

A Guidance on how to interpret climate information for the assessment of climate risks

Example of the Cai Lon – Cai Be climate risk assessment (Vietnam)

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Abbreviations

AfDB	African Development Bank
ADIS	Ice Sheet Dynamics in Antarctica
ASMB	Antarctic Ice Sheet Surface Mass Balance
AOGCM	Atmosphere–Ocean General Circulation Model
BMU	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit
CRM	Climate Risk Management
CSIS	Climate Service Information System
CSI	Climate Services for Infrastructure
DWD	German Meteorological Service (Deutscher Wetterdienst)
ECV	Essential Climate Variable
GDIS	Ice Sheet Dynamics in Greenland
GDP	Gros domestic product
GIA	Glacial Isostatic Adjustment
GIZ	German Development Cooperation
GSMB	Surface Mass Balance of the Greenland Ice Sheet
GFCS	Global Framework of Climate Service
IKI	Germany's International Climate Initiative
IMHEN	Vietnam's Institute of Meteorology, Hydrology and Environment
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
NAP	National Adaptation Plan
NFCS	National Framework for Climate Services
NMHA	National Meteorological and Hydrological Administration
PIEVC	Public Infrastructure and Engineering Vulnerability Committee
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
SIWIRP	Southern Institute for Water Resources Planning
SIWRR	Southern Institute for Water Resources Research RCP
WHO	World Meteorological Organization

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Part I Overview of the methodology and the suggested structure



Floating market on the Mekong river, Chau Doc City, Vietnam.

Photo: ©GIZ/Thomas Imo/photothek.net; ti

1 Introduction

1.1 Background and objective

Every year, emerging economies and developing countries invest billions in long-term infrastructure projects. However, their plans often fail to take account of future climate change. This leads to high risks of damage and misguided investments that harbour potentially serious consequences for the economy and society. Many countries – amongst them Brazil, Costa Rica and Viet Nam – have now launched efforts to raise the resilience of their infrastructure, prioritising this as a target in their Intended Nationally Determined Contributions (INDC).

Known as Climate Services, user-oriented climate information and products (e.g. risk and vulnerability assessments) that enable public and private decision-makers to manage climate risks and opportunities form a major cornerstone for achieving this target. Many countries so far lack the institutional, technical and service-related conditions they need to set up and mainstream Climate Services in their planning procedures and regulations. Amongst the first international initiatives to take up this challenge is the Global Framework for Climate Services (GFCS) of the World Meteorological Organization (WMO).

The objective of Climate Services in the context of climate risk assessments is to empower decision-makers to assess the risk of climate for the infrastructure of concern in order to make decisions on adequate adaptation measures. However, climate information is mostly presented in a very technical way, which is often not understandable for non-climatologists and thus of limited use for decision-making. Climate information is often perceived as black box and results are taken for granted without being challenged, despite the existence of partly significant uncertainties. Thus, the objective of this guidance is to approach this problem and provide suggestions on how climate information should be presented to decision-makers in order to support adequate decisions regarding the assessment of risks.

1.2 Scope

The guidance implies a review process of climate information that is provided within a technical report like a risk assessment report. The guidance provides a structure on how climate information should be presented in a user-friendly way. ‘User-friendly’ refers to the usability of the climate information for the risk-assessment team in order to make best possible decisions on the assessment of risks for the specific infrastructure of concern. Hence, the guidance is to be understood as an accompanying piece to a risk assessment report itself and addresses the risk assessment team, which comprises decision-makers (users), intermediates (value-adders) as well as climatologists (providers) of climate information.

Specifically, this guidance provides the reader with answers to the following questions:

- 1. What Climate Services are needed for climate-proofing infrastructure projects?** One challenge often faced by decision-makers seeking to climate-proof their infrastructure is to know what information they need. By showing the information used in the case of the Cai Lon – Cai Be project and the process for arriving at the information, this Guidance will allow decision-makers to get a better idea of what they need and how to get it.
- 2. How were the Climate Services developed?** By giving insight into the process of developing the Climate Services, the idea is to make it easier to replicate the process in the future. This way, it helps decision-makers to mature in the sense that they get a better understanding of how to obtain the information they need. It also helps to understand better what are causes behind uncertainty and how uncertainty may be reduced in the future.
- 3. How and for what purposes can they be used?** Part of a Climate Service is receiving guidance on for what purposes and how the information provided can be used. One key element of this is understanding the uncertainty that comes with the infor-

mation and what it implies for the conclusions that can be drawn from it for the specific context of concern.

4. **How may Climate Service communication be enhanced in the future to make them more usable and thus more effective?** It being a pilot risk assessment, there were not yet any standardized procedures in place for developing the Climate Services. The focus is mostly put on the technical development of the required services (struggling with low quality or even lacking data) neglecting the aspect of information communication in order to make it usable. Based on the experiences from the assessment, options are presented on how the process may be further streamlined in the future.

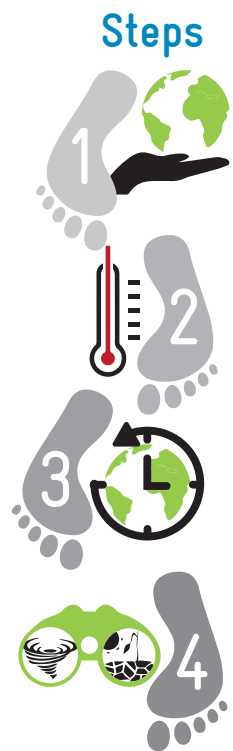
1.3 Structure

In order to provide the reader with guidance towards how to present climate information in a more user-friendly way and thus attain a better assessment of risks, this document has been structured in the following way.

Chapter 2 entails information about the two opposing approaches for assessing climate risk and their implications on climate information. This is followed by a sub-chapter describing the development of climate information **subdivided in 4 steps** as well as the main uncertainties within each step. Along each of the 4-steps, sub climate products are developed. To enhance the user-friendlier presentation of those sub products,

Chapter 3 suggest a methodology built upon a 7-steps procedure for each of the 4-steps. General recommendations are also given in this chapter.

Finally, for a better understanding of the methodology, the procedure for each of the 4-steps has been exemplified by applying it to the risk assessment for the Cai Lon – Cai Be sluice gate project in Vietnam.



Houses on the banks of the Mekong river in the Kien Giang province, Vietnam.

Photo: ©GIZ/Thomas Imo/photothek.net; ti

2 Conceptual background

2.1 Challenges for the integration of climate information into risk assessments

The main challenge of integrating climate information into risk assessments are opposing approaches for assessing climate risks and adaptation options and its implications for the design of climate information products. The two main categories of approaches are commonly depicted as ‘top-down’ and ‘bottom-up’ approaches, which refers to the sequence of steps needed to develop adaptation and disaster risk management plans Figure 1. The ‘top-down’ approach has the opening question: “what if climate extremes change according scenario x, y, z?” and thus starts with the analysis of relevant climate changes and then following the impact-chain downwards assessing relevant impacts and design and assess adequate adaptation options. This classic approach is commonly applied in most climate change research activities and thus for the development of climate information products. The portfolio of climate change information products is characterized by classic climate parameters and indices (e.g. ECVs) which have a broad applicability and a high quality. In contrast, small-scale parameters and phenomena which cannot be resolved by the climate models and do not provide sufficient quality are neglected.

In contrast: the ‘bottom-up’ approach starts with the question: “where are the sensitivities, thresholds, and priorities considering climate variabilities?” and thus follows the impact-chain backwards (upwards). Bottom-up approaches start on the level of decision-makers and are per definition tailored to the user’s specific context. They are thus very useful for the identification and prioritization of specific coping and adaptation options. However, the climate information required for this approach also needs to be tailored to the specific context reflecting individual critical climate conditions and thresholds. Standard climate projections provided by the climate research community are often not available at the scales relevant for the decision-maker; they are often not applicable for the specific purpose of the decision-maker and do often neglect current risks from natural climate variability and from non-climatic stressors as well as key uncertainties along with their implications for decision-making on adaptation.

The consequence is, that for climate risk assessments that are based on a bottom-up approach (like the PIEVC protocol) the individual tailoring and contextualization of climate information is required in order to make them useful for specific contexts. Furthermore, guidance on the interpretation of non-perfectly suitable climate information and the handling of partly high uncertainties is necessary to make the information usable for decision-makers.



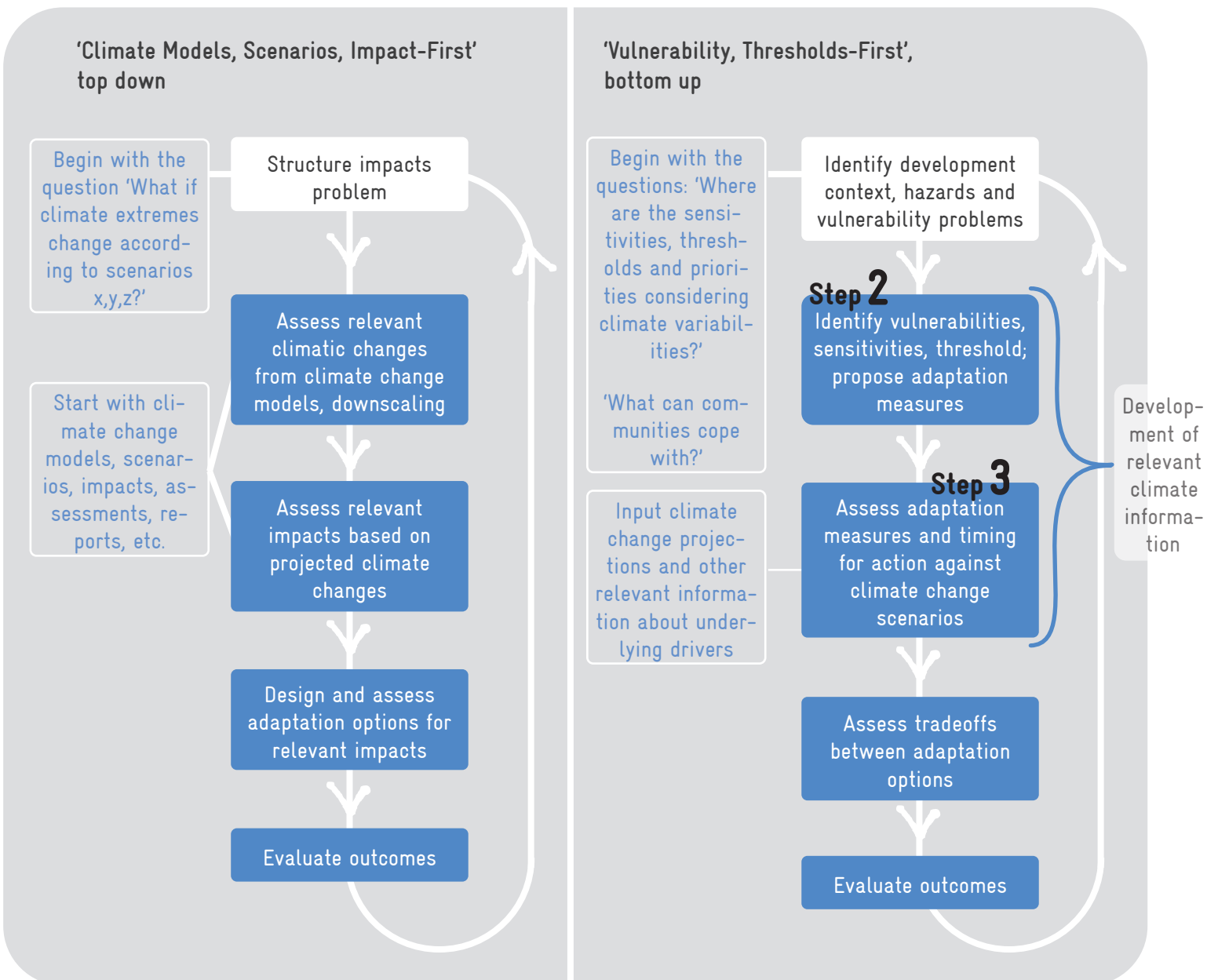
2.2 Development of climate information products – 4-step approach

The climate risk assessment for specific objects commonly follows a bottom-up approach (Figure 1 right side). The development of relevant climate information

products for the risk assessment occurs parallel to these steps. In general, this process can be aligned to step 2 and 3 in Figure 1.

