improvement of the organizational structure of the Service and policies which strengthen the role of IMN as Climate Service provider. This also may refer to an enhancement of the cooperation structure to other stakeholders like data providers (e.g. ICE, AYA, CORBANA, CATIE, etc.) as well as sectoral stakeholders (line ministries) in order to establish a National Climate Service as envisaged by the GFCS.

6 Evaluation of the Climate Service inventory

This chapter provides an approximate (qualitative) evaluation of the state of the climate information provider network in Costa Rica. This evaluation is done in two parts: part 1 provides an overview on the stakeholder interaction map. Part 2 provides a classification of IMN as central stakeholder of the climate information provider network in Costa Rica in the WMO classification system for NMHSs. The WMO classification defines 4 hierarchical categories. The categories 1-4 provide a qualitative assessment of the prevalent state of existing climate data services and information products provided by a NMHS (1= basic; 2=essential; 3=comprehensive; 4= advanced) (for details of each category please refer to Appendix 2). The focus of this system is on products and services which mainly refer to the "Climate Service Information System" component of GFCS. However, aspects from the other components are also considered since they are reflected to a great extent within the product and service portfolio. This is also valid for contributions from other stakeholders from the National Climate Service. Nevertheless, an assessment of the NCS for the context of the road infrastructure in Costa Rica as well as recommendations on the enhancement of the NCS will be done in chapter VII and chapter IX.

6.1 Climate information provider network

The climate information provider network is visualized in Figure 8. The result of this stakeholder map is focused on the road infrastructure sector and is based on the findings from the interview and workshop with IMN. Therefore, there is no pretension to completeness. The stakeholder map indicates a central position of IMN in the network. IMN provides a wide range of climate product types which are based on the input of data, information and tools provided by other national stakeholders as well as external stakeholders. It is important to realize, that the large part of the network is constituted by external data providers as well as the academic sector of Costa Rica (besides CNE) instead of national providers. Secondary information on climate impacts, risk and vulnerability is mainly produced in co-production with ministries (MINAE and MIDEPLAN), the academic sector as well as various consultants and international organizations (e.g. UNDP) that have the function of sector un-specific intermediates. This continuous cooperation is indicated by the solid lines. In contrast, national climate and especially hydrological data providers are not actively incorporated in the network. There is no continuous cooperation agreement with these stakeholders and thus data and information from these sources is not available for a central data base but only for specific projects for which this data needs to be purchased.

6.2 Classification of IMN as NMHS of Costa Rica

IMN basically covers all functions of category 1 which comprises a basic range of climate data services and information products. However, challenges exist in the need to enhance the density of the observation system in order to increase the data coverage as well as the conversion of mechanic to automatic climate stations with WIFI interface to guarantee a better and faster data transmission. Data management, data archiving and quality control systems are in place but needs are indicated to review and enhance the quality and efficiency of these systems. For example by the application of an interface (e.g. ORACLE) for database management and a technology for the automatisation of data management processes. In order to provide a comprehensive monitoring network a radar system [17] is required especially for the observations of storms.

The functions of category 2 (essential climate data services and information products) are also generally covered by IMN. Major challenges concern user interaction: though there is already interaction with users from various sectors, IMN desires the improvement of knowledge of customer needs and how to approach the client in order to better fulfil their role as Climate Service provider and their coordinating function of the NCS. Regarding the latter, guidance is desired on how to help the users to understand the application of climate products for their specific contexts. Also, evaluation systems for developed products and services are still very basic. User feedback on the usefulness and effectiveness of the information and services provided is

[17] A radar system has been purchased and is being launched during the writing of this report.

generally possible; however, capacities to consider such feedbacks are very limited. Whilst weather warnings are standard products provided by IMN, early warnings on climate scales like climate watches or sector-specific warnings are not provided.

Category 3 functions (comprehensive or full range of climate data services and information products) are only partly covered by IMN. Specialized climate analyses for specific sectors are provided only for selected sectors. For other sectors (like road infrastructure) specialized analysis are not generated or marketed standardly but only on request. There are capabilities to downscale long-term projections. And also Climate Risk Management (CRM) elements are about to be increasingly supported by IMN. IMN has some experience in doing that especially for the Disaster Risk Reduction sector (close collaboration with CNE) but there is yet little experience and knowledge for CRM in other sectors and no routines and frameworks for a systematic consultation of climate information for CRM processes.

Only some functions of category 4 are covered by IMN to a limited extend. With respect to climate projections, results from Global Climate Models are being used but not run by IMN itself. There is also a Regional Climate Model run; however, one model run is not sufficient for an ensemble forecast with good signal and reliable uncertainty information. This is not yet sufficient for the development of impact models but valuable for raising societal awareness of climate change issues. Although there is a good cooperation with the UCR on the research of sector-specific climate applications and tools, there is no co-production of new products together with users due to limited capacities in terms of available staff, training and equipment. Also, capabilities and capacities to serve as a node of a Global Production Centre or Regional Climate Centre are not given.

As conclusion, IMN generally covers functions of category 1 & 2 as well as important functions of category 3. Some functions are covered from category 4, especially due to the cooperation with regional and international partners. However, as of yet, with no or only little relevance for users and thus for Climate Service provision.

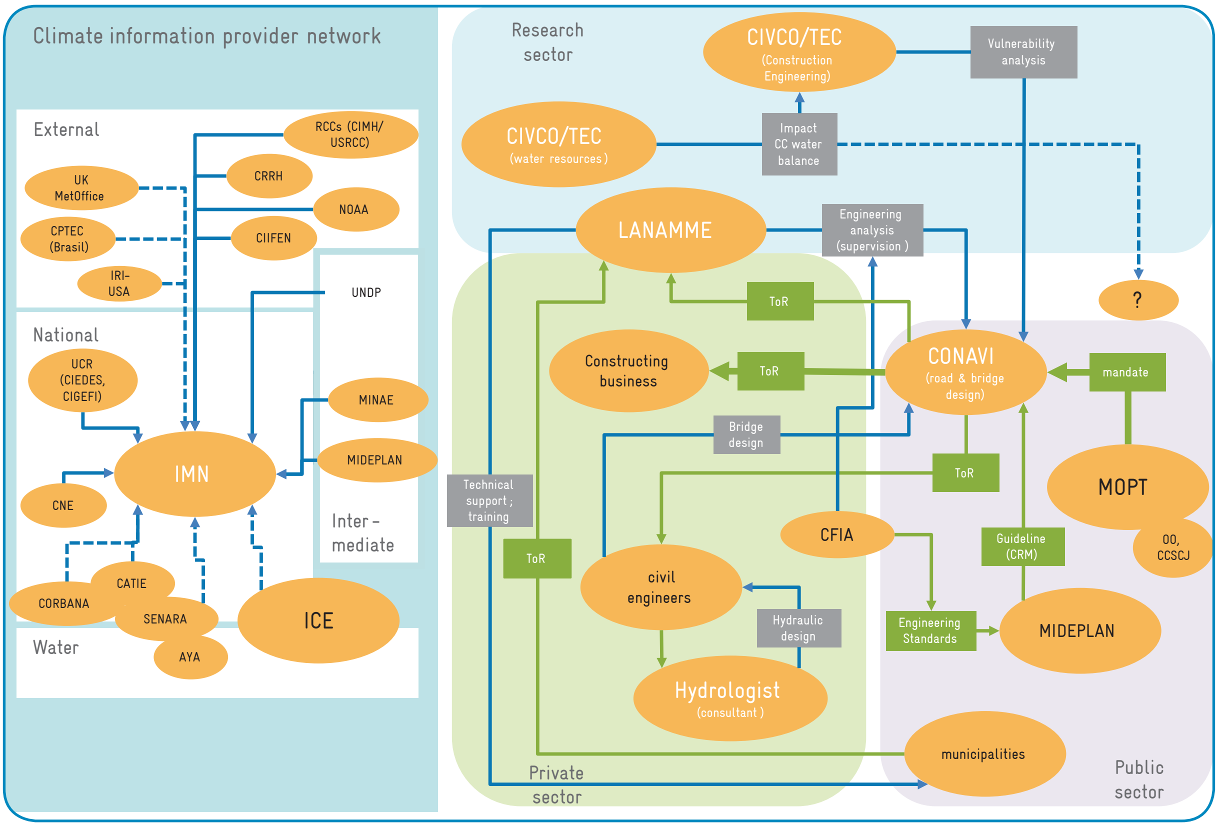
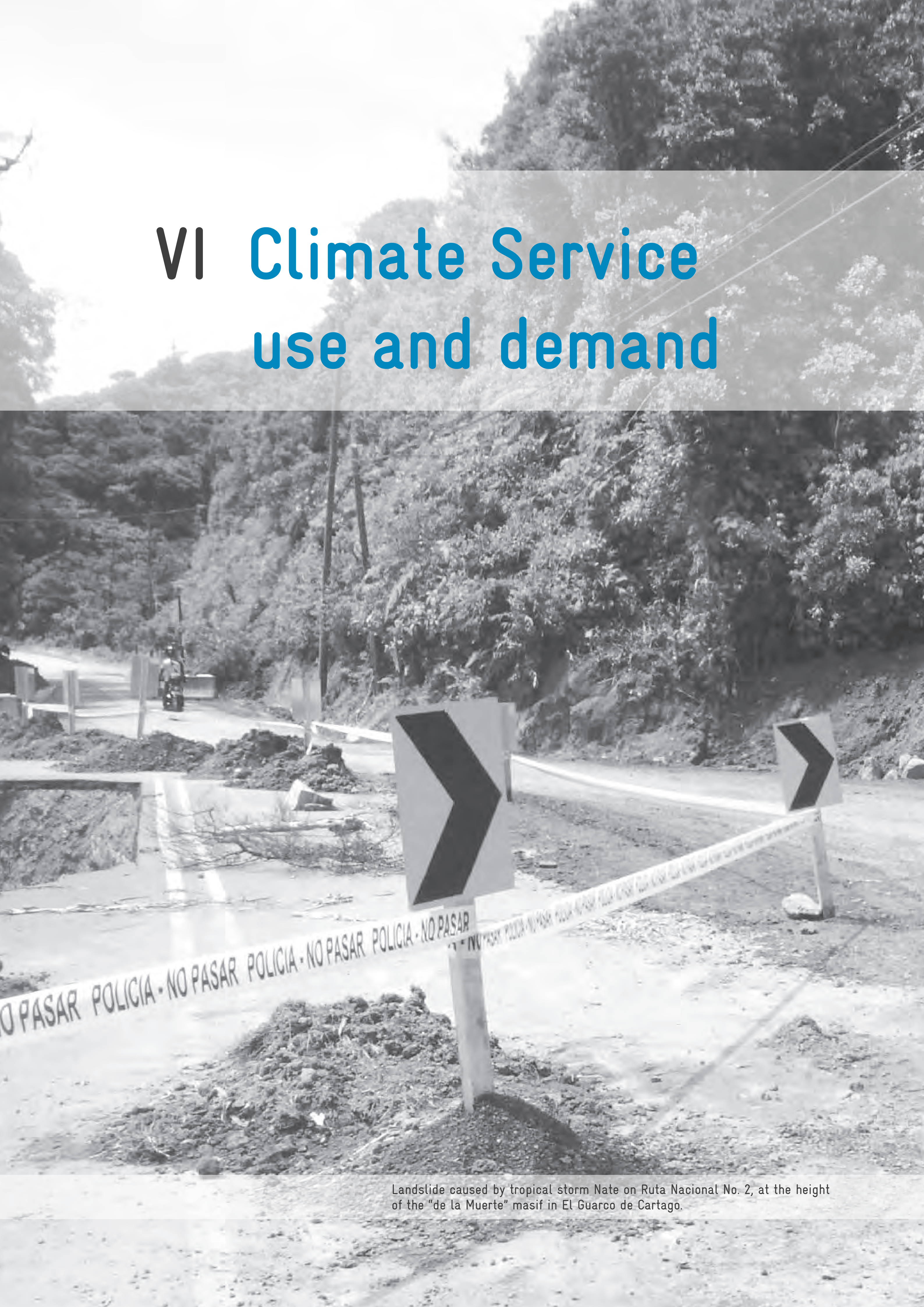


Figure 8 Overview of the climate information provider network (left side). Solid lines indicate a continuous flow of data and information based cooperation of stakeholders (agreements). Dashed lines indicate restricted flow of data and information (no agreements – purchase required). Right side: key sectoral stakeholders and interaction processes of the road infrastructure sector in Costa Rica. Green lines and boxes indicate mandates for sub-tasks of infrastructure planning processes (ToR = terms of references). Blue lines and boxes indicate the delivery of products based on these mandates. The stakeholders (red bubbles) are sub-divided into various sectors: research sector (blue shading), private sector (orange shading) and public sector (purple shading). Stakeholders highlighted with white writing were interviewed for this baseline report. Explanation of the stakeholders is given in the abbreviations list.

VI Climate Service use and demand



Landslide caused by tropical storm Nate on Ruta Nacional No. 2, at the height of the "de la Muerte" masif in El Guarco de Cartago.

Planning processes for the design and implementation of a bridge in Costa Rica in the context of a climate risk assessment are visualized in a stakeholder interaction map in Figure 8. This stakeholder map is preliminary and is based on the findings from the interviews with the users and has no pretension to completeness. The stakeholder map depicts key stakeholders and their interaction regarding information and product exchange in the context of a value chain. The stakeholder map indicates the central position of CONAVI in the planning process of bridge construction. CONAVI is in charge of implementing mandates from MOPT for the planning and implementation of bridge projects. CONAVI takes a coordinating role delegating and reviewing sub-tasks and products of the planning and building process by formulating terms of references. Within these terms of references, regulations and guidelines valid for the road infrastructure sector need to be considered (e.g. building codes) which are defined by sectoral and administrative ministries (e.g. MOPT, MIDEPLAN) and developed and proposed by CFIA. The coordinating role of CONAVI also applies for the handling and consideration of climate information: all relevant climate information is commissioned by and provided to CONAVI. Thus, terms of references provided by CONAVI also need to consider the handling of climate data and information by the sub-contractors.

Within this chapter the results of the user interviews are presented. Altogether, 6 questionnaires were completed by nine users from six different organizations (see Table 1). This is done in two parts: within the first part the interviewed stakeholders are introduced, especially their role and interaction within sectoral planning processes as well as pathways of climate data and information flow. In the second part, an aggregated overview of the use and demands of climate data, information and services as well as stakeholders' habits of application are presented.

Please note: "CIVCO/TEC water resources" is the only interviewee who has no active part (related to decision-making) within the context of the road infrastructure sector. Consequently, the interviewee made no specifications on questions related to regulating frameworks, motivation of using climate information and decision-making (sub-chapter X.2.1-X.2.3). Respectively, this interviewee was not considered in statements about "percentage of respondents". In conclusion: for sub-chapter X.2.1-X.2.3 100% correlate with 5 respondents; for sub-chapter X.2.4 100% correlate with 6 respondents.