Figure 1

Top-down and bottom-up approach. Top-down scenario (left panel) and bottom-up approach (right panel) – comparison of stages involved in identifying and evaluating adaptation options under changing climate conditions (IPCC-SREX 2012)





**Cai Lon – Cai Be
sluice gate.**

Photo: ©GIZ/Ngoc Nguyen Thi Minh

Going into detail, the process of climate information development can be subdivided in 4 steps which are detailed in Figure 2.

Figure 2
4-step-approach of climate service development for climate risk assessments in the context of a bottom-up approach.





Step 3

Historic climate analysis

Climate information product

The key product is a time series of observed values of the identified climate-related parameter for the locality or region of interest. The time series is often provided as graph accompanied with text that highlights key results, which are provided by the figure and relevant for the context of analysis as well as information on uncertainty. If appropriate, information is provided on trends and incremental changes to the baseline.

Purpose

The analysis of observations of the identified climate-related parameter has a twofold purpose: (i) past and current exceedances of identified climate-related thresholds (step 2) can be assessed which helps to relate and assess the probability of projected threshold exceedances; (ii) historic time series allow the analysis of observed trends and the conduction of sensitivity analysis, which help to assess future developments of the climate parameter (step 4).



Step 4

Future climate analysis

Climate information product

The key product are climate projections. The output is mostly provided in form of maps or in form of diagrams (box-plots) for specific regions or individual stations. Information on future occurrence is provided for a specific time slice (near future, mid future, far future) and specific scenario. Results are provided as value ranges referring to the results of the individual model-chains (members) of the ensemble. If no (useful) projections are available, trends of time series (step 3) may also provide some indications on future developments of the critical climate event.

Purpose

The information on future occurrence of critical climate events is the key information for a climate risk assessment. Decision-making regarding climate adaptation measures mainly refer to this information: (i) this climate information indicates if climate adaptation is necessary at all and (ii) which levels of types of adaptation need to be considered referring to the degree and certainty of changing occurrence of critical climate events.

2.3 Cascade of uncertainties

The provision of climate-related information is always accompanied by uncertainties. The emergence of uncertainties in climate information has various sources and can be referred to the individual steps of climate information generation Figure 3.



In **step 1** uncertainties mainly refer to the incomplete description and characterization of vulnerabilities. Besides incomplete process understanding (which refers to the current state of research) the main reason for the emergence of uncertainties within this step is an undervaluation of this assessment process.



In **step 2** uncertainties refer to a mismatch of impact threshold and actual impact as well as a mismatch of climate threshold and impact threshold. Main reasons for the emergence of uncertainties are missing quantitative thresholds that require more elaborated impact analysis, which is

limited due to non-existent or non-accessible impact data. However, a second major reason is a lack of effort that is put into the assessment of such thresholds, which is interlinked with the characterization of vulnerability (step 1).

In **step 3** uncertainties mainly refer to missing and/or low quality observation data. However, also the type of analysis of the existent data, which is often not as issue orientated as possible (e.g. threshold analysis) as well as the presentation of the data and results contribute significantly to uncertainty.

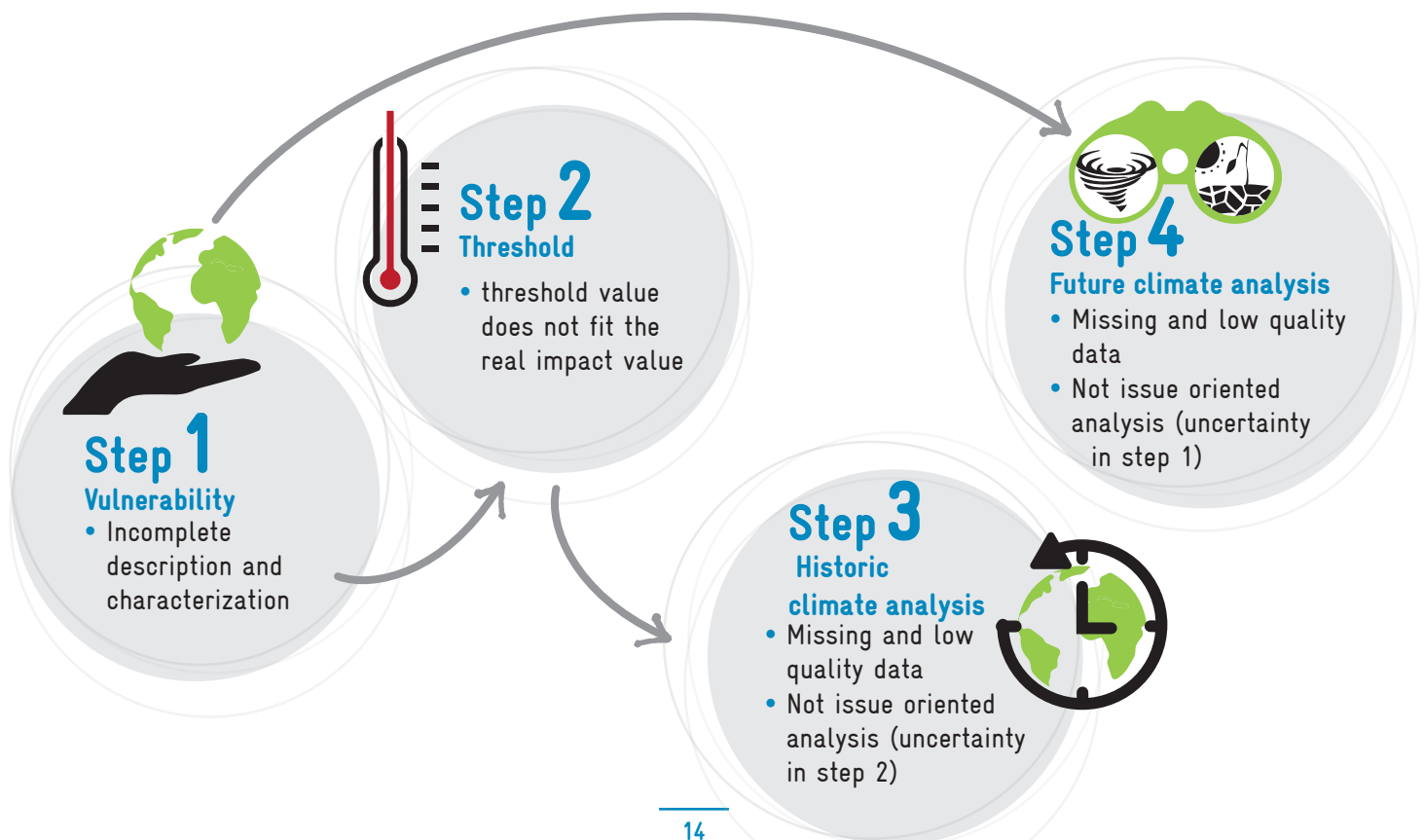


In **step 4** uncertainties mainly refer to missing and/or low quality projection data. Also in this step, a better tailoring (i.e. selecting threshold-related parameters and methods of analysis) and communication would help to limit uncertainties. This, however, requires a good characterization of the vulnerability as well as a well-developed climate service provider that is able to tailor climate information.



Figure 3

Overview of the uncertainties within each step. Arrows indicate the cascade of uncertainties.



In summary it can be concluded that whilst many uncertainties refer to missing or low quality data, major uncertainties can be avoided or minimized by issue-oriented analysis of existing climate data, a smart and vivid presentation of climate information as well as a thoroughly conduction of step 1 and 2. The latter are even considered as key since the characterization of vulnerability is basis for the identification of the relevant threshold values, which is in turn the reference for analysis of any climate data. Thus, uncertainties that emerge within step 1 and 2 are uncertainties that refer to the accuracy of the entire climate risk assessment

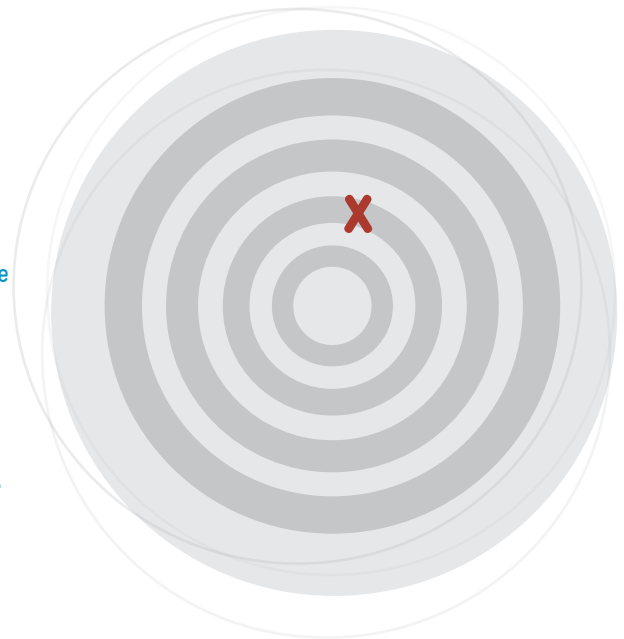
(i.e. defining the target) Figure 4. In contrast, uncertainties that emerge within step 3 and 4 are uncertainties that refer to the precision of the analysis (i.e. trying to hit the target continuously). Consequently, perfect (i.e. highly precise) climate data is of little use if the target is not well defined. However, uncertainties in the definition of the target are less dependent on climate data but on the effort and expertise that is involved in this process. Thus, uncertainties (and hence the usability of climate information) can be significantly enhanced by valuing the processes of vulnerability characterization and threshold determination.

Figure 3

Overview of the uncertainties within each step. Arrows indicate the cascade of uncertainties.

Info box on the definition of accuracy and precision:

The dart game is about precision and accuracy. To win the game you select your target regarding the demands of the game (e.g. to make many points as possible you might want to select "triple twenties"). Selecting an adequate target refers to "accuracy". Furthermore, you want to hit the target as frequently as possible. The more often you hit the target the more "precise" are your throws. If you, for instance define your target wrong (e.g. by selecting the bulls eye), you will fail to attain the aspired goal (to make as many points as possible), even if you throw precise. Whereas accuracy is the first step towards reaching the goal, hitting the target is also a condition to win the game. Even when the target is well defined (as in the dartboard), it is also possible to miss the target due to low precision of the throws.



3 Methodology for a structured presentation of climate information

3.1 Scope

The basic assumption of this guidance is that there are always, no matter how good the data basis, unavoidable uncertainties in climate data and information. Thus, in order to make this imperfect information useful and usable for decision-maker, uncertainties need to be highlighted and accompanied with relevant information and guidance in order to support interpretation and contextualization.

3.2 Procedure

The guidance implies a review process of climate information provided within a technical report like a risk assessment report. Hence, the revision of the climate information products refers to the presentation and communication of this information in a user-friendly way. The user-friendly presentation comprises relevant explanation of graphs and figures as well as adequate documentation and communication of uncertainties and data quality. Furthermore, a contextualization of the climate information and its uncertainties is provided, which enhances the interpretation of the climate data for the specific issue. The provided contents are not being challenged, i.e. it is assumed, that the provided climate information is the best possible information that is available and achievable in the assessment context. Consequently, no new analysis has to be done and no additional data has to be collected. Only existing material is supposed to be used and restructured according the guidance's structure. If applicable, existing information can be visualized in an appropriate way that implies the generation of new figures. Furthermore, complementing interpretation of existing data can be done if required.

Additionally, guidance information on the purpose and characteristics of provided information is given as well as recommendations on enhancing the communication of climate information for better interpretation and thus decision-making.

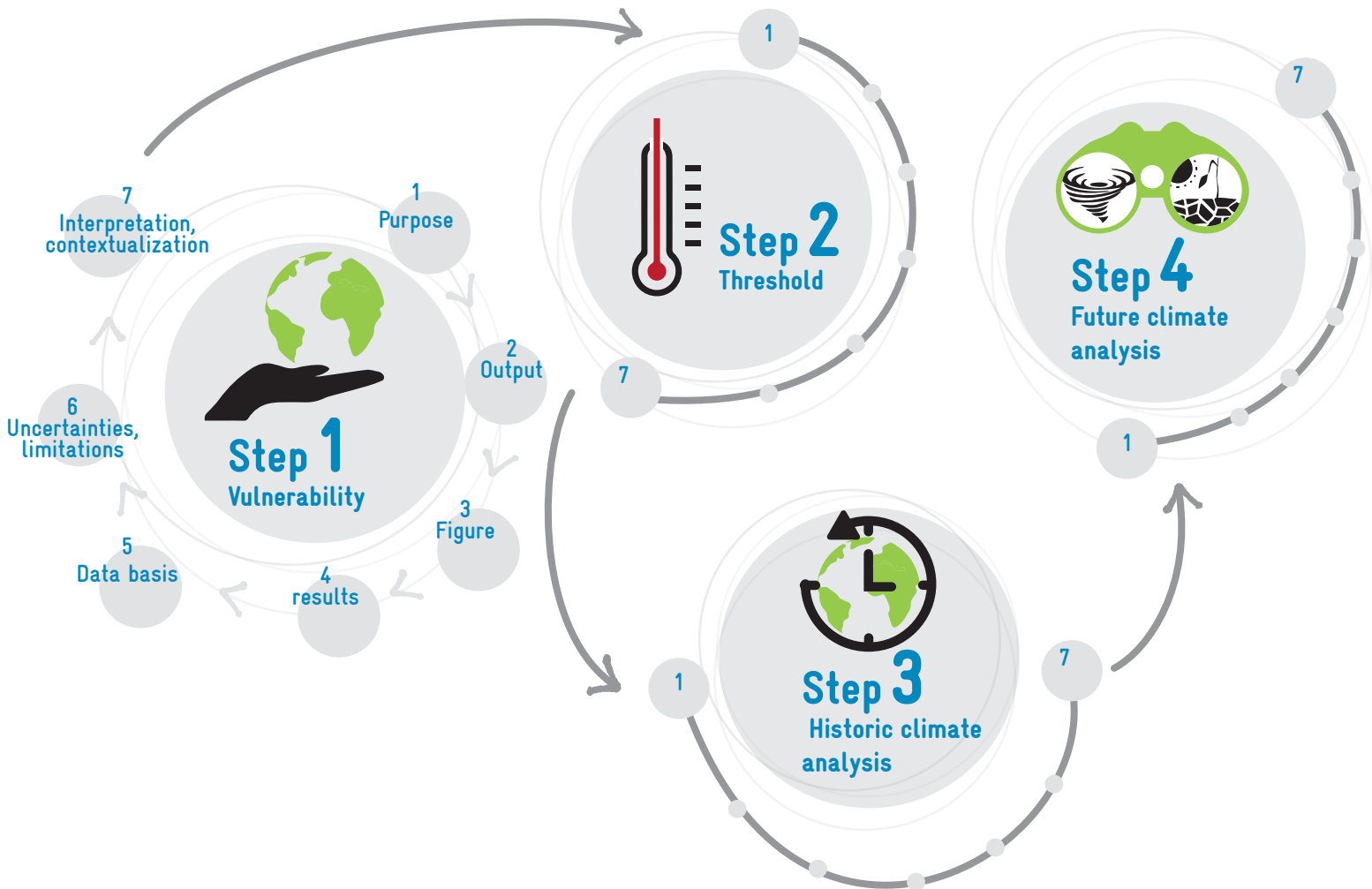
3.3 Structure

Climate information products are generated within a 4-step approach as outlined in Figure 2. For each step, an individual (sub-)product is generated. In order to provide a comprehensive synthesis of the (sub-) products with all relevant information the following structure of product presentation is suggested below. A visual representation of the structure within each step is illustrated in Figure 5.

1. Purpose (What is the added value of this this information?): the purpose of the presented product is briefly described. This information helps the user to classify the provided information and to see the added value for his specific context.
2. Output (What can be expected from this information?): the scope of the product's output is briefly defined and delineated. This helps the user to assess what he can expect from the product in terms of information and check the completeness of the provided information.
3. Figure (The figure - what does it show and how to read it?): a figure or graph displays the results of the (sub-) product. Accompanied text explains the content of the figure and how to read it. A figure or graph enhances the tangibility of the results and reveals the entire data volume. This enables the user to reconstruct conclusions on the results and empowers him to make his own conclusions.
4. Results (The facts - what information is at the bottom of the figure?): key results of the product that are displayed within the figure are extracted and formulated in text form. This guarantees a misinterpretation of the figure by the user or rather provides an agreement on the results.

Figure 5

The structure of the project presentation within each step. Throughout each of the four steps climate products are developed. Thus, to enable decision-makers a better understanding of the information, limitations and opportunities of the climate products developed, the following structure was elaborated



- 1 Purpose** > What is the added value of this this information?
- 2 Output** > What can be expected from this information?
- 3 Figure** > The figure - what does it show and how to read it?
- 4 Results** > The facts - what information is at the bottom of the figure?
- 5 Data basis** > Trust, but verify...! - what are the ingredienst?
- 6 Uncertainties & limitations** > Watch out!
- 7 Interpretation & contextualization** = So what? - what does it mean?

5. Data basis (Trust, but verify...! – what are the ingredients?): the data basis and methodical steps of product development are made transparent. This provides trust and empowers the user to assess the plausibility and robustness of the results as well as assumptions done by the information provider.
6. Uncertainties & limitations (Watch out!): limitations in data quality, data availability and completeness of information (output serves as reference) as well as uncertainties related to the results are explicitly outlined. Transparency on data and information enables the user to make an adequate interpretation of the data, to assess information robustness and to reconstruct assumptions made by the information provider.
7. Interpretation & contextualization (So what? - what does it mean?): concluding statements are formulated (explicit assumptions) or derived (implicit assumptions) regarding the vulnerability context based on the prevalent results and uncertainties. Such conclusions help the user to contextualize the results regarding the specific vulnerability of concern.

A summarizing chapter provides an overview on the interpretation of the climate information as well as a summary and assessment of uncertainties.

The presentation of the climate information is accompanied by comments that explain content added to the individual sections especially regarding “uncertainties” and “interpretation and contextualization”. The comments also comprise guidance and background information for the presentation of specific information content in order to enhance the usability in terms of understanding, transparency and credibility. This can be visualized in chapter 4 when applying the guidance to the case Cai Lon – Cai Be.

3.4 Added-value and recommendations on implementation

The benefit of this format of presentation of climate information is a better understanding of the climate information, how it is generated, its meaning and relevance for the analysed vulnerability of concern and thus for the assessment of risks and the identification of adaptation options. It furthermore enables the evaluation and prioritization of uncertainties as well as their consideration for the interpretation of the climate information.

The case-study in chapter Error! Reference source not found. can be understood as template for the implementation of the suggested structure for the presentation of climate information. However, some general recommendations, which also go beyond the presentation of climate information but address the assessment process as such, are summarized in order to enhance the generation of useful and usable climate information products:

R1 – Conduct the process of vulnerability characterization very thoroughly

A well-defined vulnerability is the basis of the entire risk assessment and determines the quality and usability of the climate information to be developed. Take sufficient time and integrate comprehensive expertise in order to describe and characterize the vulnerability in detail. This also demands the explicit identification of an impact (how is the undesired situation characterized?) and its consequences (for infrastructure safety, operation, functionality and dependent systems) as well as the characterization of critical climate conditions (just identifying the climate variable is not enough).

R2 – Make a quick assessment of criticality as well as of adaptation options of each vulnerability

If a component emerges as not significantly critical for the safety and functionality of the infrastructure itself as well as for dependent neighbouring systems, from a further consideration of this component in the risk assessment can be desisted. This saves time and resources. The characteristics of potential adaptation options determine the lead-time of the decision (when do I need to know about critical climate conditions in order to be able to cope with it?) and thus the characteristics of the climate information. If the implementation of a possible adaptation option requires relatively short lead times the demand on climate projections is less significant.

R3 – Visualize the results from vulnerability characterization and threshold identification

Thresholds are the fundamental reference for the analysis of the climate data! Rework the results in a graphical format in order to enable the reproduction and check of completeness and plausibility of cause-effect relations. Identify and characterize remaining uncertainties as detailed as possible.

R4 – Document uncertainties and make explicit assumptions

Unknown uncertainties make an adequate interpretation and contextualization of climate information difficult. Therefore, uncertainties should clearly be named, documented and justified. This especially refers to (i) the use of surrogate values or analysis methods, (ii) factors or data sets, which were not considered in the analysis; as well as (iii) deviations from standards (best practices) in climate data processing. Indications on the consequences of these uncertainty on the context of interpretation are always recommended!

Where are uncertainties there are assumptions. Always try to make these assumptions explicit in order to avoid non-plausible conclusions (implicit assumptions) by the user. The formulation of assumptions help to check their plausibility.

Transparency (of uncertainty) provides trust, which is a basic criterion for the usability of climate information.

R5 – Provide sufficient description of graphs and results

In the context of a climate risk assessment, climate information always has a specific purpose and is no independent and stand-alone product. Always try to tailor the type of analysis and mode of visualization as well as highlight of results to the context of analysis. Provide sufficient description of the graph and its elements so that it can be well understood also by non-climatologists (non-scientists). Regard a uniform format of presentation of climate data regarding units and scenarios (time slices) in order to make them comparable. If required, provide extra guidance (by text of graphs) to understand the benefit of the provided climate information for the specific issue.

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K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

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Kien Giang An Giang.

Photo: ©GIZ/Katharina Lotzen





**View of the Mekong
at Can Tho, Vietnam,**

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**Part II Implementation
of the guidance:
Example from the
Cai Lon – Cai Be
climate risk
assessment (Vietnam)**

1 Introduction

1.1 Background

Like all countries around the globe, Vietnam is facing an infrastructure gap. This even though the country is allocating considerable funding to infrastructure investments. Following the medium-term public investment plan (Resolution No. 26/2016/QH14), 2 M billion VND of the state budget are available for infrastructure investment between 2016 – 2020, equivalent to 400,000 billion VND or USD 20 billion per year (around 9 % of GDP). Though already considerable, this funding will only meet 30 % of the investment needs of ministries and localities (MPI (2020)).¹ At the same time, Vietnam is one of the countries more vulnerable to climate change where disasters and extreme events caused direct losses of around 1.5 % of GDP each year for the last 15 years.²

If infrastructure in Vietnam is to remain a pillar of success and economic development, it will be necessary to make it more resilient towards climate change. This means funding for climate change adaptation efforts is needed to climate-proof infrastructure and make society and economy more resilient. Part of this is finding the right tools and information that help identify and prioritise the most effective and efficient ways for mitigating climate risks.

1.2 Making Infrastructure in Vietnam Climate Proof

Vietnam is working with the global project Enhancing Climate Services for Infrastructure Investments (CSI) to climate-proof its infrastructure. CSI is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in cooperation with the German Meteorological Service (DWD) and Engineers Canada. The project is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) as part of the International Climate Initiative (IKI). In Vietnam, CSI works with the Ministry of Planning and Investment (MPI), Ministry of Agriculture and Rural Development (MARD) and the Ministry of Natural Resources and Environment (MONRE) to make better use of tailor-made climate information and climate risk assessments (i.e. Climate Services) for the planning and management of infrastructure.