1 Interviewed stakeholders of the road infrastructure sector

CONAVI is the National Road Council of Costa Rica and is subordinated to the Ministry of Public Works and Transportation (MOPT). The main tasks and responsibilities of CONAVI are planning, financing and operational management of the national road network in accordance with the programs prepared by MIDEPLAN in order to guarantee the functionality, operation and safety of the national road network. This implies the execution of construction and maintenance work by contracting the required services as well as the supervision and quality control of this work. Furthermore, the promotion of research, development and technology transfer in the field of road construction and maintenance. CONAVI acts as a coordinator and operational manager of the road planning process that receives mandates mainly from MIDEPLAN according to e.g. the National Development Plan and National Transportation Plan and delegates the development of infrastructure design and construction to appropriate sub-contractors.

Climate information is integrated in the basic operational processes of CONAVI's tasks like the planning of drainages (culverts and sewers) as well as bridges. In some cases (depending on the funding source), the mandates from MIDEPLAN are accompanied by a guideline which demands carrying out pre-investment studies on potential climate and other risks. Furthermore, there are design manuals on the use of climate parameters in construction designs[18]. To guarantee the implementation of this manual, technical terms of references need to be formulated and communicated by CONAVI with sub-contractors. The consideration of climate-related issues especially challenges related to climate change are anchored in the objectives of CONAVI. To implement these objectives, CONAVI works closely together with other institutions and established an exclusive working group analyzing and tackling climate issues. However, necessary and relevant information on climate change impacts on road infrastructure is not yet available.

For the implementation of basic operational processes, CONAVI obtains climate and hydrological information from IMN and ICE. The relation to both data providers is a customer relation, i.e. the contact is on data requests and CONAVI has to pay for the climate information and services. CONAVI considers itself as end-user within the climate-value chain. However, additional literature research and modelling is done by CONAVI to integrate the received climate and hydrological information into the decision-making context. Due to a vast experience in working with climate data, CONAVI assess its ability to formulate its needs on climate information products as "very good".

Consultant (hydraulic design): for the development of hydraulic designs of civil structures like bridges, sewers and others usually private companies or consultants are commissioned. This service is demanded directly by CONAVI or by private construction companies which carry out work for CONAVI or CNE and feeds directly back to the purchasing entities as input for infrastructure construction projects. For this assessment a consultant who also works as researcher at UCR was interviewed who is regularly taking assignments as freelancer for hydraulic designs.

Climate information is the essential basis for the completion of hydraulic designs. The kind of climate information being used is determined by the work team developing the project or by technical terms of references provided, if available, and thus by the purchaser of the work. Uncertainty in climate information, especially, feeds back in the determination of how conservative a design needs to be. This has consequences for the vulnerability of the construction to climate threats and related consequences with respect to safety and economic losses. In the context of climate change the challenge of uncertainty increases. Climate change is not considered yet in the production of hydraulic designs, especially because appropriate data and information on climate change are still not available. Thus, hydraulic designs are based on historic climate and hydrological conditions.

The interviewee obtains relevant climate data and information from prevalent climate information providers like IMN and ICE but also from other providers like CORBANA and UCR in the context of specific projects. As a researcher the interviewee does not have to pay for climate information from IMN. However, as private consultant he needs to pay especially for hydro-

[18] Hydrological and hydraulic considerations manual on Central American roads, issued by SIECA in 2016

logical information from ICE. In the context of a climate-value-chain, as consultant, the interviewee considers himself as climate broker or value-adder. In order to produce his hydraulic design he has to do own data processing steps which includes data analysis, among others. He furthermore receives support from UCR institutions like CIGEFI (Center for Geophysical Research) to exchange experiences and knowledge in the field of data processing and projecting climate change. Due to a vast experience in working with climate data, the interviewee assesses his ability to formulate his needs on climate information products as "very good".

School of Construction Engineering (CIVCO/TEC). CIVCO is the Center of Investigations in Housing and Construction of the Technical Institute of Costa Rica (TEC). CIVCO is mandated by the government via the research and extension plans to support the integral development of the country's infrastructure. In a currently running research project with CONAVI, the role of CIVCO is to provide tools for the management of bridges and to avoid failures or collapses. The product will be a complete bridge inventory of the national road network with visual evaluation of the structural conditions regarding damages of various causes. The research work is done in cooperation with other TEC research units such as the School of Electronic Engineering, Forestry Engineering and with support from foreign universities such as Virginia Tech University and the University of New Mexico.The results will be provided to CONAVI and MOPT for practical considerations.

Climate and climate change are considered as one of many factors which may affect the condition and durability of bridges besides seismic and structural factors. However, the importance of climate increased during the past years especially in the context of bridges located in urban areas. Climate information is required to assess the vulnerabilities of bridges to climate events in the past and in the context of climate change. The type of information being used is expected to be determined by the purchaser of the study, which is MOPT/CONAVI.

CIVCO obtains climate information from IMN and hydrological information from ICE. The data from IMN is for free due to the academic context; however the data from ICE has to be purchased. The relationship to IMN is considered as institutional which is based on bi-lateral agreements. Regarding climate change, CIVCO can refer to TEC resources and expertise on climate change modeling and the impact on the hydrological systems. Beyond that, a multidisciplinary working group is planned to be formed to tackle the issue of climate change. In the context of a climate-value-chain, CIVCO considers itself both as end-user as well as intermediate. They do a lot of value adding to the received climate data like data analysis, modelling and research activities. Due to the daily work with climate data and the specific education of the TEC staff in this field, CIVCO assesses its ability to formulate its needs on climate information products as "very good".

Water Resources (CIVCO/TEC): the section of water resources is part of the School of Engineering and Construction and supports the research line as defined by CIVCO (TEC). A current infrastructure-related project is implemented in cooperation with AyA and has the objective to quantify the impact of climate change on hydrological basins destined as supply of drinking water in Costa Rica. The output of the project will be reports on climate change impact projections on the water balance of 18 watersheds in Costa Rica. The study is produced specifically for AyA but is also being used as input by other TEC research projects like the bridge inventory study of CIVCO.

Climate data from IMN and ICE are provided for free. In addition, international sources on climate information and support like the CORDEX-group are consulted. The interviewee considers himself as intermediate that uses climate data to produce climate information. Consequently, a lot of data processing is done by himself, like data analysis, modelling and research activities. Support is provided by national partners (e.g. AyA) and international expert groups like the MetOffice (UK) and Max-Planck Institute (MPI). Due to the daily work with climate data and his academic training in this field, the interviewee assesses his ability to formulate his needs on climate information products as "very good".

Bridge Unit (LANAMME): LANNAME is the National Laboratory of Materials and Structural Models of the University of Costa Rica (UCR) which is attached to the School of Civil Engineering. The Bridge Unit is part of the Structural Engineering Program at LANAMME. The general task of the Bridge Unit is the inspection of bridges of the National Road Network to guarantee an efficient use of resources. This includes inspection of priority national routes, preparation of national regulations on the subject of bridges and training for the respective sector. LANNAME has a mandate to supervise work under construction and road work in service, but is also empowered to act under a formal request from the Minister of MOPT (and CONAVI). The output of this work is an inventory and visual inspection reports determining the condition of the bridge of concern. Additionally, research reports may be submitted on the subject of bridges, but also the preparation of manuals that, once approved by the MOPT, become official (but not binding). The documents that are prepared are issued to the MOPT, the General Comptroller of the Republic, the Legislative Assembly, the Ombudsman's Office, the Ministry of the Presidency[19], CONAVI and, if necessary, the National Concession Council[20].

In most projects which refer to bridge inspection, hydrological-hydraulic studies are required that at least take into account the historical climate records at the design stage. Here, the expected long-term performance of a bridge is determined which includes the consideration of climatological and hydrological extreme events in the past and in the future. The use of climate information for this task is not regulated in general. However, project specific ToRs[21] determine the use and type of climate information for the design stage of bridge construction. Consequently, type, quality and scope of the use of climate information may vary between projects since they relate to the specific ToR. The quality or detail of the ToR depends on the knowledge, experience and demands of the purchaser which is in general MOPT/CONAVI. However, in contrast to other types of information, the relevance of climate information is not considered as particularly high for the appropriate fulfillment of the tasks of the institution. Obligatory regulations and guidelines on how bridges should be designed and managed with respect to climate risks are desired but do not exist yet. Such guidelines, if they were to be developed, are considered as relevant and most important motivation for using climate information. In the context of climate change, the significance of climate for the fulfillment of LANAMME's tasks may increase and thus the need for implementing and regulating the use of climate information in engineering practices. LANAMME is aware of these challenges and in order to meet those, LANAMME uses UCR resources (e.g. multidisciplinary working group on climate change) to get advice and information on the changing climate and its implications for the road infrastructure sector.

UGM (LANAMME): UGM is the Municipal Management Unit (UGM) at LANAMME. The general task of UGM is the technical support and training of municipalities in the area of road engineering, bridges, road/track diagnostics and investment schemes. For each project on cantonal roads the UGM receives requests by the municipalities and mandates from the municipal council. The services provided by UGM are demanded and used exclusively by the municipalities who also define the degree of involvement of UGM in specific projects. Thus, the services provided by UGM may comprise advisory and technical support in cantonal road projects but also project execution.

The motivation for using climate information within infrastructure planning processes is in general considered to be low. This is mainly due to missing regulations and guidelines on the use of climate information. However, LANAMME is aware of the additional value of climate information. Therefore, such regulations and guidelines are desired and would be considered as very relevant. However, in order to fulfill their tasks as advisor and consultant and providing support to the municipalities, UGM requires fundamental information on climate conditions and potential climate risks at the locations of interest. Up-to-date information is especially important for infrastructure planning pro-

[19] The Ministry of the Presidency is a ministry of the Republic of Costa Rica created on 24 December 1961 through Law 2980. Its work prescribed by law consists in providing support to the President of the Republic, serving as a liaison between the Presidency and the other branches of government, civil society and the various ministries (Wikipedia; 05.07.2018)

[20] The National Concession Council (CNC) was established in 1998 in order to allow a faster development of the national infrastructure. The council consist of heads from MOPT, Finance Ministry, MIDEPLAN, BCCR (Central Bank of Costa Rica), and 3 representatives from industry

[21] ToR: terms of reference

cesses and the development of risk management plans in the context of climate change. Such endeavors are also supported by the institutions agenda, in which the term "sustainability" was recently integrated. UGM has a general awareness on prevalent and changing climate threats and vulnerabilities of the road infrastructure sector and the economic consequences. This awareness also enhances institutional efforts to increase resilience of municipal road infrastructure to climate change.

LANAMME receives free climate information from IMN due to the academic context. Information related to climate change is also obtained from CNE and UCR. The relationship to the information providers is based on agreements. In the context of the climate-value-chain, LANAMME considers itself as end-user, whereas the research branch (bridge unit) also acknowledges its role as climate information broker. They also execute data processing activities like data analysis and literature research. Support for these activities is provided by other UCR institutions. Due to the sometimes limited relevance of climate data for LANAMME's regular work, the self-assessment of the ability to formulate needs for climate information products ranges from "poor" to "good".

2 Use and demand of climate information by interviewed stakeholders

The results from the user interviews are comprehensively evaluated according to individual aspects of Climate Service application. Answers from individual users will not be revealed beyond the user characterization in chapter X.1. The objective of presented results below is to get an idea about the general habits of using and purveying climate information within the road infrastructure sector.

2.1 Legal and regulatory frameworks

The consideration of climate information is not explicitly regulated in road infrastructure planning processes.

The consideration of climate and climate change risks and the use of Climate Services in the road infrastructure sector are only considered indirectly in regulating frameworks in Costa Rica. The planning of road infrastructure objects requires a pre-investment study in order to develop a risk management plan, especially regarding natural hazards. This pre-investment study is required and guided by MIDEPLAN. However, this pre-investment study does not explicitly address climate change issues. Furthermore, design manuals provide general guidelines on the consideration of climatic and climate-related considerations for road constructions[22]. However, there are no frameworks, regulations or guidelines on the explicit consideration of climate change and the use of climate information for the road infrastructure sector. Referring to the sectoral stakeholder interviews, 60% of the respondents see at least some relevance of such guidelines for their decision-making also relative to other laws, decrees and regulations. Furthermore, 40% explicitly desire the development of such frameworks with participation from MOPT, CONAVI and IMN.

[22] Hydrological and hydraulic considerations manual on Central American roads, issued by SIECA in 2016.

2.2 Motivation for the use of climate information

The main motivation for using climate information is internal motivation which refers to the organization's vision, objective and policy.

The awareness of issues related to climate and climate change is prevalent in the majority of the responding organizations and organizational structures are about to be adjusted. In 60% of the interviewee's organizations there is some kind of agreement about the objectives and values related to climate-related issues in general and climate change in particular. However, all responding organizations have an actual or potential focal point (expert or working group) on the topic of climate and climate change they can refer to if necessary. And furthermore, the organization's main motivation to use climate information is internal motivation which refers to the organization's vision, objective and policy. The second most important motivation is the obligation by potential or existing laws, decrees or regulations on the use of climate information as well as external motivation like image and user demands. Business interests cause the lowest motivation to use climate information (Figure 9). However, climate information as decision criterion has no explicit priority ("some relevance") relative to other decision-making criteria.