¹ <http://www.mpi.gov.vn/en/Pages/tinbai.aspx?idTin=41648&idcm=128>
<https://ashui.com/mag/chuyenmuc/nang-luong-moi-truong/14147-co-so-ha-tang-lan-tang-de-chong-bien-doi-khi-hau.html>

² <https://vietnamnews.vn/environment/376860/disasters-a-threat-to-vn-development.html>

Part of this cooperation was piloting a climate risk assessment for the Cai Lon – Cai Be sluice gate project. It is an infrastructure investment project still in the initial stages of development, which will be ready by the end of 2021. This assessment served a variety of objectives:

- Create capacities for implementing climate risk assessment for infrastructure in Vietnam.
- Test and validate one approach for climate risk assessment for infrastructure to see how it may be adapted to the Vietnamese context.
- Analyse climate risks for the Cai Lon – Cai Be project to inform the detailed design.

1.3 Summary of main features of the infrastructure and its region

The Mekong Delta accounts for 12 % of Vietnam's territory and 27 % of its agricultural land, housing 22 % of the country's population (World Bank (2012)). It feeds 245 million people in Asia and worldwide (GIZ (2017)). As these numbers suggest, 76 % of the population of the Mekong Delta is engaged in agriculture (World Bank (2012)). These livelihoods are endangered already today by extreme events and human interventions, like upstream hydropower development, leading to a reduced water and sediment flow. Climate change is expected to exacerbate these negative impacts with expectations of more floods and droughts as well as some areas being permanently inundated due to sea level rise. Together with an increase in salinity intrusion, this will likely lead to the agricultural production suffering.

This high vulnerability is why the Mekong Delta was chosen as pilot region for the CSI project. Given the climate risks the region faces, coastal protection and other risk mitigation measures are of high relevance. At the same time, currently only sea level rise projections are taken into account in their design and planning. This is why the idea for the climate risk assessment was to analyze an infrastructure aimed at increasing resilience, considering all potential climate risks, including changing trends in extreme events.

Cai Lon – Cai Be Sluice Gate

The Cai Lon – Cai Be sluice gate project is one of the biggest investments funded by the Vietnamese government in the region, with expected costs of 3,300 billion VND (approx. 142 M USD). It is categorized as Group A of construction works, level 1 of irrigation works for agriculture and rural development. The objective of the Cai Lon – Cai Be sluice gate project is to help mitigate climate risks, thereby allowing for a stable development in the region. Its main purposes are:

- **Water management:** Retaining freshwater during the dry season
- **Controlling salinity:** This also helps to resolve conflicts between coastal aquaculture and agricultural production of Kien Giang, Hau Giang and Bac Lieu provinces and contributes to a stable fisheries development in the coastal areas of Kien Giang province
- **Strengthening drainage and flood water management**
- **Enhancing land and water navigation systems**

For the risk assessment, the focus was placed on Cai Lon and Cai Be sluice, leaving out the other elements that are part of the bigger structure that will be the Cai Lon – Cai Be sluice gate system. The risk assessment was conducted using the basic design of Cai Lon – Cai Be sluices.

Cai Lon – Cai Be sluice gate at a glance:

- **Approved** by the Prime Minister for Phase I in April 2017 (Decision No. 498/QĐ-TTg)
- **Decision-making context:** Basic Design stage, using the risk assessment results to derive recommendations for the detailed design
- **Design Life:** Overall 100 years, but design life for the components varies from 5 – 10 years for the watertight gaskets (made of rubber) to 70 – 100 years for the physical structures (made of concrete)
- **Relevant Stakeholders:**
 - Ministry for Agriculture and Rural Development (MARD): Investor
 - Water Resources Investment and Construction Board 10 (PMU-10): Project Manager assigned by MARD
 - National Meteorological and Hydrological Administration (NMHA) under MONRE: Main Climate Service Provider for the assessment
 - Southern Institute for Water Resources Planning (SIWIRP): Coordinator of the Climate Risk Assessment
- **Size of the infrastructure:**
 - Cai Lon: 410 m wide, consisting of 11 sluices
 - Cai Be: 85 m, consisting of 2 sluices

For the selection of the specific pilot infrastructure, a Multi-Criteria-Analysis was used. The idea was to identify a project that is

- i. highly vulnerable,
- ii. of high relevance for the economic development of the region and
- iii. provides a good example for infrastructures in the region in terms of replicability of the experience. In the end, the Cai Lon – Cai Be sluice gate project was selected.

It is located on Ca Mau Peninsula in the Cai Lon – Cai Be river basin. The area studied for the assessment covers about 909,248 ha, spreading over 31 districts in 6 provinces (Bac Lieu, Ca Mau, Kien Giang, Hau Giang, Soc Trang and Can Tho City). It inhabits 20.6% of the overall population of the Mekong Delta. People living in the area generally are low-skilled, depending on agriculture, forestry and aquaculture for their livelihoods. While aquaculture provides more income, it is deemed less stable than agriculture. Like in the rest of the Mekong Delta, salinity intrusion and annual flooding are the major risk factors. In addition, due to a lack of nearby freshwater sources, water scarcity is also problem faced by the local population.

1.4 Review of Cai Lon – Cai Be climate information for the vulnerability of the watertight gasket

This is done by the revision of the process of developing climate information products in the context of climate risk assessments. This process is exemplified by the climate risk assessment for the Cai Lon – Cai Be sluice gate project (Vietnam) using the example of one specific infrastructure component. The climate information products developed in the context of the climate risk assessment are presented in a format tailored to the needs of decision-makers.

As example for the guidance, the watertight gasket was selected. The watertight gasket is a component of the sluice gate. Its functionality is to prevent leakage of water through the gate when this is in a closed position. The design life of the gasket is envisaged for 5–10 years. This component was selected considering several factors like the quality of the existing climate information, the relevance for the infrastructure, the severity of potential impacts and to the existence of typical uncertainties.



2 Steps



1 Purpose > What is the added value of this this information?

2 Output > What can be expected from this information?

3 Figure > The figure - what does it show and how to read it?

4 Results > The facts - what information is at the bottom of the figure?

5 Data basis > Trust, but verify...! - what are the ingredienst?

6 Uncertainties & limitations > Watch out!

7 Interpretation & contextualization = So what? - what does it mean?



Step 1
Characterization
of vulnerability

Kien Giang An Giang

Photo: ©GIZ/Katharina Lotzen



Step1 Characterization of vulnerability

1 What is the added value of this information?

The detailed characterization of the climate-related vulnerability of an infrastructure component has a threefold purpose: (i) to qualitatively characterize the climate-related stressor as accurate as possible for the up-coming risk assessment; (ii) to assess the relevance of a component affected by climate-related events regarding the significance of impacts and consequences; and (iii) to identify relevant time slices for climate projections.

2 What can be expect from this information?

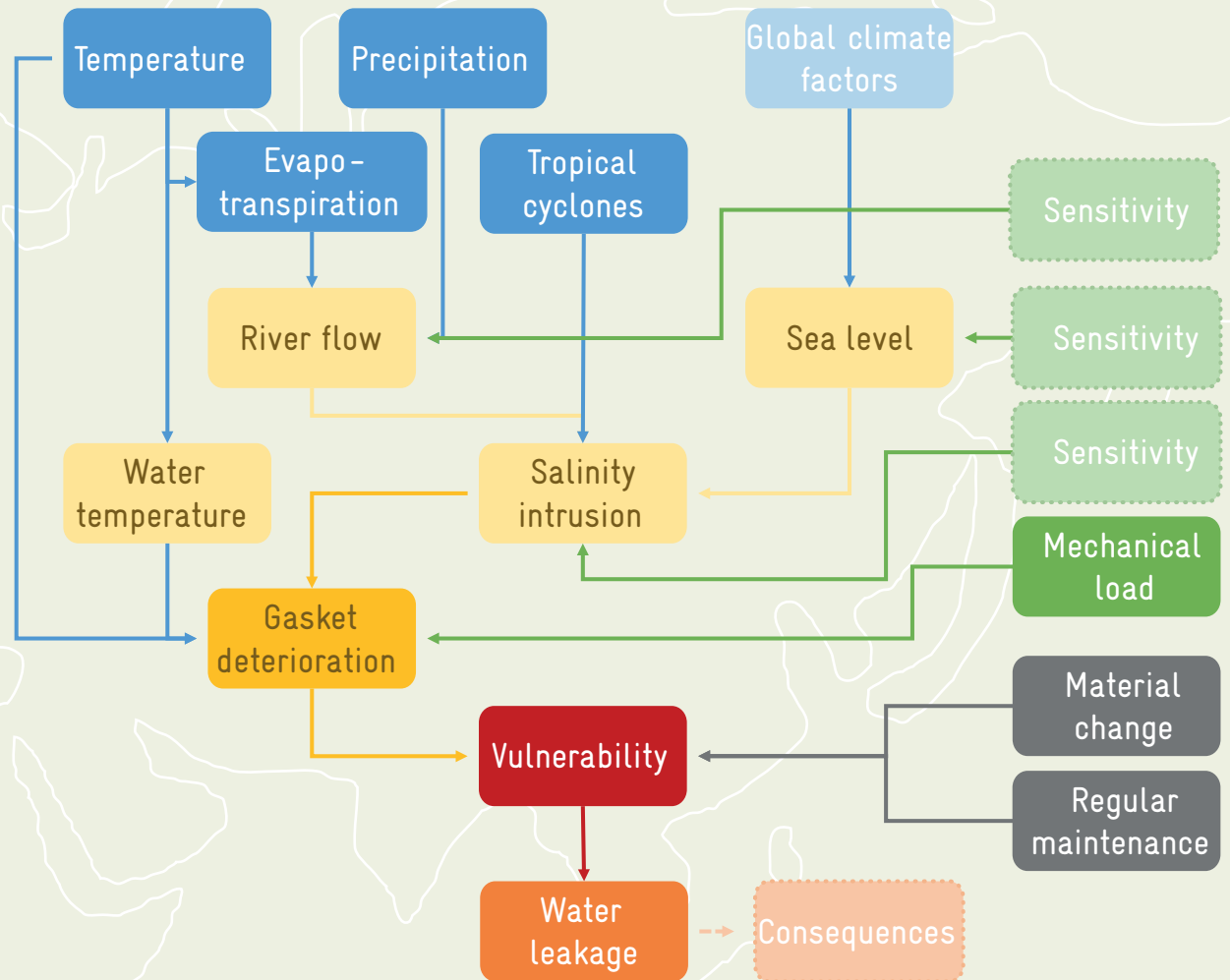
A climate-impact chain that interlinks an undesired impact with a relevant climate stressor describes a vulnerability. A vulnerability is sufficiently described when the cause-effect relationship between climate (exposure) and the component of concern is identified and factors that influence that relationship (sensitivities) are characterized

3 The figure – what does it show and how to read it?

Comment

The methodology of identifying and displaying vulnerabilities is adopted from the Vulnerability Sourcebook (GIZ 2014). For the context of a risk assessment, the factor “consequences” was added which helps to assess the criticality of the analysed component.

Figure 6
The climate impact chain for the climate-related vulnerability of the watertight gasket



The vulnerability is marked by a red box. The dark-yellow box indicates a potential climate-related impact that causes the vulnerability. Blue boxes indicate climate variables and phenomena which trigger the potential impact and to which the component is thus exposed. Light-yellow boxes indicate intermediate impacts of the impact chain. Green boxes indicate sensitivity factors, which control the effect the climate triggers on the intermediate impacts and the final impact. Orange boxes indicate consequences of the climate-related impact. Grey boxes indicate adaptation options that may help to reduce the vulnerability and thus the occurrence of subsequent consequences. Pale coloured boxes with dashed frames indicate uncertain or missing information (own figure aligned to GIZ (2014)).





4 The facts – what information is at the bottom of the figure?

The gasket deterioration is mainly caused by the mechanical stress caused by the operation of the sluice gates. However, the rate of deterioration is sensitive to climate, which might have an influence on the lifetime of the gasket. The consequence of gasket deterioration may be the limitation or even loss of functionality preventing leakage of water through the gates. Adaptation options to higher deterioration due to intensified climate conditions would comprise regular maintenance of the gasket including checking and exchange of the gasket when damaged. Furthermore, alternative material could be developed which is more resistant to climate stressors.

Salt as well as high (water) temperatures are erosive agents for gasket material (rubber) that are related to climate: the watertight gasket is exposed to saltwater when the gates are closed and exposed to heat when the gates are open. An increasing salinity of the river water as well as increasing air temperatures may enhance the deterioration of the gasket. Whereas the relation of (water) temperature to climate is obvious, the salinity may be increased due to the combined effect of high sea levels (due to thermal expansion and input of melt water) and reduced river flow (due to reduced precipitation and increased evapotranspiration). In addition, tropical cyclones can push seawater into the river channels and cause temporal increase of salinity.

Comments

The composition of experts should be named to assess the expertise that was integrated in this process.

5 Trust, but verify...! – what are the ingredients?

Climate vulnerabilities of sluice gate components were identified by the inspection of design reports and discussion in a workshop with experts. Comment: the composition of experts should be named to assess the expertise that was integrated in this process.

Comments

Information on sensitivities is relevant in order to assess the significance of the climate stressors for the deterioration process (cause-effect) and how this relation is characterized. The knowledge of sensitivities enhances the identification of threshold values as well as the identification of adaptation options.

6 Watch out!

- there are uncertainties on the sensitivities that influence cause-effect relationships. No information on sensitivities is provided: e.g. what are the factors that control the effect of salinity and heat on the rate and magnitude of gasket deterioration?
- there are uncertainties about the relationship between air temperature, salinity and deterioration process: how does air temperature and salinity affect the process of deterioration? How do these two processes interact? Do they happen along each other or may they probably amplify/hamper each other?

- there are uncertainties on the consequences of a watertight gasket that loses its functionality before the designed life time is reached: what is the effect on the overall functionality of the sluice gate structure? What is the effect on operational processes? How feasible is the implementation of adaptation options? How critical are possible consequences?
Comment: information on sensitivities is relevant in order to assess the significance of the climate stressors for the deterioration process (cause-effect) and how this relation is characterized. The knowledge of sensitivities enhances the identification of threshold values as well as the identification of adaptation options.

Comment: the process of deterioration needs to be understood well in order to identify an impact threshold (step 2) and thus to be able to interpret changes of the climate stressor (step 4)

Comment: the impact and consequences need to be clearly defined in order to determine a risk. Furthermore, this is important information for the assessment of the component's criticality and to identification of adaptation options.

7 So what? - what does it mean?

- The watertight gasket is vulnerable to high water/air temperature and increase of salinity
- The impact of intensified climate conditions may reduce the life time of the gasket
- Since the process between climate stressors and the deterioration process is not defined in more detail, it is assumed that:
 - there is a linear relationship between temperature and deterioration as well between salinity and deterioration: the higher the air temperatures, the higher the deterioration rate; the higher the salinity the higher the deterioration rate;
 - the effects of heat and salinity on the deterioration process do not influence each other (e.g. no positive or negative feedback) but operate separately and additive.
- Since the criticality of the consequences is not defined but the climate vulnerability is considered for further assessment, it is assumed:
 - The consequences of climate impacts on the watertight gaskets are of significant relevance for the functionality of the sluice gate and other systems that are dependent on the services provided by the sluice gate.

Comments

The process of deterioration needs to be understood well in order to identify an impact threshold (step 2) and thus to be able to interpret changes of the climate stressor (step 4)

The impact and consequences need to be clearly defined in order to determine a risk. Furthermore, this is important information for the assessment of the component's criticality and to identification of adaptation options.

Comment

The assumptions formulated here are implicit, i.e. they are derived from the information collected above and the existent uncertainties (i.e. missing information). If the implicit assumptions are incorrect, explicit assumptions need to be formulated or missing information to be collected.





Step 2

Determination of thresholds

Mekong river bank ecosystem,

Photo: ©GIZ/Harald Franzen

Step 2 Determination of impact and climate threshold

1 What is the added value of this information?

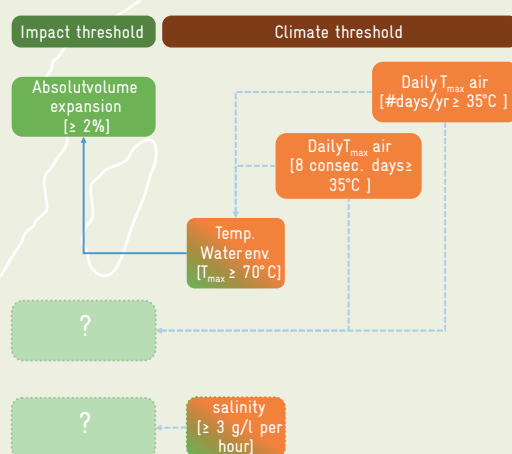
The definition of a climate threshold value is the basis for the identification and selection of an adequate climate information product. It defines the relevant climate-related parameter or index as well as the mode of statistical analysis. Furthermore, a threshold value provides a reference for interpretation of results from climate analysis and the assessment of uncertainties.

2 What can be expected from this information?

A climate threshold is generally characterized by a critical magnitude and optionally by specifications regarding duration, frequency and timing. The climate-related stressor can be represented by a single climate-related parameter or by a combination of parameters that together define the event (e.g. as index or phenomenon).

3 The figure – what does it show and how to read it?

Figure 7
Representation of threshold



On the left hand side, the interlinkage of impact threshold (green boxes) and climate thresholds (orange boxes) is visualized. Dashed lines and boxes indicate a knowledge gap or uncertainty regarding the relationship (correlation) of the respective thresholds (own figure).

Comments

There is no established format how to display the relationship of thresholds. This figure is a suggestion. The visualization of impact and climate thresholds helps to check which information is available and where the uncertainties are, i.e. where the formulation of assumptions are required.



Comments

A climate-related threshold was added here (high water temperature) which was originally not explicitly defined by the risk assessment team.

The method for threshold determination has severe implications for the vulnerability of the component. This implies lot uncertainties (see below) that require explicit assumptions.

Water temperature was not identified as climate-related threshold. Thus, no climate analysis regarding water temperature was done. Instead, air temperature was taken as surrogate which again generates uncertainties about the interlinkage of air temperature on the threshold of water temperature.

Uncertainties that came up in step 1 (limited understanding of the deterioration process, incomplete) are reflected here in the threshold determination.

4 The facts – what information is at the bottom of the figure?

- An **impact threshold** of the watertight gasket related to temperature is defined by a maximum tolerable volume expansion of 2% in a water environment which corresponds to 70°C.
- Relevant **climate-related thresholds** which refer to the vulnerability of the watertight gasket were defined as follows:
 - “high water temperature” [$T_{max} \geq 70^{\circ}C$]
 - “high temperatures” [#days with $T_{max} \geq 35^{\circ}C$],
 - “heat wave” [period of 8 consecutive days with $T_{max} \geq 35^{\circ}C$],
 - “salinity” [≥ 3 g/l per hour] and
 - “salinity and high temperature” [≥ 3 g/l per hour & #days with $T_{max} \geq 35^{\circ}C$]

5 Trust, but verify...! – what are the ingredients?

Climate thresholds were determined by selecting extreme values referring to the baselines of the respective parameter. I.e. there is one threshold value for each climate-related parameter. Temperature thresholds are not impact-related. The salinity threshold refers to concrete production standards for coastal areas. Comment: the method for threshold determination has severe implications for the vulnerability of the component. This implies lot uncertainties (see below) that require explicit assumptions.

6 Watch out!

- The impact-threshold related to water temperature is not characterized in detail: what exactly happens to the gasket when the provided threshold is exceeded? Does the threshold have to be exceeded only once or several times within a specific period to decrease the gaskets capacity (i.e. life time)?
- The interlinkage of climate threshold for air temperature to the impact threshold is imprecise: how are temperature-related climate thresholds for air temperature (#days with $T_{max} \geq 35^{\circ}C$) and heat wave (8 consecutive days of $T_{max} \geq 35^{\circ}C$) and the impact threshold related? How is the capacity of the watertight gasket related to the temperature threshold?
- An impact threshold directly related to air temperature is not defined: what is impact of high air temperatures on the gasket?

- An impact threshold related to salinity is not precisely defined: the provided threshold is valid for concrete. To what extent does this threshold also apply for rubber? What is the capacity of the watertight gasket related to the salinity threshold?
- An impact threshold for the combined effect of temperature and salinity is not defined: how much salinity in combination with which temperatures are critical for the process of deterioration of rubber?

Comment: water temperature was not identified as climate-related threshold. Thus, no climate analysis regarding water temperature was done. Instead, air temperature was taken as surrogate which again generates uncertainties about the interlinkage of air temperature on the threshold of water temperature.

Uncertainties that came up in step 1 (limited understanding of the deterioration process, incomplete) are reflected here in the threshold determination.

Comment: if a threshold cannot be determined a surrogate value can be taken if necessary. However, plausible assumptions should be made regarding the representativeness of this value (i.e. systematic over- or under-estimation).

7 So what? – what does it mean?

- Since impacts and consequences of climate-related threshold exceedance are not sufficiently defined, it is assumed that the impact is effective on rather longer timescales similar as erosion. Consequently, it is assumed, that the climate-related thresholds can be understood as follows:
 - The probability for a decrease of the design life of the gasket below 5-10 yrs increases with each day with $T_{max} \geq 35^{\circ}\text{C}$ and increases significantly when $T_{max} \geq 35^{\circ}\text{C}$ last for at least 8 consecutive days
- It also needs to be considered, that the identified climate threshold may have no relevance for the impact threshold, i.e. that 70°C water temperature will never or very difficultly be reached under prevalent climate conditions. Therefore it is assumed that
 - The deterioration process is a continuous process with sub-critical failure mode which is enhanced at high temperatures and salinities

Comments

if a threshold cannot be determined a surrogate value can be taken if necessary. However, plausible assumptions should be made regarding the representativeness of this value (i.e. systematic over- or under-estimation).

Comments

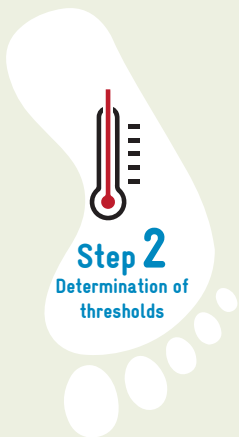
Fundamental assumptions of the interaction of climate and deterioration process of the gasket need to be done due to uncertainties in step 1 and 2. If they are not plausible, step 2 and/or step 1 has to be reviewed.

Comments

These conclusions are made based on the provided information above. If they are not plausible, step 2 and/or step 1 has to be reviewed.

- Rubber deterioration is sensitive to similar salinity thresholds like concrete corrosion
 - The probability for a decrease of the design life of the gasket below 5-10 yrs increases with each time salinity exceeds 3 g/l per hour.
- The effects of heat and salinity on the deterioration process do not influence each other (e.g. no positive or negative feedback). I.e. both drivers enhance deterioration rates linearly. Comment: fundamental assumptions of the interaction of climate and deterioration process of the gasket need to be done due to uncertainties in step 1 and 2. If they are not plausible, step 2 and/or step 1 has to be reviewed.

Comment: these conclusions are made based on the provided information above. If they are not plausible, step 2 and/or step 1 has to be reviewed.