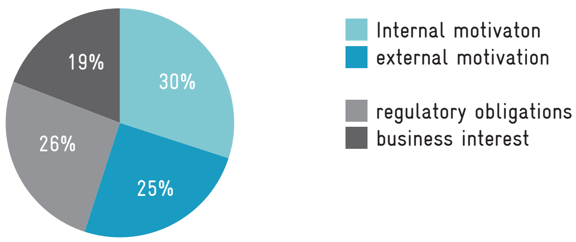
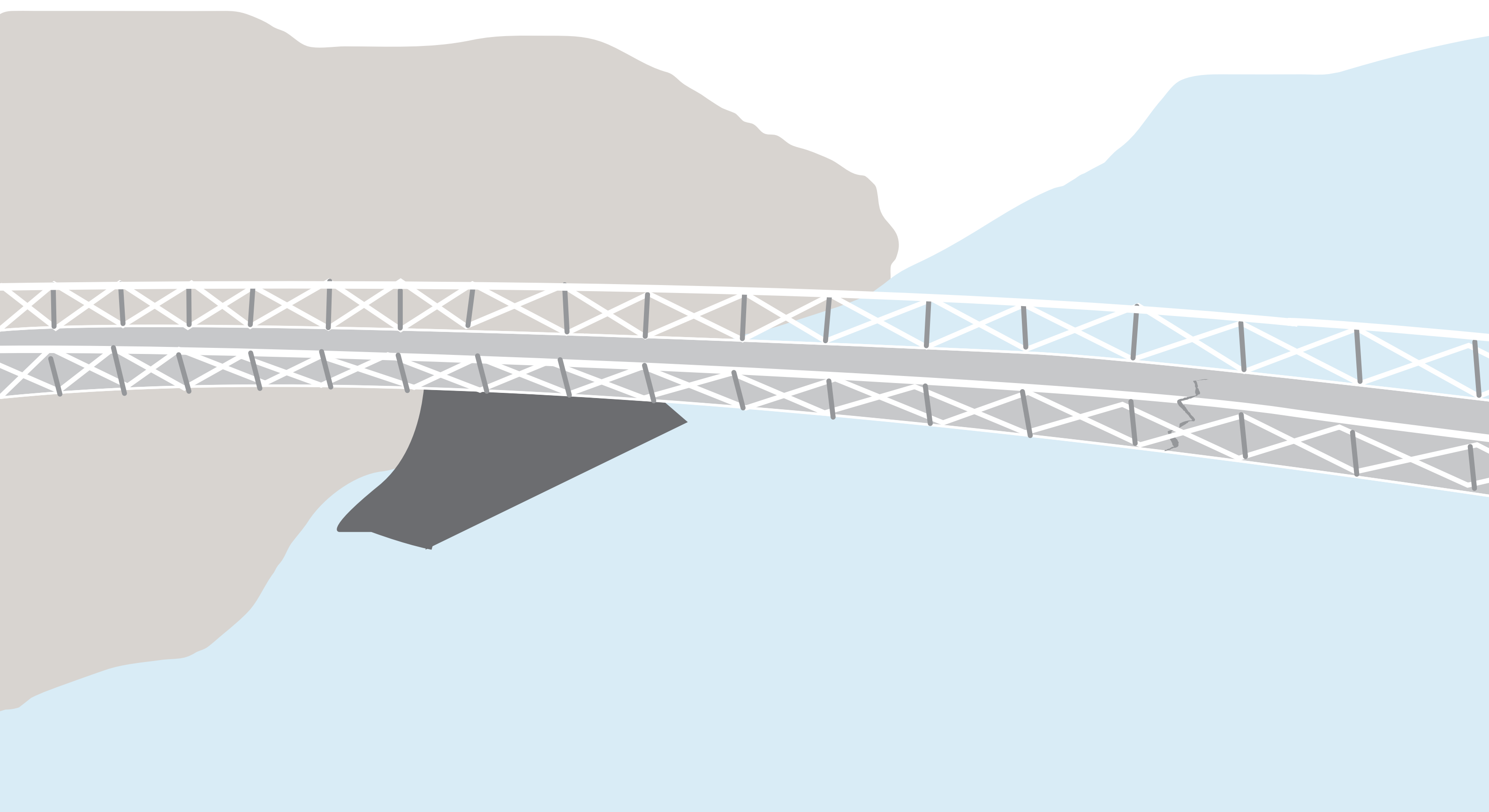


Figure 9 Motivation of stakeholders of the road infrastructure sector to use climate information. Internal motivation refers to organization's vision, credo or policy etc.; External motivation refers to PR, image, etc.; Regulatory obligations refer to the consideration of laws, decrees, etc.; Business interests refer to competition benefit, economic value, etc.

2.3 Climate information and decision-making

Climate information is predominantly used for decision-makings processes which refer to infrastructure planning and implementation as well as the development and implementation of risk management plans. Most favorable risk management strategies are risk prevention by protection and risk prevention by transformation.

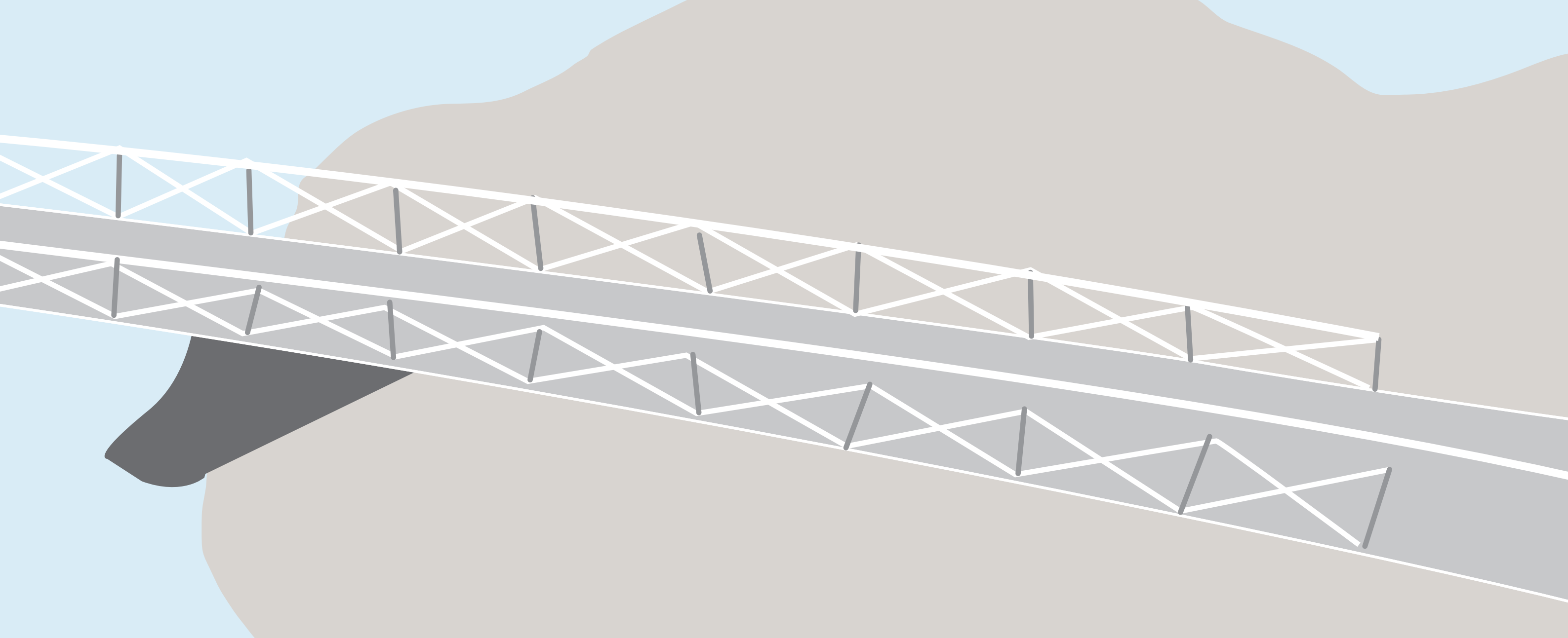
Within the organizational structure of most of the organizations, climate information has an impact at various levels of decision-making, which also have various temporal scopes (e.g. day-to-day operations (short-term); planning and maintenance activities (mid-term); strategic planning (long-term)). Climate information is considered as "very relevant" for decision-making processes that refer to "infrastructure planning and implementation" as well as the "development and implementation of risk management plans" and as "relevant" for "maintenance and organizational planning processes" and "strategic planning processes". There is only "some relevance" of climate information for "education and awareness creation and "day-to-day operation management" processes. Despite the tendency to apply climate information for rather long-term decision-making processes, only 60% of the respondents state that they consider climate change in their decision-making processes which is mostly due to the lack of appropriate information. With respect to climate risk management options the responding organizations pursue two main strategies (100%): "risk prevention by protection" and "risk prevention by transformation". The first comprises the construction of objects which protect the infrastructure object of concern (e.g. dams or sewers) and the latter the transformation of the infrastructure object to make it resilient to climate impacts (e.g. adaptation of design parameters). Other strategies like "awareness creation", "early warning systems", "recovery planning" and "business continuity management" are pursued by 50% of the respondents. The prioritized risk management strategy options do closely correspond to the temporal level of decision-making processes, which primarily focus on long-term technical and design solutions (Table 2). The most important



risk management strategies regarding climate change, which are already implemented, planned or potentially considered, are again technical prevention solutions as well as "awareness creation" and as mainly potential option also "contingency planning accommodating climate change risks".

Table 2 Pursued and optional risk management strategies of the respondents. In the first column (from left) types of risk management strategies are listed. The second column (blue shading) indicates whether the specific strategy is already implemented regarding current climate risks. Within columns 3-6 (red shading) it is indicated whether each specific strategy is an option in the context of climate change (no option, potential, planned or already applied). Given numbers indicate the number of responses for each strategy.

	Current climate conditions	Climate change			
Purpose	Implemented strategy	No option	Potential option	Planned option	Applyed option
Awareness creation	3	1		2	1
Prevention: Protection (e.g. protective constructions like dams)	5	1	2		1
Prevention: Transformation of object of concern (e.g. change of building design, or specific components)	5	1	2		2
Prevention: Retreat (e.g. relocation of constructions)	2	1	1		
Contingency planning accommodating climate change risks	2	1	2	1	
Business continuity management accommodating climate change risks	3	1	1	1	
Early warning systems	3	1	1		1
Responses to warnings (e.g. evacuation, temporal protection)	2		1		
Recovery planning	3		1		



2.4 Climate information products and services

Most used climate information products are predominantly data products, both climate data and hydrological data, as well as basic climate statistics. The greatest demand for climate information products refer to climate change impact information, vulnerability and risk information as well as methodical products like trainings, workshops, lectures and information material on climate issues and tools which support decision-making, strategy development and financial planning. Urgent demands for services refer to support for data processing and application as well as for the assessment of the information value for the specific context. The most important reason for not using climate information is the limited access to freely available climate information, the fact that the existence of the product is not known as well as the lack of regulations that make the use of climate information products binding.

The climate information product types which are predominantly used and demanded are displayed in comparison in Table 3. Climate information products which are being used by stakeholders from the road infrastructure sector are predominantly data products, both climate data and hydrological data, as well as basic climate statistics (5 of 6 respondents). Also, less used climate information products like "regional climate conditions", "tailored climate statistics" and "hazardous climate events" (2 of 6 answers) predominantly belong to this product category. Long-term climate predictions and climate projections are only marginally used. In contrast, the greatest demand for climate information exists for those climate information product types that are currently used the least. These are climate change impact information, vulnerability and risk information as well as methodical products like "trainings, workshops, lectures and information material on climate issues" and "tools which support decision-making, strategy development and financial planning". Further desired products comprise information on historical climate and hydrological events and their impacts, climate predictions and projections, any kind of sector-specific climate information (statistics, impacts and current vulnerabilities and risks). In the context of the product matrix, further aspects of climate information provision were asked for individually for each product type. These factors are amongst others: the degree to which user needs were considered in the product specifications, the usability of the product, limitations of use and provided support. The answers do differ between respondents but not between products. This clearly shows that quality and tailoring is strongly user-specific rather than a product-specific characteristic.

The used product portfolio clearly characterizes a specific climate problem that needs to be tackled by stakeholders from the road infrastructure sector: flooding events and flash floods. All required climate information refers to precipitation analysis: rainfall means, extremes and distribution, event analysis (intensity, duration, frequency) as well as similar hydrological information products. Data and information availability becomes a challenge as soon as cross analysis are required. This may involve correlation analysis of flooding events and climate events but also vulnerability and risk maps, which integrate other information like terrestrial data, impact information and socio-economic data. The availability of the same information on the future is often not given and thus object of most demanded climate information products.

Table 3 Overview of climate product types provided by the climate information provider network in Costa Rica and used or required by responding users from the road infrastructure sector in Costa Rica. Provided products: Column 2 (from left) lists general portfolio of climate product types potentially provided by an advanced climate service provider (category 4) (Appendix 2). Column 1 indicates the provider of the product types in CR. Column 3 provides specific examples for a product type provided by the provider listed in column 1. Used and required products: in column 4 climate product types are marked which are used by the interviewees. Specific products which were mentioned by the users are listed for each product type. The variety of green shadings of the used product types indicates the degree of usage (see legend below). The green shadings in column 5 indicate the share of used products which are being used as input for the production of follow-up products. These product types, thus, do not serve for immediate decision-making. In column 6 climate product types are marked which are required by the users. Required means, that they are currently not available! Required but available products are listed in column 4. The variety of red shadings of the required product types indicates the degree of requirement (see legend below). Please note: the product examples are based on the results from the interviews. They do not reflect the entire product portfolio of provided, used or required products. Also, contradictions within column 4 (e.g. product examples for product types which are marked as "not being used") refer to contradicting indications by the respondents. Stakeholders from the water sector were not assessed. Consequently, no product examples are listed in column 3.

Legend:

Number of respondents who use this product type:

5	4	3	2	1	0

Number of respondents who require this product type:

5	4	3	2	1

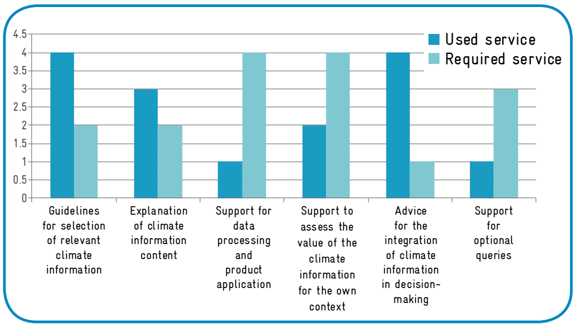
Product types which are produced and provided by IMN:

Product types which are co-produced and provided by IMN:

Provider	Product type	Provided product	Used product	Required product
IMN	Climate data	Station-based time series for atmospheric ECV's & derived variables (temperature, humidity, radiation, precipitation, wind speed, wind direction, atmospheric pressure and dew temperature)	Station data: T, RR, wind (daily min., max.; hourly); Observed & Re-analysis ECV data	
IMN	Climate statistics, diagnostics & monitoring	Examples (among others): Climate Atlas (maps climate normals for rain, temperature, sunshine [61-90]); isohyet maps (daily); monthly bulletins; ENSO bulletin; scientific publications; satellite images; ephemerides; tides; climate analysis and summaries on demand	average isohyet maps; Intensity-duration-frequency analysis; Summaries of climatic data per year	
IMN	Regional Climate Conditions	Regional climatologies; monthly bulletins; climatology of airport locations; Reports: Atlas of watersheds of Costa Rica; services on demand		Patterns of climate behavior in different areas
IMN	Statistics on climate extremes / hazards	Weather warnings; monitoring of the Turrialba volcano (ash dispersion); reports and studies on climate variability/climate events/ENSO events and impacts; services on demand	Storm records	
IMN	Tailored climate statistics	Services on demand	Rainfall indices by region	Data processed for average and extreme events, rain or flow
IMN	Climate statements for sectors	Reports on specific events and support material for aeronautics		
ICE, SENARA, AYA	Hydrological data & information		Station data flow (max.; mean; min); Correlation analysis of precipitation and flow (averages and extreme events); Analysis of individual extreme events	
IMN/ others	Impact information on terrestrial systems	Reports and studies on climate variability/climate events/ENSO events and impacts	Map of flood zones	Landslide hazard map
IMN/ others	Impact information for specific sectors	Reports and studies on climate variability/climate events/ENSO events and impacts	Statistics of events and effects on the National Road Network	
IMN/ others	Vulnerability/risk information	Reports on hydro-meteorological risks for specific regions; analysis of the current risk of the water sector	Hazard vulnerability maps	Risk and vulnerability maps of national roads to climate events
IMN	Long-range forecasts and outlooks (seasonal – decadal)	monthly and seasonal (3-month) predictions on rainfall (national and cantonal scale); climate outlooks (6 month, annual; regional scale); outlooks on canicula days an Indian summer; ENSO bulletin;		
IMN	Climate change projections	precipitation, average temperature, maximum temperature and minimum temperature, for the period 2011–2100 [30 a periods; 1 RCM; scenario A2&B2]; report on regionalized climate change scenarios for Costa Rica	Projections of climate change (RCM)	
IMN/ others	Climate change impacts	Reports on climate change impacts on the agricultural production in CR; availability of water resources in CR; effects of climate variability and change on human health in CR.	Projection models of discharge, floods and landslides	
IMN/ others	Climate change vulnerability/risk information	Reports on climate change consequences for food security in CR; vulnerability and adaptation of infrastructure to climate change; climate change risks of water sector in CR; vulnerability of the water system to climate change.	Hazard vulnerability maps	Risk and vulnerability assessments of national roads to climate events
IMN/ others	Further education on climate (change) issues (methods & awareness)	Educational material and information: atlas of clouds; climatological atlas; storms; hurricanes, UV-index; Meteorological instruments; Meteorological glossary; weather, climate and climate variability in CR; ENSO; climate change, -risks, -impact, -mitigation, -adaptation and research and development capacities; Talks on demand		Training and exchange on development and analysis of impact projections
IMN/ others	Further education for decision-making support	Reports on integration of activities and studies of vulnerability and adaptation to climate change; adaptation of water resources to climate change in CR; identification and prioritization of measures to adapt the water system to Climate Change in CR; importance of the Costa Rican agricultural sector in mitigating global warming		

Beyond the technical products, additional services are being used which help to apply available climate information products for decision-making. Used and demanded services are displayed in Figure 10. Predominantly used services are guidelines, which support the process of "selecting and assessing relevant climate information" as well as "advices and support on integrating climate information in decision-making processes". Also, the service of "explaining the content of climate information" is appreciated. Urgent demands for services refer to "support for data processing and application" as well as for the "assessment of the information value for the specific context". Support for formulating letters of inquiries is also demanded. In contrast, some processes on value adding are undertaken by the users themselves in order to get the required information from the climate data they received from the provider. It is notable, that most of the used product types are being used as input for follow-up products instead of direct use for direct decision-making in the context of infrastructure planning processes (Table 3). The two dominant tasks that are done by the users themselves are data analysis and modeling. Beyond that, research tasks in terms of fact-finding are done by most of the stakeholders. However, both tasks are typical methods in the research sector which many of the respondents are part of. This is also reflected in the availability of sufficient resources to accomplish such tasks (5 of 6 answers) and the access to external support for the integration of climate information in decision-making (3 of 6 answers). On the other hand, tasks which comprise value adding are also among the services which are demanded the most.

Figure 10 Services which are being used and required by stakeholders from the road infrastructure sector in Costa Rica. The y-axis shows the number of entries. Blue pillars indicate services which are being used by the respondents. Orange pillars indicate required services which are not yet available or useful.



The reasons why climate information products are not or only limitedly used in the road infrastructure sector are of both, technical and institutional nature (Figure 11 & Figure 12). In the first category, the most important reason is that the access to climate information is limited but also the fact that the existence of the product is not known. The latter may refer to a lack of transparency of available products but also to the non-existence of desired products. Further important reasons are a limited quality of the product as well as the temporal availability of the information. Issues of contextualization of the information as well as the usability of the product are also relevant, but of less importance. This reflects the use of respective services covering these issues (see above). Reasons on the institutional level for not using climate information products are dominated by the fact that climate information is not freely available. Other important reasons are the lack of regulations that obligate the use of climate information products and what is often perceived to be an unfavorable cost-benefit ratio in using climate information. Another interesting reason is the absence of an obligation to use climate information in decision making. This reason is not a dominant one but also not the most dispensable reason.

Figure 11 Technical reasons for a limited or no use of climate information products

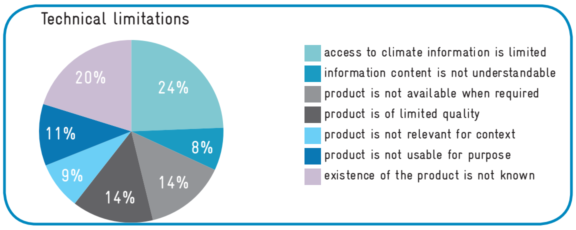
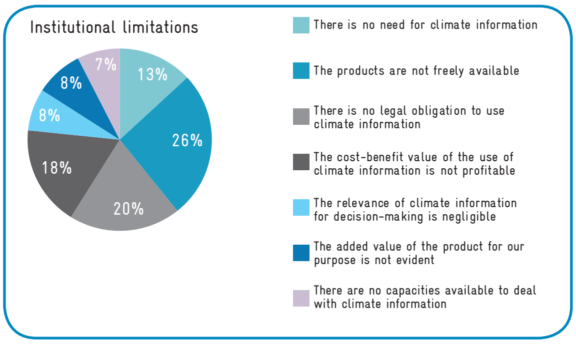


Figure 12 Organizational reasons for a limited or no use of climate information products



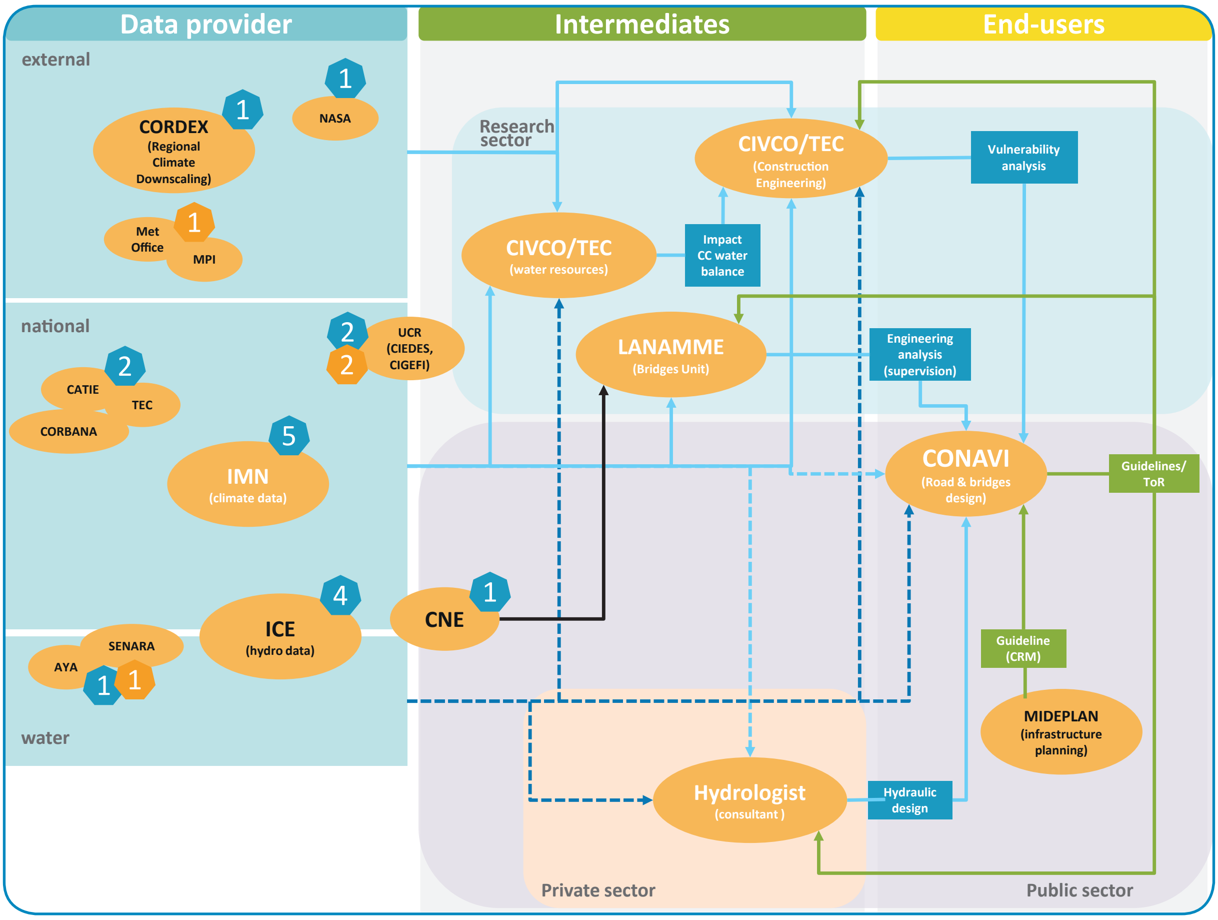
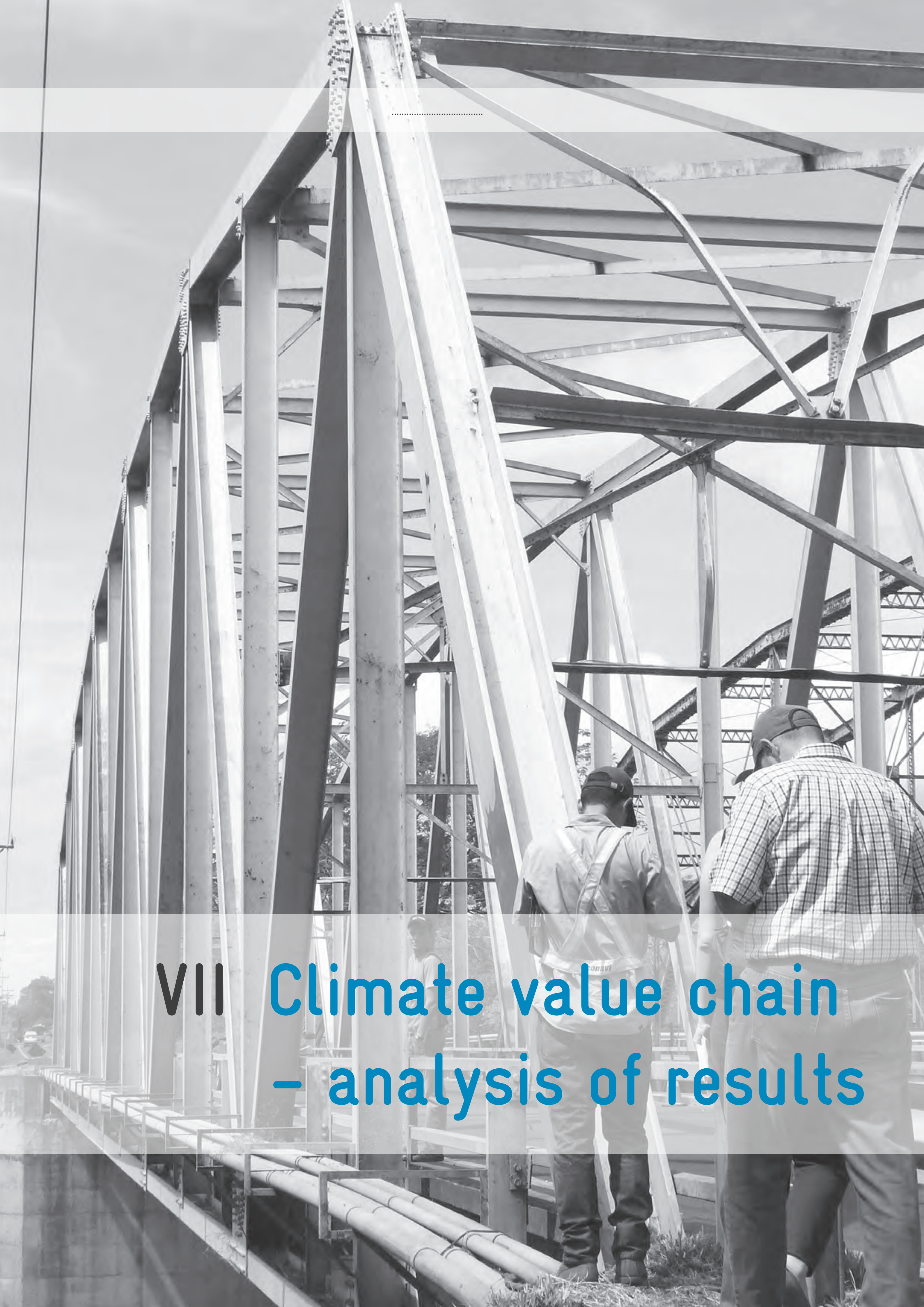


Figure 13 Overview of the Climate-Value-Chain for the road infrastructure sector in Costa Rica. The graphic is structured according the concept of a climate-value-chain and roughly subdivides the stakeholders in providers (left), intermediates (middle) and end-users (right). The providers on the left side are furthermore subdivided in external providers (top), national providers (middle) and hydrological data providers (bottom). Intermediates and end-users are sub-divided in different sectors (private, public and research) which are shimmed accordingly. Stakeholders with white writing have been interviewed for this report. The light blue lines indicate a purchase of climate data or information. Dark blue lines indicate the purchase of hydrological data. Black lines the purchase of other climate-related data. Green lines indicate the application of regulations, guidelines or terms of reference (ToR) in the context of climate information. Solid lines indicate a free purchase of data and dotted lines a paid or restricted purchase. For overview reasons these lines interlink purchaser and type of data provider (extern, national, hydro). The blue numbers next to the providers indicate the number of users purchasing data from this specific provider. Orange numbers indicate the utilization of advice or support (no data).



VII Climate value chain – analysis of results

Within this chapter the interrelation of climate information providers and users shall be analysed and discussed. This interrelation can be described best by the climate-value-chain. The analysis is done from two perspectives: the provider as well as the user perspective.

The interrelation of the stakeholders of the road infrastructure sector as well as the climate information providers is visualised in Figure 13. Figure 13 highlights the roles of stakeholders regarding the climate-value-chain and identifies providers, intermediates and users of climate data and information. Furthermore, pathways of climate information provision, as stated by the interviewees, are illustrated which depict the network of information flow and specific relationships between stakeholders.