Step 3

Historic climate
analysis

Construction of the
Cai Lon-Cai Be sluice
gate, Vietnam

Photo: ©GIZ/Ngoc Nguyen Thi Minh



Step 3 Assessment of historical and current occurrence of critical climate events

1 What is the added value of this information?

The analysis of observations of the identified climate-related parameter has a twofold purpose: (i) past and current exceedances of identified climate-related thresholds can be assessed which helps to relate and assess the probability of projected threshold exceedances. (ii) historic time series allow the analysis of observed trends and the conduction of sensitivity analysis, which help to assess future developments of the climate parameter.

2 What can be expect from this information?

The key product is a time series of observed values of the identified climate-related parameter for the locality or region of interest. The time series is often provided as graph accompanied with text that highlights key results, which are provided by the figure and relevant for the context of analysis as well as information on uncertainty. If appropriate, information is provided on trends and incremental changes to the baseline.

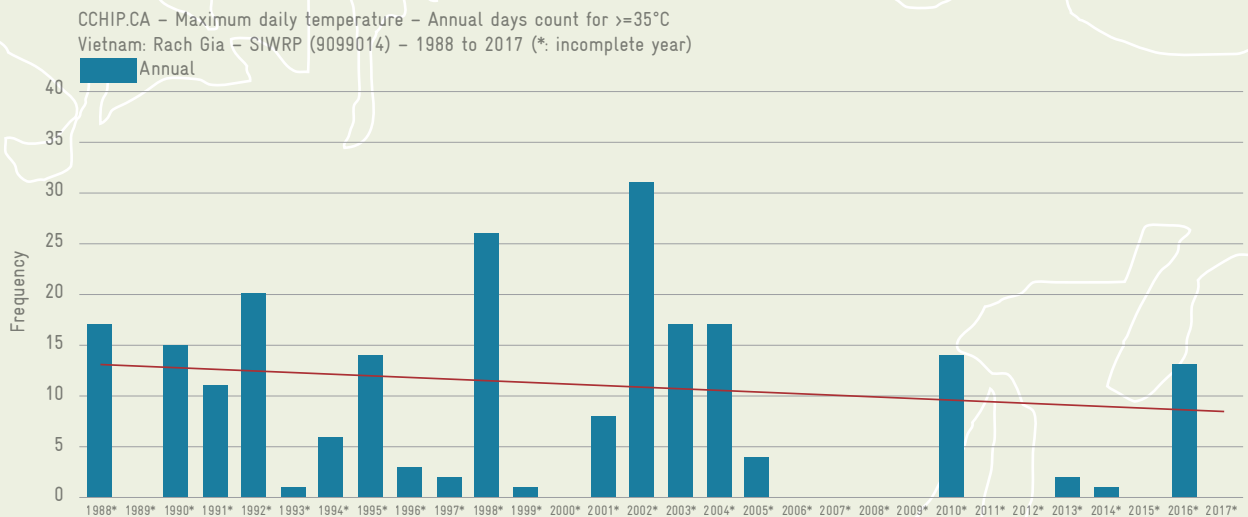
Threshold analysis for: air temperature

Threshold values:

- “high temperatures” [#days with $T_{max} \geq 35^\circ$],
- “heat wave” [period of 8 consecutive days with $T_{max} \geq 35^\circ$],

3 A) The figure – how to read it?

Figure 8
PIEVC report for Cai Lon – Cai Be infrastructure



The graph shows for each year between 1988 to 2017 (x-axis) the number of days with daily maximum temperatures equal or above 35°C (blue beams; y-axis). The red line shows the trend of the development of days with maximum temperatures $\geq 35^{\circ}\text{C}$ over the analysed period.

4 A) The facts – what information does the figure provide?

The graph tells that for the period from 1988-2017

- The year with the most days $\geq 35^{\circ}\text{C}$ was 2002.
- In 10 of 30 years, the threshold of daily max. $\geq 35^{\circ}\text{C}$ was not exceeded.
- 80% of the years the threshold was not exceeded are in the second (current) half of the time series (2003-2017).
- In average, each year 7.5 days $\geq 35^{\circ}\text{C}$ with a decreasing trend (-0.13 days per year).
- Additional information (not depicted in the graph): there were four heat waves (8 consecutive days with $T_{\text{max}} \geq 35^{\circ}\text{C}$): two in 1988 and two in 2002 for which no trend can be determined.

Comments

It is not necessary to generate a figure for all results but it is always helpful to visualize all relevant information. E.g. heat waves could be integrate in Figure 8 by marking all years at which heat waves occurred. That enhances the readability and understanding of the results in the text.





Step 3 Historic climate analysis

Comments

Possible consequences of uncertainties for the results or the interpretation of results should be made transparent; if they are considered as not significant (and thus neglected) this must be justified. An open handling of uncertainties provides trust and credibility.

Recommendation

An additional analysis of the entire distribution of daily temperatures over the period would help to assess the trend of daily temperatures, which might increase even when extreme daily temperatures $\geq 35^{\circ}\text{C}$ do decrease.

5 A) Trust, but verify...! – what are the ingredients?

- Temperature observations from Rach Gia climate station (ca. 20 km from the sluice gates) were analysed for the period 1988 to 2017.

6 A) Watch out!

- Data from only one climate station was analysed. This station was assumed to be representative for the location of the sluice gates, however, data from one station may reflect very site-specific climate characteristics or even may involve systematic measurement errors.
- The type of analysis focuses on the exceedance of the daily 35°C threshold, which may not reflect the total truth about temperature development within the period. Comment: possible consequences of uncertainties for the results or the interpretation of results should be made transparent; if they are considered as not significant (and thus neglected) this must be justified. An open handling of uncertainties provides trust and credibility.

Recommendation: An additional analysis of the entire distribution of daily temperatures over the period would help to assess the trend of daily temperatures, which might increase even when extreme daily temperatures $\geq 35^{\circ}\text{C}$ do decrease.

7 A) So what? – what does it mean?

- The purpose of the historic analysis is to determine “normal” climate conditions under which the vulnerability of infrastructure components is under control, i.e. they are adapted. Therefore it is assumed:
 - that a watertight gasket that is exposed to maximum daily temperatures over 35°C by 7.5 days per year has deterioration rates that correspond to a life time of 5-10 years.

Threshold analysis for: salinity

Threshold values: “salinity” ≥ 3 g/l per hour

Comments

This assumption aligns to the assumption made in step 2: the climate threshold is not hard but it provides unfavourable conditions. However, for a risk analysis, it is good to know: how much is 7.5 days? What is the risk that this can happen under prevalent climate conditions (it is assessed as “frequent” in the PIEVC assessment report)? And how much can the gasket take before the process of deterioration is significantly enhanced (this question refers back to step 1 and 2)?

If the assumption made here is correct, the threshold needs to be reconsidered: if the threshold is defined for daily max. $T_{air} > 35^{\circ}\text{C}$ but the actual relevant impact occurs at “x days per year with max. $T_{air} > 35^{\circ}\text{C}$ ” the threshold is wrong. A wrong threshold has significant implications for the risk scoring: max. $T_{air} > 35^{\circ}\text{C}$ occur already “frequently” by having no relevant impact. I.e. there is high probability of a non-relevant event. However, a high probability of occurrence raises the risk score for the current risk. I.e. the risk will be overestimated. Furthermore, if the risk score is already high, its potential to increase in the future is limited even when the number of days with $T_{air} > 35^{\circ}\text{C}$ increases drastically (as suggested in Figure 9– 12). This in turn, would underestimate the increase of risk in the future.

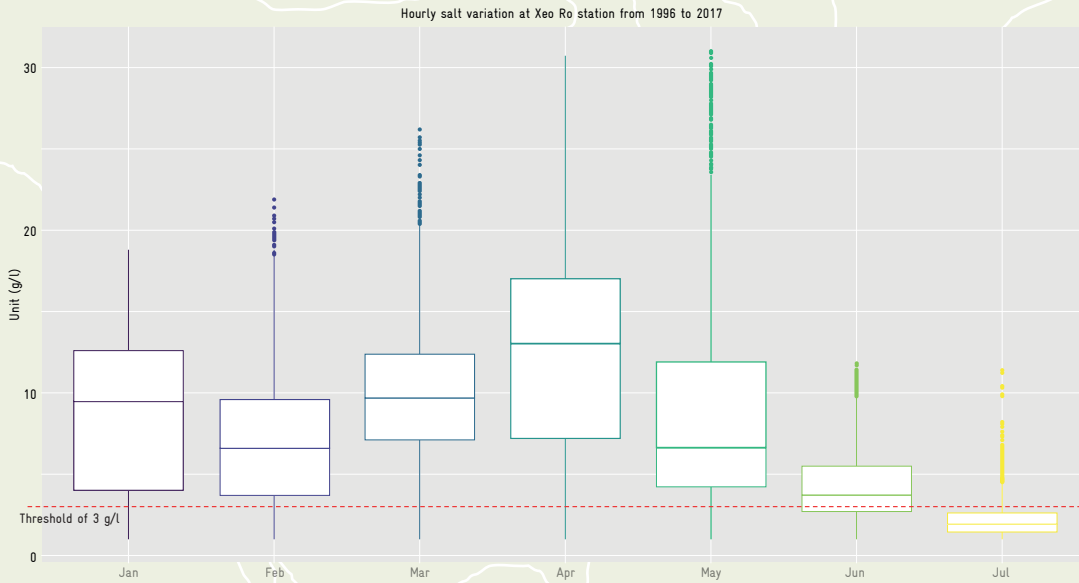




Step 3
Historic climate
analysis

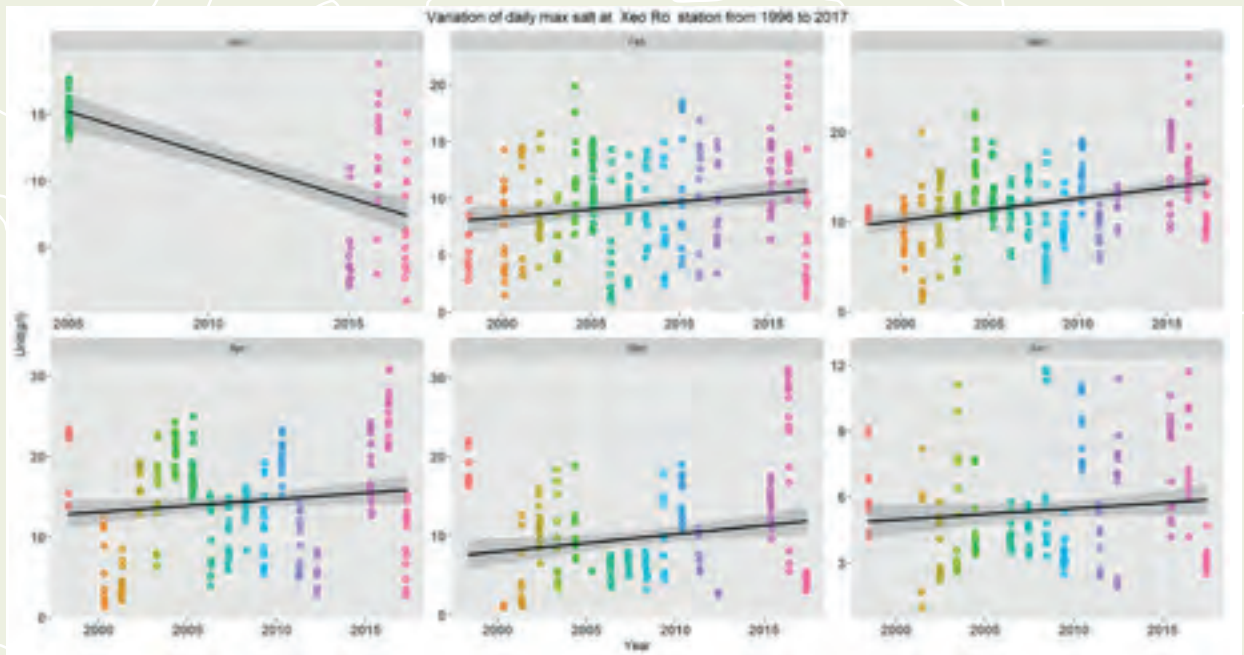
3 B) The figure – how to read it?