Figure 13 clearly identifies the main sources of climate-related information, which are the IMN for climate data and ICE for hydrological data. The central entity for hazard information, CNE, seems to have a minor role for information provision (only one reference). Furthermore, the interaction of climate providers is visualized which clearly shows a basically non-existent systematic interaction between IMN and private climate and hydrological data providers. This also becomes apparent in Figure 8. The graphic also indicates the roles of the stakeholders within the climate-value chain for the road infrastructure sector: here CONAVI appears as the only end-user. All other stakeholders do have a function as intermediates since they produce value-added information which they provide to CONAVI in order to enable the planning and implementation of bridge infrastructure projects. Especially stakeholders from the research sector often do not consider themselves as intermediates, and thus as producers of climate information, but as end-users and thus are not aware of their actual role in the climate-value-chain. It is also the stakeholders from the research sector who do not only consult the common sources of climate and hydrological information (IMN and ICE) but also address external data providers. They also differ from other stakeholders in the road infrastructure sector since they often have special agreements with climate data providers (especially IMN) and pay the least for the information.

1 Provision of climate information

The evaluation of the used and required climate information products of the stakeholders of the road infrastructure sector clearly highlights the focus on water-related issues. Of major interest are events like floods and flash floods, which impend to inundate and thus block or damage roads and bridges or trigger landslides which may have similar effects. Climate information is thus primarily required as input data for further hydrological analysis, climate impact and risk assessments (Figure 13). These are complex products which comprise additional data besides climate data and thus require processing activities of basic climate information products (e.g. data analysis, modelling or research activities). Such value-added products are rarely available for the road infrastructure sector in Costa Rica or are not being used. It is noteworthy that, on the one hand, there are already a considerable number of useful products provided by IMN in the context of climate risk assessments for current and future climate (e.g. hazard information, impact information, vulnerability and risk information (Table 3)). From the user perspective, however, these product types are indicated as being required and thus not available or usable yet. According to the interviewees, the main reasons are a limited access to these products and a limited knowledge about the existence of these products. However, the exact reason why specific products are not being used cannot be identified based on this assessment. As a consequence, relevant value-added climate information needs to be generated by the sector-specific intermediates themselves. This is an activity that intermediates like to delegate to the climate service providers or at least require more support for more efficient and meaningful processing (Figure 10).

This enormous effort of value-adding to acquire the desired climate-related information relevant for the road infrastructure sector indicates a gap within the climate-value-chain (Figure 14). The reason for this gap may be threefold:

First of all, a hydrological service is not existent in Costa Rica. All hydrological measurements are done by various public institutions with specific sectoral interests that sell their data but do not adopt standard monitoring tasks. Consequently, standard hydrological observation and diagnostic products are not available but need to be generated by users and intermediates additional to the development of value-added products.

Secondly, a sectoral partner of the climate information provider network is missing, who adopts important sectoral functions: (1) provision of standard climate information products relevant for the road infrastructure sector, both, by producing relevant climate information (e.g. by tailoring of climate data or by value-adding by merging climate and other data to produce new information) and by collecting and archiving existent and emerging information (e.g. products and methods which were developed in the context of research projects); (2) the communication and representation of sectoral needs and interests for climate information to IMN in order to make useful and usable sector-specific climate information standardly and timely available.

Thirdly, there are no or only limited cooperating structures between key stakeholders to enhance the functioning of such a climate-value chain: (1) a cooperative interaction between IMN and ICE is practically non-existent; (2) the cooperation between IMN and CNE is existent and good regarding the support of CNE's tasks; however, the incorporation of CNE as climate service provider to enhance the production of follow-up products is limited (only one reference as info provider is given); (3) the relationship to stakeholders from the road infrastructure sector is a usual customer relationship (i.e. information is provided only on demand, often for money and strongly limited to project-specific use) instead of being based on partnership with common objectives and agreed and easy archiving and exchange of data and information.

The consequence of such a gap is that value-added climate information that is generated within a project is not being archived and available to other projects and thus getting lost after the project is finished. Thus, all analysis and modelling activities have to be done anew for each project. This is a very effortful, costly and ineffective process because of missing coordination processes between stakeholders as well as data policies which do not allow the transfer and re-use of climate products. On the other hand, such a gap implies the lack of important intermediate functions which enable the continuous production, availability and accessibility of useful and usable sector-specific climate information.

2 Use of climate information

Figure 13 highlights the fact that CONAVI is a central end-user within the climate-value-chain of the road infrastructure sector. This means that all climate products developed and processed by any of the stakeholders within the value-chain end up at CONAVI. Furthermore, CONAVI is also in charge to define the type of climate information which is being used. Consequently, CONAVI should have the capability to assess the quality of the returning climate information products and thus requires a profound knowledge about climate and climate information. Consequently, CONAVI takes not only a central position within the sectoral planning processes for national road infrastructure but also for the coordination of climate information.

However, the pathways of climate data flow compose a contrast to this centralized sectoral role of CONAVI: all stakeholders within the value chain purchase climate data for their context from various sources that are often project dependent. Despite the main sources of climate information being the same (IMN and ICE), all stakeholders purchase often similar information to different conditions regarding costs and regulations on data use. This procedure counteracts the central sectoral role of CONAVI as coordinating hub for climate information within the planning processes of road infrastructure projects, since no uniformity and thus reliability of climate information can be guaranteed by CONAVI. To support the role of CONAVI, it could adopt the role of a sectoral partner within a National Climate Service and thus fill an important gap of climate information provision for the road infrastructure sector.

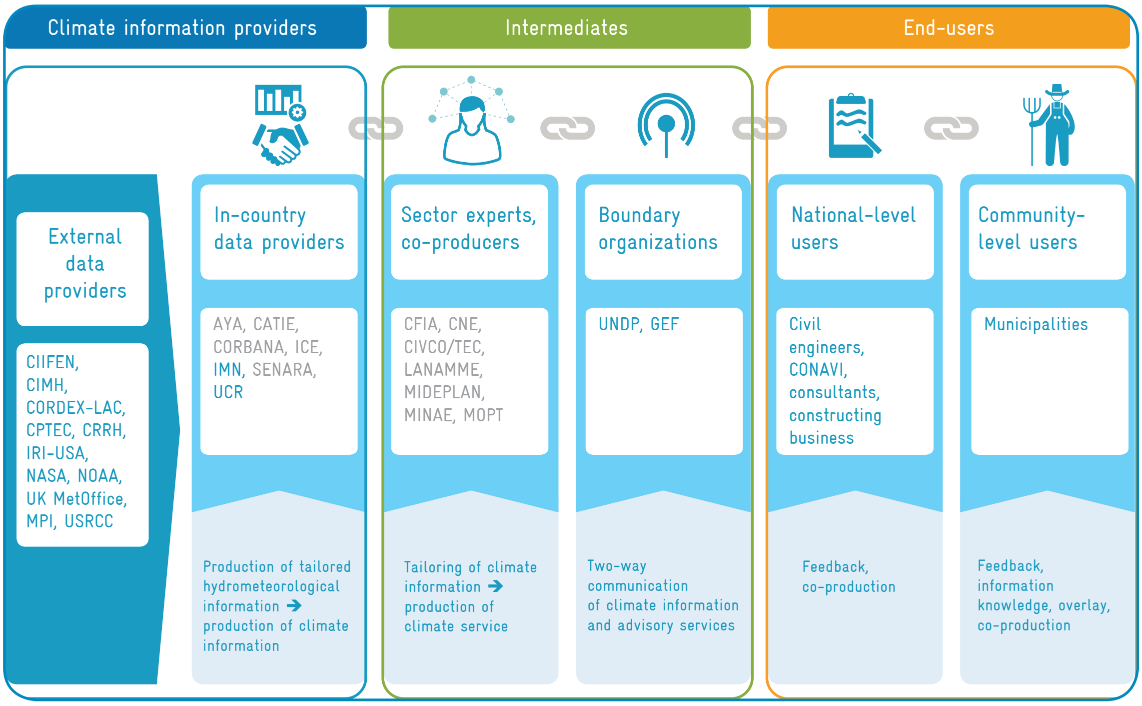


Figure 14 Hypothetical climate-value-chain for the road infrastructure sector in Costa Rica. Identified stakeholders are based on the results of the baseline assessment. Grey colored stakeholders may potentially take the allocated role within the value-chain; however, they are not (yet) systemically and organizationally integrated in such a value-chain. Italic formatted stakeholders are not identified as specific organization (modified and based on WMO 2018).

3 National Climate Service in Costa Rica

A model of a climate-value-chain for the road infrastructure in Costa Rica is constructed and visualized in Figure 14. The specified stakeholders of this value-chain may also be potential partners of a road infrastructure section within the National Climate Service. This value-chain is based on the conceptual model of a value-chain of WMO (Figure 2) and the findings from the baseline assessment and thus yet hypothetical. At the current state of the Climate-value-chain, IMN is in charge to develop and produce all climate relevant information products for all kinds of sectors at various degrees of value-adding (also see product portfolio in Table 3). Sectoral experts do exist and are also involved in the production of climate information products to some extent; however, they are structurally not integrated in the production and provision process of Climate Services. This puts a lot of responsibility and work load on IMN. Without discussing or questioning the ability of IMN in providing these products and services in sufficient quality, it becomes already apparent from this assessment that personnel and technical capacities of IMN are not sufficient to provide such products and services for all sectors in a timely and continuous manner as it is required to make these products not only useful but also usable for sectoral users.

Alternatively, a National Climate Service would envisage the incorporation of sectoral and political partners which adopt various functions in the development, provision and communication of Climate Service products. Such a partnership does not only imply MoUs on the use of data and information and a closer interaction with respect to regular meetings but also the sharing of tasks: tailoring of climate data, value-adding processes as well as sectoral communication and provision of climate information can be outsourced to sectoral partners and thus a crucial part of Climate Service development. Knowhow, staff capacities and technical equipment of the sectoral partners can be used and IMN capacities relieved. IMN as NMHS of Costa Rica would take a coordinating role in order to guarantee the quality, homogeneity and continuity of climate product and service production and provision on a sectoral level and to foster the regular interaction with sectoral partners. For the road infrastructure sector in Costa Rica such a sectoral partner (sector champion) of the National Climate Service could be MOPT/CONAVI (also see Figure 8, Figure 13, Figure 14). The incorporation of CFIA would help to keep expertise at hand regarding climate risk assessments and standards for infrastructure objects. Also academic stakeholders like CIVCO/TEC and LANAMME can be incorporated in such a sectoral climate service branch. This would enable the continuous availability of relevant research results for practical application in the road infrastructure sector and in turn provides the opportunity for the sector to govern research projects and strategies. The integration of other partners on a higher inter-sectoral level may be valuable in order to provide sector-relevant but not sector-specific information and services (e.g. CNE) or to establish appropriate policies and frameworks (regulation, guideline) to define and regulate the use of climate information within the road infrastructure sector. This would support a sectoral champion (like CONAVI) to clearly define and assess climate information relevant for planning processes. Political partners for the transport sector would be MINAE, MIDEPLAN and MOPT. Such a framework is also supported by the users who explicitly suggest that such guidelines should be developed in cooperation of these political partners and IMN. The existence of regulations on the use of climate information would also help to overcome major limiting factors of using climate information which is an unfavourable cost-benefit ratio. Thus the motivation of using climate information would also be of economical nature and not only internal or external.

Intersection of a cantonal road with Ruta Nacional No. 2 in Lima de Cartago.

VIII Evaluation of results

Fundamental results from the assessment are summarized in this chapter. The results refer to the most comprehensive guiding question for this baseline assessment: what is the current state of a National Climate Service in Costa Rica for the context of the road infrastructure sector in Costa Rica? The evaluation of the findings is structured according to a SCOT analysis: strengths and challenges of a current NCS are identified regarding existing entities, stakeholders and processes which support the functionality of a NCS. Furthermore, opportunities and threats are identified regarding the establishment or enhancement of such a NCS.

1. **Strengths of the current NCS for the road infrastructure sector in Costa Rica**

   1.1 The existent NCS of Costa Rica has a committed and stably positioned National Meteorological Service with governmental mandate and budget. The development of Climate Services is based on a fundamental tasks and the related infrastructure which refer to observation and monitoring of climate variables as well as the archival storage of this data and quality control. These tasks require thorough and continuous operational processes which are often adopted by non-profit orientated but publicly funded and mandated organizations like the most NMHSs. NMHS are furthermore main contact point to WMO facilities and thus provide access to regional and international resources and capacities regarding, climate data, tools, standards and norms as well as training etc.

   1.2. The NMHS of Costa Rica (IMN) has a salient position within the NCS. Within the road infrastructure sector IMN is perceived as prime institution of contact regarding the provision of climate data and information. Such a prime contact within a NCS is valuable in order to guarantee quality of climate data and homogeneity of climate information as well as user friendly access to climate information.

   1.3. The National Climate Service of Costa Rica is able to provide essential climate data services and information products (category 1 & 2) as well as important functions of category 3 (Appendix 2). The product portfolio of the NCS covers all relevant product types (Appendix 3) relevant for sector specific climate risk assessments for current and future climate conditions. Not all products of this product portfolio are yet usable for all sectors and users due to limited tailoring and quality but the general knowhow for the production of each product type is given and thus the potential for future extension of the portfolio.

   1.4. The NCS of Costa Rica has experiences in cooperating with stakeholders from the road infrastructure sector. Key stakeholders from the road infrastructure sector are known as well as their climate-related problems and decision-making processes. IMN is experienced to deal with very specific sectoral user demands also in the context of climate risk assessments. Existing sectoral experiences facilitate the establishment of a sectoral branch of a NCS.

   1.5. Users from the road infrastructure sector use a wide range of available climate information products but predominantly data products. Parts of the available product portfolio of the NCS have already been used by users from the road infrastructure sector also without specific tailoring.

   1.6. Users from the road infrastructure sector generally have basic to advanced skills in using and processing climate data and information for their purpose. Competences of the sector community in data processing enhance the usability of standard products without specific tailoring.

   1.7. Users from the road infrastructure sector generally have a profound ability to formulate their needs regarding the required climate data and information. This facilitates the provider-user interaction as well as the provision and use of climate information.

2. **Challenges for the current NCS for the road infrastructure sector in Costa Rica**
    - **2.1. Challenges regarding the Climate Service inventory (chapter V).** Challenges which refer to problems and shortcomings identified by IMN for each GFCS pillar:
        - 2.1.1 OM: there is a need for a higher national coverage of climate stations in order to increase the spatial density of climate records.
        - 2.1.2 OM: there is a need for better monitoring systems and archiving of hydro-meteorological events in order to assess current and future climate risks.
        - 2.1.3 CSIS: there is a need to review the data management processes, data archiving and data quality control systems in order to guarantee timely available and continuous high quality time series.
        - 2.1.4 RMP: there is a need for an increased funding to enhance and focus research activities (e.g. by national budget).
    - **2.2. There is a co-existence of several climate observation systems in Costa Rica.** Besides several organizations that operate a couple of climate stations, IMN and ICE both operate a climate observation network. However, only the data from the IMN network currently continually feeds into the central data base which is the basis for national climate information products.
    - **2.3 Challenges regarding climate product portfolio for the road infrastructure sector (chapter V.3). Insufficient availability of:**
        - 2.3.1 statistics for extremes and climate hazards
        - 2.3.2. hydrological data, events and information
        - 2.3.3. sector-relevant hydro-meteorological impact information
        - 2.3.4. high qualitative and sector-relevant climate change projections
        - 2.3.5. high qualitative and sector-relevant climate change impact projections
        - 2.3.6. sector-relevant climate and climate change risk and vulnerability information
        - 2.3.7. sector-relevant trainings, workshops, lectures and information material on climate issues

Climate information is considered as most relevant for long-term decision-making processes by users from the road infrastructure sector. However, this is in contrast to the availability and usability of climate information products.

- **2.4. Restricted data access to climate data and services.** Climate data as well as specialized and tailored climate information products and services are not freely accessible and not free of charge for many users. The purchasing process of climate data is furthermore in large parts non-transparent and timely extensive due to the preparation of individual contracts. The in-time availability is a major obstacle of using climate information products by stakeholders from the road infrastructure sector.
- **2.5. Product visibility and transparency is limited and active marketing is non-existent.** Product description regarding technical limitations as well as the value and relevance for a specific application context is not or only limitedly provided. This hampers the user in identifying a potentially useful product and to assess the usability of a product.
- **2.6. There is no cooperative integration of the road infrastructure sector in the NCS.** Key stakeholders from the road infrastructure sector (e.g. CONAVI, MOPT) have no institutional relationship to IMN as key climate information provider but a customer relationship. Interaction processes are based on this customer relationship. No structured communication protocols exist. This hampers a continuous interaction, exchange of knowledge and formulation of needs as well as the co-production of sector relevant Climate Services.

  Value-added products are currently produced by the users/intermediates of the road infrastructure sector. However, due to the missing cooperative integration of key stakeholders, such value-added products are lost for the road infrastructure branch of a NCS.

2.7. **There are no frameworks, regulations or guidelines on the explicit consideration of climate change and the use of climate information for decision-making within the road infrastructure sector.** Such guidelines are desired by many of the stakeholders of the road infrastructure sector. The obligation to use climate information would enhance the use of climate information products and improve their cost-benefit ratio.

3. Opportunities for the establishment of a NCS for the road infrastructure sector in Costa Rica

3.1. **The development and provision of Climate Services is politically supported and motivated by the National Adaptation Policy.** The embedment of Climate Service provision in the NAP indicates the significance of Climate Services for climate change adaptation. This finding provides great opportunities for an effective implementation of capacity development measures regarding new strategical cooperation and the enhancement of a National Climate Service. In turn, several measures (recommendations of this report) which enhance the provision of Climate Services need to be implemented in order to realize the implementation of the NAP (IV.2). This especially refers to the establishment of an open data policy (RXIV), the strengthening and support of appropriate risk assessments (RIX), the enabling of Climate Service information platforms (RVI, RVII) and the organization of an adequate observation and monitoring system (RII, RIV) as well as the provision of risk and sector relevant climate information (RVIII).

3.2. **The NCS of Costa Rica consists of an established network of national, regional and international partners of climate data providers and research institutions.** This enables the NCS to extent the already existing portfolio of climate service products, which also partly cover category 4 functions, despite limited capacities of IMN.

3.3. **CONAVI takes a central position within the sectoral planning processes for national road infrastructure but also for the coordination of climate information.** This role of CONAVI provides a great opportunity for it to become a sectoral champion for the road infrastructure sector within a National Climate Service.

3.4 **Stakeholders of the road infrastructure sector consider climate information as very relevant for key decision-making processes of their sector (infrastructure planning and implementation).** This provides favorable basic conditions for the use and impact of climate information if they are salient, credible and legitimate.

4. Threats for the establishment of a NCS for the road infrastructure sector in Costa Rica

4.1. **The public use and sharing of meteorological data in Costa Rica is restricted by respective data policies.** Such a data policy is a fundamental obstacle for the establishment of a sector-integrative and effective NCS. The establishment of an open data policy is part of the objectives of the NAP (IV.2).

4.2. **There is no hydrological service in Costa Rica which executes structural hydrological observations and provides basic hydrological services.** Such analysis need to be done by intermediates and users anew for each project. Additionally, due to restricted data access and individual agreements on data use such information is not available for other stakeholders and projects. This procedure is laborious, costly and thus ineffective. However, activities regarding the consolidation of hydrological data in Costa Rica have already started (V.1).

Upstream view of Barranca river above the bridge of Ruta Nacional No. 1, in Esparza de Puntarenas.

IX Conclusion & Recommendations

The prevalent National Climate Service of Costa Rica is predominantly represented by the National Meteorological Institute (IMN). Owing to an established and extensive cooperative network on the regional and international level, the NCS can provide a comprehensive range of climate data and information products covering the entire range of climate product types (Table 3; Appendix 3). However, the service component of climate information provision is, as of yet, rather underdeveloped. This comprises tools and processes which support the access to climate information, the purchasing and provision process for specific demands and the visibility and marketing of products and services as well as an active support program for sectoral users. A limited service component consequently hampers the effective use of the provided climate information by sectoral users and thus the impact of climate information on decision-making.

Considering the climate-value-chain for the road infrastructure sector, a gap can be identified regarding the institutionalization of production and provision processes of sector-specific climate information products which are required by the road infrastructure sector in order to appropriately consider climate in their decision-making processes. This gap is predominantly owing to the fact that sectoral key stakeholders are not integrated in the NCS in a cooperative context. As a consequence, sectoral products and services cannot be provided to users in a structured and efficient manner and in turn, sectoral knowledge, experiences, products and capacities are not available to the NCS. Despite the high ambitions and endeavours of IMN to enhance the provision of Climate Services in Costa Rica, their capacities, especially regarding staff and technical equipment, are limited. At the same time, the consideration of sector-specific demands requires substantial resources. To meet this demand the establishment of an extended National Climate Service with sectoral branches is recommended which integrates relevant and potential data and information providers (e.g. University, CNE) as well as key sectoral stakeholders in order to co-produce sector-relevant climate service products. According to the vision of the Global Framework for Climate Services, such a comprehensive National Climate Service is aiming for the better impact of climate information on decision-making. Concurrently, organizational structures and process within IMN should be reviewed in order to enhance their efficiency. Such a restructuring process provides the opportunity to achieve more output with prevalent capacities and funding.

Based on this conclusion several recommendations are given in order to enhance the provision of Climate Services by the establishment of a National Climate Service. The recommendations are structured according the three levels of capacity development: (i) Societal level (cooperation systems; enabling framework); (ii) Organizational level and (iii) Individual level of activity (GIZ, 2015). The recommendations are also allocated to the 4 components of the GFCS which is indicated by the component's abbreviation.

1 Societal level: enabling framework

Recommendation 1

Establishment of a National Climate Service with the incorporation of the road infrastructure sector (=> CSIS)

In order to provide a sustainable and efficient provision of Climate Services for the road infrastructure sector in Costa Rica, relevant tasks and processes should be institutionalized. This implies an expansion of the prevalent National Climate Service of Costa Rica by integrating relevant climate information providers as well as sectoral line ministries and key stakeholders from the road infrastructure sector.

Climate information providers comprise the area of climate and hydrological information (R2[23]), hazard information (e.g. CNE) as well as the academic sector (CONAVI/TEC; R5, R8). Key sectoral stakeholders comprise line ministries (MINAE, MIDEPLAN, MOPT), sectoral expert organizations like CFIA and respective research departments (LANAMME, CIVCO/TEC) as well as CONAVI as central user and potential coordinator of climate information within the road infrastructure sector. IMN would take a coordinating role in order to guarantee the quality, homogeneity and continuity of climate product and service production and provision on a sectoral level and to foster the regular interaction with sectoral partners (II.5). The collaboration within the NCS should be based on a cooperative partnership with MoUs regarding the use and exchange of data, knowledge and information which should be as open and barrier-free as possible (i.e. transparency, timely and non-bureaucratic access) in order to enhance a timely and qualitative production, provision and use of Climate Services on a sectoral level.

The benefit would be a common understanding and access to data, information and knowledge which is relevant for climate risk issues of the infrastructure sector. Products and knowledge which is being produced by any of the partners would feed into this data base and would be available to all partners. Furthermore, resources and capabilities can be shared to produce costly and laborious tasks.

Specific recommendations on the embodiment of a NCS are given below.

[23] Reference number which links to detailed recommendations below

2 Societal level: cooperation systems

Recommendation 2

Coalescence and harmonization of existing climate observation networks and climate stations in one central observation system (=> OM)

In order to enhance to spatial coverage of climate observations in Costa Rica, existent resources should be used. This refers to the climate observation network of IMN and ICE as well as the climate observation stations from other stakeholders (e.g. CORBANA, CATIE, SENARA and AYA) (Figure 8). A cooperation of these stakeholders is recommended which implies the coalescence (one observation network) and harmonization (technical assimilation) of the existing climate stations as well as the archiving of the observation data within one central data base. However, the coalescence of the observation network may increase the number of stations but not necessarily the spatial coverage of climate data. A strategic and cooperative planning of new climate stations and relocation of existing climate stations (R12) may provide a meaningful and effective observation network that serves the entire NCS. The development of a concept for such a cooperation which defines fees, costs and right of data use is recommended.

Recommendation 3

Establishment of a basic hydrological service (=> CSIS)

Fundamental systematic hydrological services are not provided in Costa Rica. Hydrological data can be purchased from stakeholders like ICE, AYA or SENARA, however, these observations are not systematically and continuously collected, analysed and provided for the production of hydrological information relevant for other users and sectors beyond the scope of the providers' organizations.

It is recommended to cooperate with ICE, AYA and SENARA in order to provide access of the NCS to hydrological observations. It is furthermore recommended to establish a basic hydrological service that continuously provides basic hydrological monitoring products and statistical analysis on a catchment and national level. This task can be adopted by any of the above mentioned organizations as cooperation partner of the NCS or by a newly established department within IMN.

Recommendation 4

Systematic observation and archiving of sector-relevant climate impacts (=> OM)

Regarding climate risk assessments for the infrastructure sector, information on climate impacts is very valuable. Beyond the observation of climate variables and events, a National Climate Service should also support a systematic observation and archiving of climate impacts on terrestrial systems and relevant infrastructure objects. Such observations need to be done directly by affected stakeholders. This information needs to be centrally collected and coordinated and cross-analysed with climate hazard information. Such a coordinating role could be adopted by the sectoral champion (CONAVI) in cooperation with IMN (climate data) and CNE (hazard information) (e.g. by the establishment of respective cooperation or agreements). However, hazard information and hydrological information, amongst others, should also be available for other sectors and tailored to their contexts. Thus, the role of coordinating entities should also be discussed in an inter-sectoral context having the big picture of a NCS in mind, which goes beyond the specific branch of the road infrastructure sector. Consequently, key sectoral stakeholders from all sectors should be involved in the coordination on impact information.

Recommendation 5

Enhancing the development of high quality and sector-relevant climate projections (=> RM)

Climate projections are fundamental for climate change risk assessments of road infrastructure objects. However, they need to be useful and usable for sectoral decision-makers. I.e. projections are required for relevant parameters (e.g. hydro-climatic events) at relevant spatial and temporal resolutions and with sufficient uncertainty information. The latter requires the availability of several model runs, ideally from different Regional Climate Models (ensemble-runs). Climate projections are, however, laborious and costly to develop which often exceeds the staff and technical capacities and the available budget of the NMHS (here IMN).

Therefore, it is recommended to identify and consider all existent and potential available sources and resources for the development of climate projections for the region to which Costa Rica belongs. This may comprise regional WMO institutions (e.g. RCCs) as well as the academic sector on the national (CIVCO/TEC) and regional level (e.g. members from CORDEX-LAC). The cooperation with these stakeholders is recommended in order to bundle capacities and competencies to develop and run climate models as well as to produce useful and usable analysis relevant for the road infrastructure sector.

Recommendation 6

Establishment of a sectoral user-interaction platform (=> UIP)

A sectoral user interface platform is an essential part of a NCS. The scope of a sectoral User Interface Platform (UIP) is to provide a forum for climate information providers and sectoral stakeholders and users to meet and interact, to establish mutually beneficial collaborations and finally develop usable and decision-relevant Climate Service products. The UIP provides room for users and intermediates to formulate and explicate their needs regarding Climate Services related to all three dimensions: technical, service and institutional (chapter II.4). The UIP provides room for Climate Service providers and intermediates to define and explicate their (technical) capabilities and capacities of Climate Service development and provision. The objective of the UIP is to reconcile and harmonize user needs and provider capabilities at all three dimensions in order to establish potentials of feasible Climate Service products and organizational structures. And finally the UIP provides room for the development and promotion of usable and decision-relevant Climate Service products and organizational structures in co-production with sectoral stakeholders. The format of an UIP can be regular meetings, workshops or others which help to maintain a continuous exchange of knowledge, experience and needs regarding climate information for the road infrastructure sector.

It is recommended to establish such a UIP for the sectoral context of the road infrastructure sector incorporating all relevant sectoral stakeholders (Figure 8). IMN as central stakeholder and coordinator of the NCS in cooperation with CONAVI as potential sectorial champion may be in charge for this user interface.

Recommendation 7

Development of an informative and transparent product information system (=> UIP)

The visibility of climate information products as well as information on their potential use for specific sectoral contexts helps the user to value Climate Services and can increase the readiness to use them. An attractive public appearance of the National Climate Service is recommended. This appearance provides detailed information on available or potentially available Climate Services, their technical scope and potential use for specific applications within a sectoral context. Ideally, additional material like guidebooks, case studies etc. is provided as well as guidance for further consultation and advice as well as on data or product purchase procedures.

It is recommended to the NCS to establish a web-interface which provides a clear overview on the existing Climate Services of the NCS for the road infrastructure sector which is intuitive to handle and informative regarding the usability and usefulness of specific products and services for specific sectors. IMN as central stakeholder and coordinator of the NCS in cooperation with CONAVI as potential sectorial champion may be in charge for such an information system. Such a web interface may be an extension or add-on of existing interfaces (e.g. web-page of IMN and/or MOPT/CONAVI) but can also part of an inter-sectoral climate knowledge portal which integrates similar information from other sectors.

Recommendation 8

Development of sector-specific climate information products in co-production with sectoral users and research partners (=> RM)

User demands for climate information may be very specific and laborious to identify. This may involve research for the development of models and tools (e.g. indices; impact models; decision-support tools). However, for an effective use of climate information by sectoral application this may be necessary. The development of such sector-specific Climate Services should occur in co-production of IMN with sectoral users and respective scientific institutions. A sectoral User Interface Platform of the NCS can help to identify user needs from the road infrastructure sector. The close cooperation of IMN with relevant sectoral academic departments (e.g. LANAMME, CIVCO/TEC) but also with expert institutions like CFIA may help to develop sector-relevant climate information products.