Figure 9
An overview of the hourly salinity concentration (in g/l) for the months from January to July (x-axis) for the period 1996-2017 at Xeo Ro station.



The box whisker plots (y-axis) comprises hourly salinity values for each month for the last 22 years. The box plots can be read as follows: the box delineates the middle 50% of the population. The horizontal line represents the median and divides the middle 50% into the upper quartile (75th percentile) and lower quartile (25th percentile) of the population. The vertical lines (whiskers) indicate the values outside the box with a range that corresponds to one-and-a-half lengths of the box (interquartile range, IQR). The dots indicate values that are beyond that range and are considered as statistical outliers or extreme values. The end of each whisker or rather the last dot indicate minimum or maximum values.

Figure 10
 An overview of the temporal development of the salinity concentration (daily maximum concentration in g/l) at Xeo Ro from 1996–2017.



The individual years are outlined on the x-axis and salinity concentration values are outlined on y-axis (in g/l). Values from different years are discriminated by colour. Grey lines indicate the trend of average daily max salinity concentrations over the period from 1996–2017. The grey shaded area around the trend line represents the standard.

4 B) The facts – what information does the figure provide?

The graph in Figure 9 tells that for the period from 1995–2017

- the largest salinity concentration was 31 g/l (in May),
- the average value was around 8 g/l (not depicted in the graph),
- the median value of salinity was highest in April
- minimum 75% of the hourly salinity concentrations are higher than the identified threshold of 3 g/l for the months January to June. Also for July this threshold is exceeded by around 25% of the values.
- When the rainy season begins (in June and July), the salinity concentration tends to decrease

Comments

The analysis of salinity does not refer to the identified threshold. Neither do the written results. This makes the climate information difficult to understand and interpret.

If there was no alternative to this analysis, results should be presented referring best possible to the threshold. (I.e. threshold value should be marked in the figure and results in the text refer to time periods where 3 g/l are exceeded; for the purpose of this guidance, this was done preliminarily by hand in Figure 9 and the text).

Comments

The concentration on relevant figures is commendable in order to keep the focus. However, in this context the display of the entire data spectrum (also rainy season) would have been valuable when analysing the threshold exceedance of 3 g/l. The values of July arouse curiosity on the values of the upcoming months.

Comments

Decisions referring to negligence of relevant factors (e.g. like tropical cyclones) or on the selective presentation of data (e.g. omission of salinity data for the rainy season; presentation of the time series from only one observation station) should be made transparent.

Comments

if compromises had to be done in the type of analysis, this should be made transparent (e.g. no available threshold analysis). Assumptions on the usefulness of the provided type of analysis for the prevalent issue should be provided.

Uniform formats for historical and future climate analysis enhance the comparability of results. If this is not possible, guidance on the interpretation/ comparability should be provided.

The graph in Figure 10 tells that for the period from 1995-2017

- highest daily salinity at the Xeo Ro station has an increasing trend, especially in the dry months (February to April). [This trend is in line with the water level trend in the coastal stations (not depicted in the graph)]

5. B) Trust, but verify...! – what are the ingredients?

- The source of the provided information on salinity is the Xeo Ro hydrological station (located at the sluice gate). For this station, salinity measurements are available for the period 1996 to 2017.
- Data from only one observation station was presented in this plot. However, salinity data from two other stations nearby showed similar results [not presented here].
- Data was only plotted for the months from January to June/July. This is because salinity intrusion is only significant high in this period. Plots for the other months were therefore omitted.
- Tropical cyclones were not considered separately. The possible effect of tropical cyclones on salinity is reflected in salinity data series of the observation station. Furthermore, tropical cyclones mostly occur in the time of year where salinity is not critical. Comment: decisions referring to negligence of relevant factors (e.g. like tropical cyclones) or on the selective presentation of data (e.g. omission of salinity data for the rainy season; presentation of the time series from only one observation station) should be made transparent.

6. B) Watch out!

- Uncertainty on the occurrence of significant salinity values is provided since no threshold analysis was done and not all months are plotted.
- The presentation of results has a different format than in step 4 (Step 3: hourly salt variation aggregated on a monthly level; Step 4: total exposure times to salt concentrations of 2 g/l per year). Thus, results are not directly comparable.
- The scales of the y-axis of the individual graphs in Figure 10 are not uniform and thus difficult to compare.
- Uncertainty on the significance of the trend of salinity concentrations is given considering the range of uncertainty of the trend line.

- The available time series comprise a period of 20 years, may be (too) short to make robust statements on the climatology and trend on salinity. Especially when the trend is not significant. Comment: if compromises had to be done in the type of analysis, this should be made transparent (e.g. no available threshold analysis). Assumptions on the usefulness of the provided type of analysis for the prevalent issue should be provided.

Comment: uniform formats for historical and future climate analysis enhance the comparability of results. If this is not possible, guidance on the interpretation/comparability should be provided.

Comment: uniform scales facilitate the comparison and thus of graphs and prevents misinterpretation. This enhances the usability of the climate information. If uniform scales are not practical, this should be indicated.

Comment: the uncertainty on the trend should also be provided in numbers (e.g. signal-to-noise ratio) in order to be able to assess the significance of the trend (which partly should be challenged according to the graph and the limited length of the time series)

Comments

Uniform scales facilitate the comparison and thus of graphs and prevents misinterpretation. This enhances the usability of the climate information. If uniform scales are not practical, this should be indicated.

Comment: the uncertainty on the trend should also be provided in numbers (e.g. signal-to-noise ratio) in order to be able to assess the significance of the trend (which partly should be challenged according to the graph and the limited length of the time series)

7. B) So what? - what does it mean?

- The stated threshold value of salinity relevant for deterioration of the gasket (3 g/l) is almost permanently exceeded for the months from January to June. Even in July where the rainy season has already started the threshold might be exceeded for at least some days per month (~ 25%, as far as the plots do show it). Consequently, critical salinity values do more or less permanently exist during the past 20 years at least during the dry season.
- The purpose of the historic analysis is to determine “normal” climate conditions under which the vulnerability of infrastructure components is under control, i.e. they are adapted. Therefore it is assumed: Assuming that
 - that a watertight gasket that is exposed to salinity concentrations greater than 3 g/l more or less permanently during the dry season (and at some days during the rainy season) has deterioration rates that correspond to a lifetime of 5-10 years.

Comments

If this conclusion is not true, the process of deterioration needs to be clarified or the threshold value be reviewed.



Step 3
Historic climate
analysis



Step 4
Future climate
analysis

Mekong river bank
ecosystem, Vietnam

Photo: ©GIZ/Harald Franzen

Step 4 Assessment of the future occurrence of critical climate events

1 What is the added value of this information?

The information on future occurrence of critical climate events is the key information for a climate risk assessment. Decision-making regarding climate adaptation measures mainly refer to this information: (i) this climate information indicates if climate adaptation is necessary at all and (ii) which levels of types of adaptation need to be considered referring to the degree and certainty of changing occurrence of critical climate events.

2 What can be expect from this information?

The key product are climate projections. The output is mostly provided in form of maps or in form of diagrams (box-plots) for specific regions or individual stations. Information on future occurrence is provided for a specific time slice (near future, mid future, far future) and specific scenario. Results are provided as value ranges referring to the results of the individual model-chains (members) of the ensemble. If no (useful) projections are available, trends of time series (step 3) may also provide some indications on future developments of the critical climate event.

Projections of parameter: air temperature

Threshold values:

- “high temperatures” [#days with $T_{max} \geq 35^\circ$],
- “heat wave” [period of y consecutive 8 days with $T_{max} \geq 35^\circ$]



Step 4
Future climate
analysis



Step 4
Future climate
analysis

3 A) The figure – how to read it?

Figure 11 Changes in number of hot days (day/year) in the middle of the century (2046-2056) for the RCP 4.5 scenario.

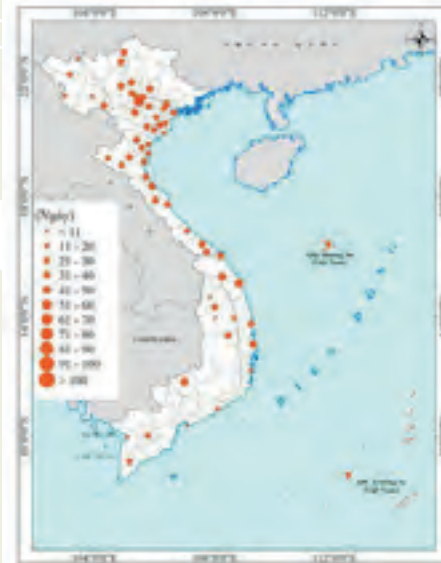


Figure 12 Changes in number of hot days (day/year) in the end of the century (2088-2099) for the RCP 4.5 scenario

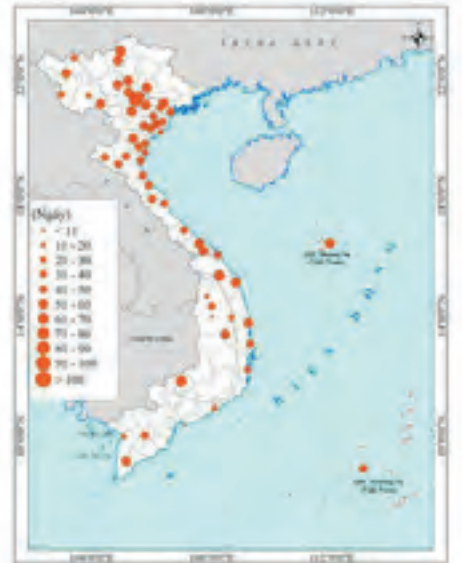


Figure 13 Changes in number of hot days (day/year) in the middle of the century (2046-2056) for the RCP 8.5 scenario.

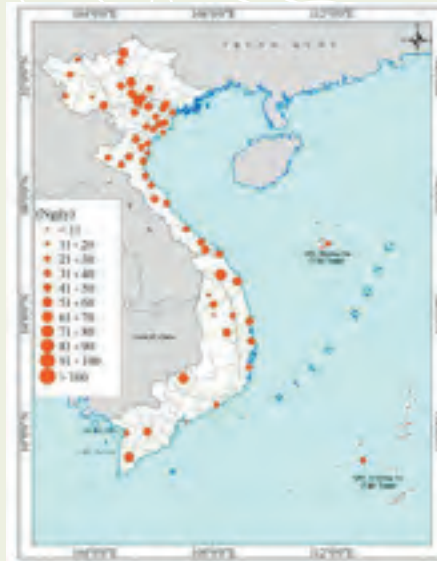


Figure 14 Changes in number of hot days (day/year) in the end of the century (2088-2099) for the RCP 8.5 scenario.

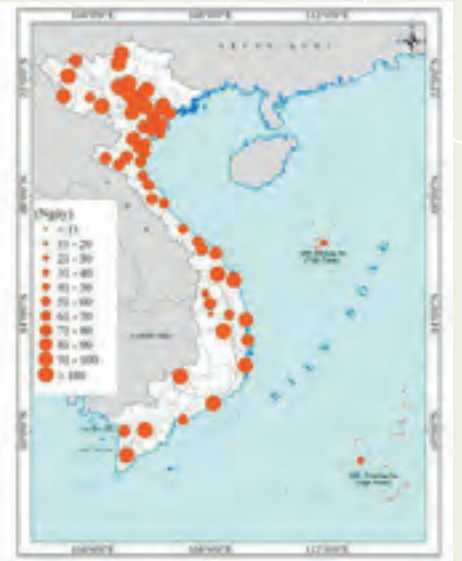


Figure 11- Figure 14 (MONRE 2016) shows the change of number of hot days ($T_{max} \geq 35^{\circ}\text{C}$) per year for the middle of the century (2046–2056) (Figure 11 & Figure 12) and end of the century (2080–2099) (Figure 13 & Figure 14). The size of the bubbles indicates the amount of change of hot days according to the legend on the right side in each figure. The location of the bubbles corresponds with the location of an observation station. Figure 11 and Figure 12 indicate the change of number of hot days for the RCP 4.5 scenario, while Figure 13 and Figure 14 indicate the change of number of hot days for the RCP 8.5 scenario.