Recommendation 9

Development of a technical guideline for the use of climate information for decision-making within infrastructure planning processes of the road infrastructure sector (=> UIP)

A technical guideline for the use of climate information for planning processes in the road infrastructure sector will determine the type, extend and quality of climate data which is supposed to be used for specific planning and implementation steps. Such a guideline would support a standardized use of climate information and thus guarantee transparency and quality of climate risks and their anticipation in road infrastructure planning processes. IMN as central stakeholder and coordinator of the NCS, MINAE and MIDEPLAN as line ministries in cooperation with CONAVI as potential sectorial champion and CFIA as technical expert may be in charge for such guidelines. If necessary, other ministries which are possibly affected by this topic may be involved (e.g. ministry of finance).

Recommendation 10

Development of trainings on the use of climate information in sectoral contexts (=> UIP)

Trainings and workshops on the use of climate information and their application in a sector specific context and decision-making will increase the usability of climate information products. The need for such trainings is explicitly expressed by sectoral stakeholders and will increase the impact of climate information on decision-making. Target groups for such trainings are intermediates and end-users of the road infrastructure sector. Such training concepts can be an output of a User Interface Platform. IMN as central stakeholder and coordinator of the NCS in cooperation with CONAVI as potential sectorial champion may be in charge for the development and implementation of such trainings.

3 Organisational level

Recommendation 11

Enhancement of the monitoring system especially for hydro-meteorological events (=> OM)

Regarding climate risk assessments for the infrastructure sector the information on relevant hydro-meteorological events is essential. Efforts and investments for the enhancement of monitoring systems by IMN should concentrate on such events. This may imply the increase of the spatial and temporal coverage of climate observations by climate stations as well as the operation of alternative monitoring systems (e.g. radar system).

Recommendation 12

Enhancement of the national climate observation system (=> OM)

High quality and comprehensive historical climate time series of sufficient length are essential for any climate risk assessment. They are the basis for hazard identification and development, calibration and interpretation of climate projections. The enhancement of climate observation systems (climate stations, radar, satellite, etc. dependent on budget and opportunities) especially regarding precipitation is always beneficial. Many regions of Costa Rica are insufficiently covered by climate observations (Figure 7). It is recommended to IMN to increase the spatial coverage by the installation of additional climate stations. Referring to hydrological hazards and events, which are key for the road infrastructure in CR, the hydrologically relevant location or re-location of climate stations should be considered (also consider R2).

Recommendation 13

Review of the data management, data archiving and data quality control systems (=> CSIS)

High quality and comprehensive historical climate time series of sufficient length are essential for any climate risk assessment. Besides the observations, the adequate management of this is of fundamental relevance for the provision of qualitative Climate Services. It is recommended to IMN to keep these systems up to date and thoroughly maintain and optimize them when possible.

Recommendation 14

Development of an effective and transparent purchasing system (=> CSIS)

The current purchasing procedure of climate data and information from IMN is perceived by users from the road infrastructure sector as intransparent and time-consuming, which is a major reason for the limited use of climate information. It is recommended to review this procedure and newly design it in order to become more transparent regarding fees and more efficient regarding access and timely availability of climate information products. Similar as in the context of the UIP, organizational structures and processed should be reviewed regarding their potential for more efficiency in order to get a better output with prevalent capacities (5.4).

Recommendation 15

Review of organizational structure of IMN

Many challenges identified and discussed in this report refer to limited capacities regarding staff and technical equipment. However, existing capacities may often be sufficient for many tasks if organizational structures and processes are reviewed regarding their efficiency. These were not analyzed within this assessment and a statement on the potential of such measures cannot be provided at this point. However, a detailed analysis of organizational structures and processes is recommended especially within the Information Department in the context of the development of a UIP but also for the provision of user-tailored Climate Services.

4 Individual level

Recommendation 16

Training on user-interaction at IMN

The identification of user needs for climate information is key for the provision of user specific climate information that has an impact on decision-making. A lot of existing climate information products might be much more useful and usable for decision-makers if IMN-staff understands the context of use of the demanded climate information as well as the type of user and his specific demands. Up to now this process is not structured and relies on the experience of individual staff members and is often elaborate, timely and often unsuccessful. In order to make this process more efficient and products more useful and usable for decision-makers, staff members from the Information Department should be trained in structured methods regarding user interaction and assessment of user demands. This recommendation is concurrent to R9.

Recommendation 17

Training on the handling of GCMs and RCMs as well as on the processing of model outputs

Information regarding climate change and its consequences is key for decision-makers who are involved in the planning of road infrastructure projects as well as other infrastructures. This information needs to be tailored to the context of the specific sector or risk; both, regarding the technical configurations (e.g. information content, scale, etc.) but also regarding support and advice in order to make this information usable for the decision-makers. The provision of such information is very elaborate and timely. Currently, IMN has only one person who has the capabilities to handle these models as well as the model outputs. It is recommended to train additional staff in handling RCMs and in processing model outputs in order to be ready to meet the user needs for tailored information on climate change impacts and consequences.

View of Ruta Nacional No. 1 in Grecia de Alajuela.

X Outlook

The establishment of a National Climate Service (NCS) for the context of the road infrastructure sector is the key recommendation of this baseline report. The recommendations above provide specific ideas on how such a NCS might be implemented based on the current institutional and organizational structure of climate service provision for the road infrastructure in Costa Rica. All recommendations are given specifically for the road infrastructure sector. However, as long-term objective, a NCS of Costa Rica should cover the needs of all relevant sectors. Similar sectorial champions can be established for other sectors getting an equivalent mandate for the respective sector. However, this would involve the coordination of several sectoral champions with key stakeholders of climate information provision (IMN) as well as key intermediate stakeholders who provide inter-sectoral information (hydrological information and hazard information (CNE)). In order to realize a comprehensive inter-sectoral NCS, the transfer of the recommendations for the road infrastructure sector to other sectors in Costa Rica should be considered and their feasibility assessed. The presented and recommended organizational model of a NCS should be discussed in the future in order to guarantee a successful and sustainable impact of technical and educational capacity development measures geared towards enhacing climate information provision on the use of sectoral stakeholders and the impact on decision-making.

The provided recommendations align to the concept of the GFCS and attempt to transfer this concept to the specific context of Costa Rica. The GFCS envisions a central role for the NMHS within the NCS based on the assumption that the NMHS is integrated in the governmental service structure. However, national governance structures may not always allow the implementation of all of the elements of the GFCS as they stand in the context of the specific country. E.g. the envisaged role of individual stakeholders may not be realized due to various structural, juridical or other reasons. Consequently, roles and responsibilities of NCS stakeholders, the regulating framework and scope of the NCS and as well as the characterization of specific operational processes and the nature of agreements between stakeholders need to be negotiated and adjusted to the national conditions.

Literature

Sewer entry head under National Route No. 317 in Pedernal de Puriscal, province of San José.

Alvarado L. F., Contreras, W., Alfaro M. & E. Jiménez (2012): Escenarios de cambio climático regionalizados para Costa Rica. Technical report for MINAET, San José, Costa Rica.

BELSPO (2014): Survey Climate Services Users (www.belspo.be/survey/climate).

Bessembinder, J. et al. (2012): Guidance to support the identification and assessment of users' requirements. (www.climate-services.org/wp-content/uploads/2015/05/jpi2012_assessment_of_users_requirements.pdf).

Comisión Nacional de Emergencias (CNE) (2017). Plan General de la Emergencia ante la Situación Provocada por el Paso del Huracán Otto Por Territorio Costarricense. San José, Costa Rica.

Costa Rica 2009: Segunda Comunicación Nacional a la Convención Marco de las Naciones Unidas sobre Cambio Climático Primera Edición 2009.

Daly, M. et al. (2016): Establishing a baseline for monitoring and evaluating user satisfaction with Climate Services in Tanzania. CICERO Rapport 2016:02, Oslo, Norway. (https://brage.bibsys.no/xmlui/handle/11250/2382516).

European Union (2015): A European research and innovation Roadmap for Climate Services. Luxembourg. (https://publications.europa.eu/en/publication-detail/-/publication/73d73b26-4a3c-4c55-bd50-54fd22752a39/language-en).

GIZ (2015): Capacity Works. Cooperation Management for Practitioners. Springer-Gabler. ISBN 978-3-658-07904-8.

IMN & CRRH (2008): El Clima, su Variabilidad y Cambio Climático en Costa Rica. San José, Costa Rica.

IMN Website (www.imn.ac.cr/inicio) (03.07.2018; 13:22)

IPCC (2000): Emission Scenarios. Summary for Policymakers. IPCC Special Report. (www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf)

IRI (2012): Climate Services for Climate-Smart Development – a preliminary guide for investment. Technical Report for USAID, Washington, US. (www.climatelinks.org/sites/default/files/asset/document/Climate.Services.for_.Climate.Smart_.Development.Guide_.for_.Investment-final.pdf).

Mesalles R.P., Diaz E.V., Ramírez, R.S. and E.R. Calderón (2014): Evaluación de la vulnerabilidad y adaptación de infraestructura ante el cambio climático. ProDUS – UCR informe 2014:04, San José, Costa Rica.

MIDEPLAN & MAG (2013): Sistematización de la Información de Impacto de los Fenómenos Naturales en Costa Rica, Período 2005--2011. San José, Costa Rica.

MINAE (2015): Costa Rica's Intended Nationally Determined Contribution. San José, Costa Rica.

MINAE et al. (2018): Politica Nacional de Adaptación al Cambio Climático, 2018 - 2030 (www.pgrweb.go.cr/DocsDescargar/Normas/No%20DE-41091/Version1/Politica_ADAPTACION_24_abril.pdf)

OECD (2016): The role of government in making infrastructure investment climate resilient: draft survey of current practices. (www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC/WPCID(2016)2&docLanguage=En).

Richard Moss, Mustafa Babiker, Sander Brinkman, Eduardo Calvo, Tim Carter, Jae Edmonds, Ismail Elgizouli, Seita Emori, Lin Erda, Kathy Hibbard, Roger Jones, Mikiko Kainuma, Jessica Kelleher, Jean Francois Lamarque, Martin Manning, Ben Matthews, Jerry Meehl, Leo Meyer, John Mitchell, Nebojsa Nakicenovic, Brian O'Neill, Ramon Pichs, Keywan Riahi, Steven Rose, Paul Runci, Ron Stouffer, Detlef van Vuuren, John Weyant, Tom Wilbanks, Jean Pascal van Ypersele, and Monika Zurek, 2008. Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies. Intergovernmental Panel on Climate Change, Geneva, 132 pp.

The Tico Times (2017): UPDATED: Tropical storm causes deaths, flooding in Costa Rica and region. (www.ticotimes.net/2017/10/05/tropical-storm-causes-deaths-flooding-costa-rica-region)

The Costa Rican News (2017): Damage Caused by Storm Nate. (https://thecostaricanews.com/damage-caused-storm-nate)

WMO (2012): Guidelines on Frameworks for Climate Services at the National Level. Geneva, Switzerland. (www.wmo.int/gfcs/sites/default/files/events/Regional%20Workshop%20on%20Climate%20Services%20at%20the%20National%20Level%20for%20the%20LDCs%20in%20Asia/GuidetoClimateServicesattheNationalLevelFinalOctober2012.pdf).

WMO (2014a): Implementation Plan of the Global Framework for Climate Services. Geneva, Switzerland. (http://gfcs.wmo.int/implementation-plan).

WMO (2014b): Annex to the Implementation Plan of the Global Framework for Climate Services – Capacity Development. Geneva, Switzerland. (http://gfcs.wmo.int/CD).

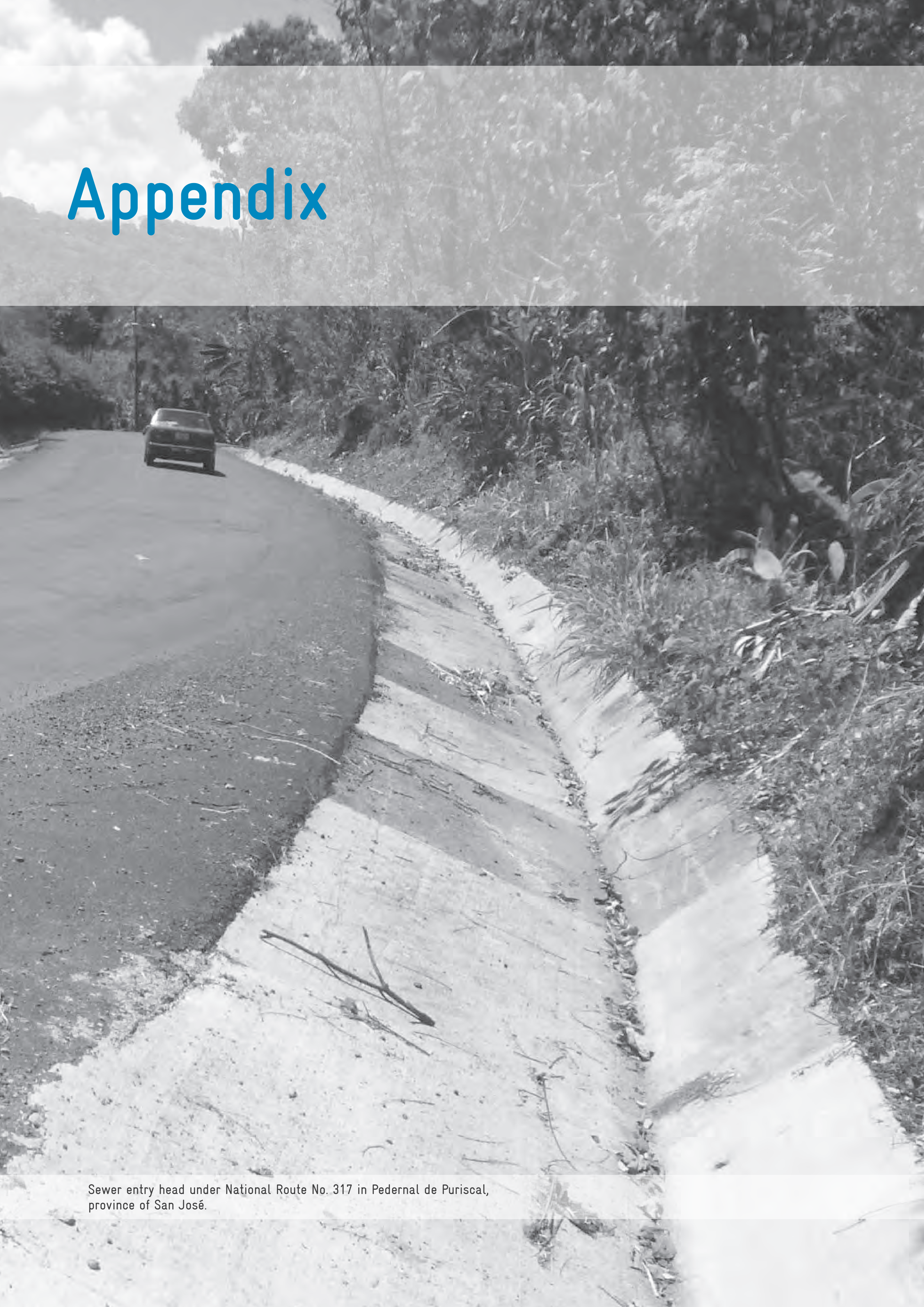
WMO (2014c): Annex to the Implementation Plan of the Global Framework for Climate Services – Climate Services Information System Component. Geneva, Switzerland. (http://gfcs.wmo.int/CSIS).

WMO (2014d): Annex to the Implementation Plan of the Global Framework for Climate Services – User Interface Platform Component. Geneva, Switzerland. (http://gfcs.wmo.int/UIP).

WMO (2018): Step-by-step Guidelines for Establishing a National Framework for Climate Services. Geneva, Switzerland. (www.wmo.int/gfcs//step-by-step-guidelines-nfcs).

WWC-3 (2009): Conference Statement – summary of the expert segment. Geneva, Switzerland. (http://gfcs.wmo.int/wwc_3).

Appendix



Sewer entry head under National Route No. 317 in Pedernal de Puriscal, province of San José.

Appendix 1 Global Climate Observing System climate monitoring principles

(Revised Reporting Guidelines as agreed by the UNFCCC at Bali, December 2007, decision 11/CP.13)

Effective monitoring systems for climate should adhere to the following principles:

(a) The impact of new systems or changes to existing systems should be assessed prior to implementation;

(b) A suitable period of overlap for new and old observing systems is required;

(c) The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves;

(d) The quality and homogeneity of data should be regularly assessed as a part of routine operations;

(e) Consideration of the needs for environmental and climate-monitoring products and assessments, such as Intergovernmental Panel on Climate Change assessments, should be integrated into national, regional and global observing priorities;

(f) Operation of historically-uninterrupted stations and observing systems should be maintained;

(g) High priority for additional observations should be focused on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution;

(h) Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation;

(i) The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted;

(j) Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

Furthermore, operators of satellite systems for monitoring climate need to:

(a) Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system;

(b) Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.

Thus satellite systems for climate monitoring should adhere to the following specific principles:

(a) Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained;

(b) A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations;

(c) Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured;

(d) Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured;

(e) On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored;

(f) Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate;

(g) Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained;

(h) Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on decommissioned satellites;

(i) Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation;

(j) Random errors and time-dependent biases in satellite observations and derived products should be identified.

Appendix 2 Hierarchy of national Climate Services (WMO, 2012)

Category 1: Basic climate data services and information products

Functions of a Category 1 capability include design, operation and maintenance of national observing systems; data management including QA/QC; development and maintenance of data archives; climate monitoring; oversight on climate standards; climate diagnostics and climate analysis; climate assessment; dissemination via a variety of media of climate products based on the data; participation in regional climate outlook forums and some interaction with users, to meet requests and gather feedback. All NMHSs should be able to function at the Category 1 level, i.e. performing the basic functions of a national climate centre. At present all but a very few NMHSs provide some measure of the basic Climate Services through their observing, archiving, data services and basic analysis capabilities. Optimally, climate service staff should be proficient in climate statistics, including basic homogeneity testing and quality assurance techniques, etc. They should also be capable of interpreting products provided by RCCs in order to place national/local conditions within a broader scale context.

Category 2: Essential climate data services and information products

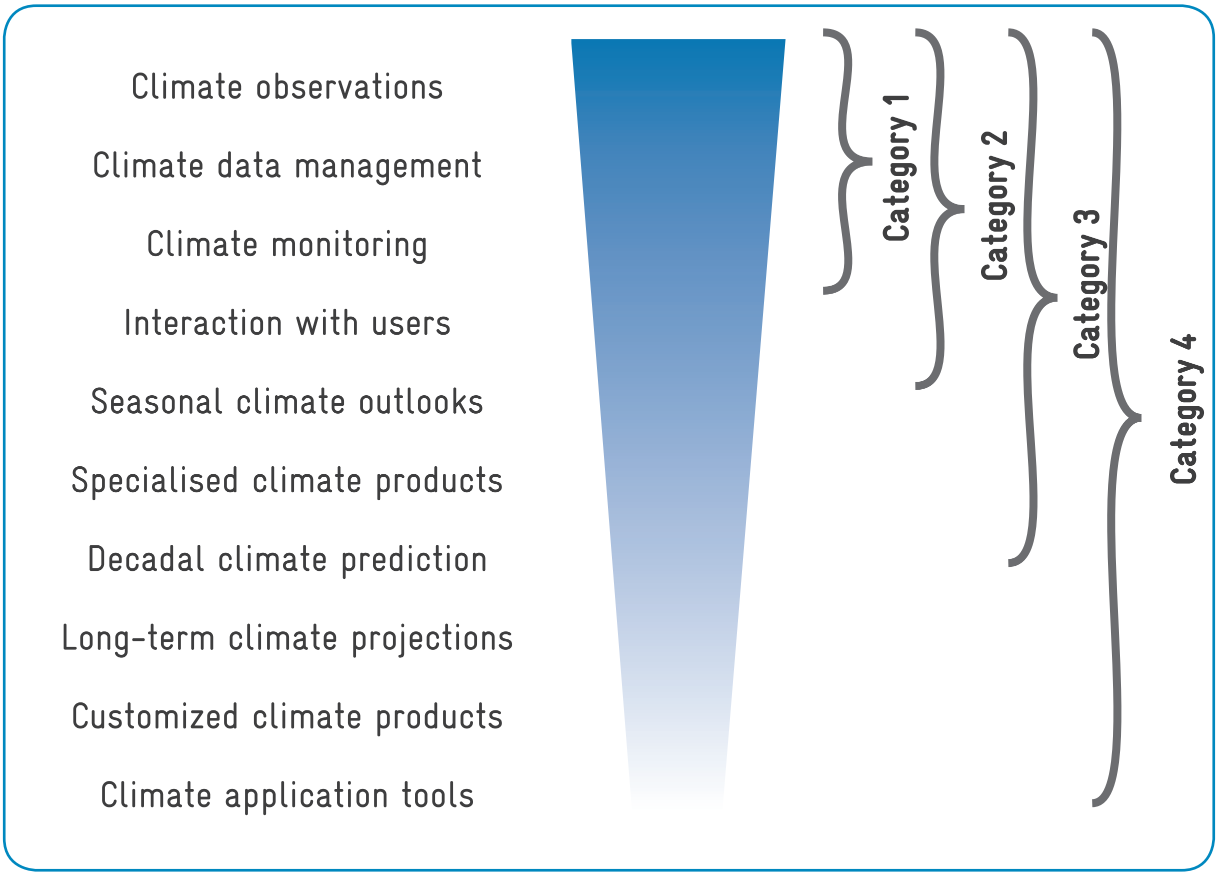
In addition to encompassing all Category 1 functions, Category 2 Climate Services should include the capacity to develop and/or provide monthly and longer climate predictions including seasonal climate outlooks, both statistical and model-based; be able to conduct or participate in regional and national climate forums; interact with users in various sectors to identify their requirements; provide advice on climate information and products; and get feedback on the usefulness and effectiveness of the information and services provided. A NMHS delivering Category 2 Climate Services would add value from national perspectives to the products received from RCCs and in some cases GPCs, conduct climate watch programmes and disseminate early warnings. Staff in category 2 NMHSs should be proficient in the development and interpretation of climate prediction products, and in assisting users in the application of these products.

Category 3: Comprehensive range of climate data services and information products

In addition to encompassing Category 2 services, organisations delivering Category 3 Climate Services would have the capacity to develop and/or provide specialised climate products to meet the needs of major sectors and should be able to downscale long-term climate projections as well as develop and/or interpret decadal climate prediction (as and when available). They would serve to build societal awareness of climate change issues, and provide information relevant to policy development and National Action Plans. NMHSs delivering Category 3 Climate Services would be capable of supplying climate information to all the elements of Climate Risk Management, and would include products supporting risk identification, risk assessment, planning and prevention, services for response and recovery from hazards. They could also supply information relevant to longer-term climate variability and change, as well as advice related to adaptation. A NMHS functioning at the Category 3 level would contribute to regional-level climate activities and could serve as a node in a Regional Climate Centre Network. Category 3 NMHSs would have staff with special knowledge in risk assessment and risk management, and who may have knowledge of financial tools for risk transfer.

Category 4: Advanced Climate Services

In addition to the ability to deliver Category 3 services, organisations delivering the Category 4 services would have certain in-house research capacities, and would be able to run Global and Regional Climate Models. They would be able to work with sector based research teams to assist them in developing applications models (e.g. to combine climate and agriculture information and produce food security products), and to develop software and product suites for customised climate products. NMHSs functioning at the Category 4 level could serve as a Global Producing Centre, a Regional Climate Centre or as a node in a Regional Climate Centre Network. Staff would have modelling and statistical expertise in a multi-disciplinary context, and would be able to downscale global scale information to regional and national levels. They would also be required to receive and respond to user requirements for new products.


Climate observations
Climate data management
Climate monitoring
Interaction with users
Seasonal climate outlooks
Specialised climate products
Decadal climate prediction
Long-term climate projections
Customized climate products
Climate application tools
Category 1
Category 2
Category 3
Category 4

Appendix 3 Product types

Product type	Examples & Definitions
Climate data	raw or processed station time series; gridded data: other data sets, etc.
Climate statistic products	information about means and extremes for individual parameters for a specific region and period in form of maps, graphs, etc.
Tailored climate data/statistics for specific purpose	climate statistic products for specific sectoral contexts (e.g. indices).
Data / statistics on hazardous climate events / extreme events	information on magnitude, frequency, duration of climate hazards; hazard information (e.g. hazard maps); etc.
Information on regional climate conditions	review and analysis in form of bulletins, synthesis reports, statements, etc.
Analysis and interpretation of climate statements or products for specific users/sectors	analysis of consequences of past and prevalent climatic conditions for specific sectors
Hydrological data / statistics and events	discharge, floods, low-flows, etc.
Data/statistics on climate impacts on terrestrial systems	impacts on ecosystems (vegetation etc.), geomorphological impacts (soil erosion, landslides, etc.))
Information/data on climate impacts/ consequences for specific sectors	information on expected crop yields, losses, costs, damage, disruptions or fatalities, etc. for various sectors like agriculture, transport, health, energy, etc.
Climate vulnerability/risk information in general or for specific sectors	data and information on exposures, sensitivities and possible consequences of regions, sectors to historical climate conditions (e.g. maps for specific sector/ region)
Climate forecasts/outlooks for specific parameters/events at various time scales	Climate predictions, projections or outlooks for upcoming weeks, months, years, etc.
Climate change projections	Climate model output (data/maps) for specific parameters, events, etc.
Climate change impact data/model outputs	Climate impact model output on ecosystems, water availability, etc.
Climate change vulnerability/risk information	data and information on exposures, sensitivities and possible consequences of regions, sectors to climate change conditions (e.g. maps for specific sector/ region)
Training, workshops, lectures and information material on climate issues, e.g. climate change and its impacts	qualitative information/education material to raise awareness; general or sector-specific
Tools which support decision-making, strategy development and financial planning	Decision-making-support systems which integrate climate information and provide recommendations for actions

Appendix 4 Product matrix

Guiding Questions (provider)	Climate product types						Guiding Questions (user)
	Processed climate data sets (historic)	Climate diagnostics (historic)	Climate monitoring (present)	Monthly/seasonal/decadal climate predictions	Climate change projections	Climate-related hazards	
Product-type specific attributes/ foci	Length, homogeneity, continuity and spatial coverage of time series		Data transfer from stations; data processing structures (temp. availability)	# used GCMs; # used RCMs; downscaling method (dynamical, statistical); capacity to run RCMs & make statistical analysis; co-operation/external access; skill/ uncertainty info		parameters (time, location, magnitude, frequency, duration, etc.); consequences; early warning;	
A1 Products: Which products do exist for this product type? • Parameter/statistical analysis/ indices/event • Spat./temp. scale/res. • Format • Periodical/occasional/on demand, standard/specialized							**A1 Specifications:** Which products have been used (past/currently) for your sector-specific context? Products of which product-type are required for your sector-specific context?
A2 Secondary products: do you make (sector-relevant) impact products/provider climate information for impact products (who is the user?)/cooperate with impact modelers? (e.g. hydrological information products, etc.)							**A2 Secondary products:** Which secondary (climate-impact) products have been used (past/ currently) for your sector-specific context? Secondary-products of which product-type are required for your sector-specific context?
B Sector-specific products: Are there tailored variations available for the sector of concern? Which products have been used/ may be of potential use for the sector of concern?							**B Sector-specificity:** Is the product specifically tailored for your sector/purpose? What are the characteristics of this tailored product? Do you have specific needs on tailoring?
C Data source & co-production: what is the data source for this product-type? Are there other organizations involved in providing/producing this data? What is the relationship to these organizations? (e.g. Universities, private companies, RCC/COF, WMO, external data)							**C Data sources & provider:** where is the data coming from? Which organizations provide the climate data/information? Are there 'intermediates' involved? What is the relationship to these organizations?

D User & value: Who are users of the product within the sector of concern? What is the specific purpose/context/decision-making for which the product is being used?							**D User & value:** What is the consequence/output of your decision-making? Are there other stakeholders who use this output/who are affected by this decision-making? What is the relationship?
E Services: are there any sector-specific services provided with this product with respect to dissemination (e.g. channel, format, access, timing & frequency of delivery) and guidance (e.g. support, training, advice and outreach, visibility)?							**E Services:** are there any specific services you receive with this product with respect to dissemination (e.g. channel, format, access, timing & frequency of delivery) and guidance (e.g. support, training, advice and outreach, visibility)?
F User-interaction: Are there specific interaction-characteristics with user(-groups) regarding the provision/development of this product-type? (e.g. meetings, fora, MoU, contracts, etc. for access, feedback, exchange)?							**F Provider-interaction:** Are there specific interaction-characteristics with your provider regarding the provision/development of this product-type? (e.g. meetings, fora, MoU, contracts, etc. for access, feedback, exchange)?
G Gaps and needs: what are the major gaps in providing sector-specific and usable products (e.g. capacity development)?							**G Gaps and needs:** what are the major gaps in using climate information products (e.g. access, knowledge, capacities, etc.)?

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