4 A) The facts – what does the figure tell?

- The number of days with the high temperature in Vietnam tend to increase in the 21st century, especially at the end of the century.
- Until 2056, for the RCP 4.5 scenario, the number of hot days will increase by 11-20 (total: 18.5 – 27.5) and for the RCP 8.5 scenario, the number of hot days will increase by 21-30 (total: 28.5 – 37.5) days.
- Until 2099, for the RCP 4.5 scenario, the number of hot days will increase by 21-30 (total: 28.5 – 37.5) and for the RCP 8.5 scenario, the number of hot days will increase by 81-90 (total: 87.5 – 97.5) days.
- For heat waves, an increasing trend was deduced from the increasing number of high temperature days (not depicted in Figure 11-Figure 14) [no analysis for heat waves based on temperature projections is available].

5 A) Trust, but verify...! – what are the ingredients?

- The results refer to an ensemble projection of daily maximum temperatures with 16 members that is based on a variety of combination of 5 RCMs and 9 GCMs. Analysis of projections were made for two time slices: mid-century (2046-2065) and the end of the century (2080-2099) assuming the RCP 4.5 scenario and the RCP 8.5 scenario (see also MONRE 2016).

6 A) Watch out!

- The time slices of analysis comprise only 20 years. The interpretation of the results should be done with care.
- The statement on the development of heat waves in the future is not based on a robust data basis. This is only assumed based on expert judgement. This statement has to be handled with care.

7 A) So what? – what does it mean?

- The life time of the watertight gasket is assessed to be 5-10 years. Considering the first adaptation option, the appropriate time slice of analysis relevant for interpretation would be the near future (2016-2035). Projections for this time slice are not available. Thus, no statements can be made about the durability of the currently installed watertight gasket. (The suitable climate information product would be a decadal prediction).

Comments

Any deviations from good practices on the generation of climate projections should be made transparent and implications for the interpretation assessed:

These are implications of the results from the projections on the life time of the gasket based on the assumptions made in step 1 and 2. An almost vanishing life time of the gasket (i.e. like a solution of the material like in acid) seems very unrealistic and physical not plausible. These results require an urgent review of step 1 and 2 in order to adequately classify and interpret the results from the climate projections.



Step 4
Future climate
analysis

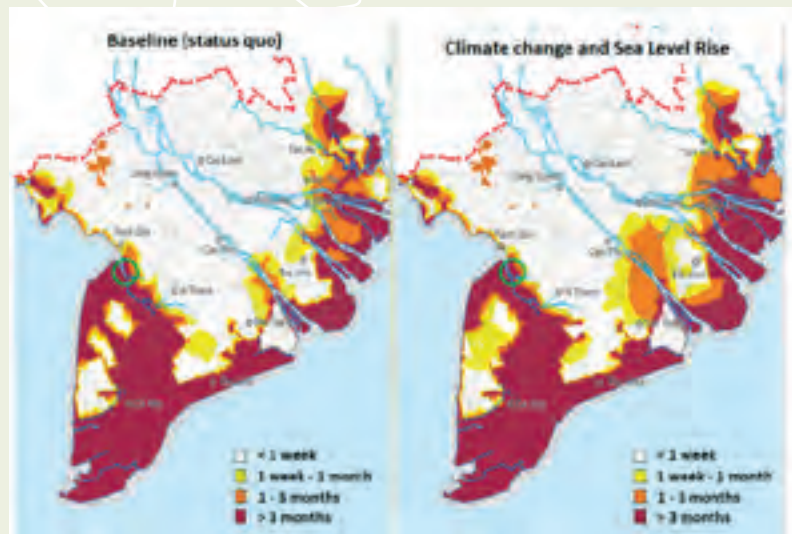
- Projections for the mid- and far-future would be interesting when considering the second adaptation option: “change of gasket material”. For this context, the number of heat days ($T_{max} \geq 35^{\circ}\text{C}$) would be doubled (ca. 14 days/year) until 2059 or even increase by 300/400% (RCP 4.5) or even 1200/1300% (RCP 8.5) in the far future (until 2099). If the assumption is valid, that deterioration rates do linearly increase with heat days the deterioration rate should be doubled within the next 2 decades and thus halve the life time of the watertight gasket. For the far-future this would mean the exceedance of the threshold every second day to every second week a year, with dramatic impact on the gasket’s life time which is almost vanishing. Comment: these are implications of the results from the projections on the life time of the gasket based on the assumptions made in step 1 and 2. An almost vanishing life time of the gasket (i.e. like a solution of the material like in acid) seems very unrealistic und physical not plausible. These results require an urgent review of step 1 and 2 in order to adequately classify and interpret the results from the climate projections.

Projections for parameter: salinity

Threshold values: “salinity” [≥ 3 g/l per hour]

3 B) The figure - how to read it?

Figure 15
PIEVC report



An Overview of the total duration (i.e. sum of all events in total) of salinity intrusion per year with a concentration of minimum 2 g/l per hour for the area of the Mekong Delta. The colours indicate different duration periods according the legend. The left figure indicates the status quo (2016) and the right figure indicates the duration of salinity intrusion for the mid-century (2046-2065) under the RCP 8.5 scenario.

4 B) The facts - what does the figure tell?

- For the entire area of the Mekong Delta it can be stated, that the impact of sea level rise and the decrease of the upstream flow, salinity intrusion is becoming more extreme in the mid-future (i.e., the higher values and the longer durations).
- For the area of the sluice gate (green circle) no change of salinity duration could be identified. Comment: results can be better reconstructed in the figure when the location of concern (sluice gate) is respectively marked (this was done by hand in Error! Reference source not found.).

Comments

Results can be better reconstructed in the figure when the location of concern (sluice gate) is respectively marked (this was done by hand in Error! Reference source not found.).

5 B) Trust, but verify...! - what are the ingredients?

- The salinity intrusion was modelled based on the sea level rise scenario based on RCP 8.5 for the mid-century (2046-2065) (MONRE 2016):
- The increase in sea level was considered as a sum of the components including: (i) thermosteric processes, (ii) melting of glaciers, (iii) surface mass balance of the Greenland Ice Sheet (GSMB), (iv) Antarctic Ice Sheet surface mass balance (ASMB), (v) ice sheet dynamics in Greenland (GDIS), (vi) ice sheet dynamics in Antarctica (ADIS), (vii) land water storage, and (viii) glacial isostatic adjustment (GIA). Sea level rise due to dynamic and thermosteric components were determined using outputs from 21 Atmosphere-Ocean General Circulation Model (AOGCMs) published by IPCC. Both of these data were downloaded at monthly resolution and on the native model grids. Other components such as glaciers, surface mass balance in Greenland and Antarctica; dynamic ice sheet in Greenland and Antarctica; land water storage; and glacial isostatic adjustment were determined based on the global mean time series published in IPCC's AR5 (IPCC, 2013).
- No information is provided on details of the salinity intrusion modelling



Step 4
Future climate
analysis

Comments

Uncertainties related to the impact modelling would be good to know for the sake of interpretation of results.

If for any reason the analysis does not directly refer to the threshold, assumptions on the relation of the provided results for the object of analysis (threshold of 3 g/l) need to be made.

The limitation in time slices and scenarios of the provided projections for salinity are crucial for the concluding interpretation of the results. Such limitations do always have to be communicated!

6 B) Watch out!

- The conditions under which salinity intrusion is modelled are not known
- The analysed threshold in this projection (2 g/l per hour) does not fit the threshold determined in step 2 (3 g/l per hour). Thus, the results are systematically over-estimated.
- Presentation of results has a different format than in step 3 (specification of total duration per year versus hourly salinity values). Thus, results are not directly comparable.
- The projection is not directly comparable to the projection of high temperatures since only projections for the RCP 8.5 scenario and the mid-century (2046-2065) time slice is provided. The combined effect of salinity and temperature on gasket deterioration can only be assessed for the mid-century (2046-2065).
- The classification of temporal categories in Figure 15 does not allow a detailed analysis of possible changes of salinity. No differentiation can be done for durations of salinity intrusion longer than 3 months. Comment: uncertainties related to the impact modelling would be good to know for the sake of interpretation of results.

Comments


The presentation of the salinity intrusion duration times is not adapted to the needs of interpretation. A further subdivision of durations > 3 months would be helpful for interpretation. Assumptions on the development of salinity intrusion duration need to be made!

7 B) So what? - what does it mean?

- The projection on salinity intrusion does not show any difference between the present and the future for the area of the sluice gate. However, this type of data presentation cannot display a possible increase of salinity intrusion. Possible increases of duration of salinity intrusion that go beyond 3 months cannot be differentiated and thus identified. Therefore it is assumed:
 - that the trend for the Mekong Delta is also valid for the location of the sluice gate which comprises an increase of salinity (but with unknown value)
- Furthermore, since the analysed threshold is lower than the target threshold, it needs to be assumed that results are systematically over-estimated. However, since historic analysis in Figure 10 indicate a permanent threshold exceedance (3 g/l) for more than 3 months it can be assumed that the results in Figure 15 (left side) would look the same for a salinity of 3 g/l.



Step 4
Future climate
analysis



3 Summary of climate information for assessing the risk of the watertight gasket

**Construction of the
Cai-lon-Cai-Be sluice
gate, Vietnam**

Photo: ©GIZ/Ngoc Nguyen Thi Minh



Key information

1. The deterioration of the material reduces the life-time of the water-tight gasket.
2. Climate stressors for deterioration are high water and air temperatures as well as high water salinity.
3. A damaged gasket causes leakage of water and needs to be exchanged earlier than planned.

1. "high water temperature" [$T_{max} \geq 70^{\circ}\text{C}$]
2. "high temperatures" [#days with $T_{max} \geq 35^{\circ}\text{C}$],
3. "heat wave" [period of 8 consecutive days with $T_{max} \geq 35^{\circ}\text{C}$],
4. "salinity" [≥ 3 g/l per hour] and
5. "salinity and high temperature" [≥ 3 g/l per hour & #days with $T_{max} \geq 35^{\circ}\text{C}$]

Key uncertainties & assumptions

1. The climate influence on the deterioration process is not clear
 - there is a linear relationship between temperature and deterioration as well between salinity and deterioration
 - the effects of heat and salinity on the deterioration process do not influence each other
2. Consequences and criticality (for decision-making) of a reduced life-time of the watertight gasket is not clear
 - consequences of climate impacts on the watertight gaskets are of significant relevance for the functionality of the sluice gate and other systems that are dependent on the services provided by the sluice gate

1. An Interlinkage of climate threshold and impact is not provided as well as details on the impact and its consequences for the infrastructure
 - the deterioration process is a continuous process with sub-critical failure mode, which is enhanced at high temperatures and salinities.
 - Rubber deterioration is sensitive to similar salinity thresholds like concrete corrosion
 - The probability for an decrease of the design life of the gasket below 5-10 yrs increases with each day with daily $T_{max} \geq 35^{\circ}\text{C}$ and increases significantly when daily $T_{max} \geq 35^{\circ}\text{C}$ last for at least 8 consecutive days
 - The probability for a decrease of the design life of the gasket below 5-10 yrs increases with each time salinity exceeds 3 g/l per hour



Step 3 Historic climate analysis

1. The temperature threshold was exceeded 7.5 days / year in average within the past 30 years
2. There were four heat waves within the past 30 years
3. The trend of threshold exceedance for air temperature is decreasing
4. The average hourly salinity in the dry season is at 8 g/l (January – June) within the past 20 years
5. minimum 75% of the hourly salinity concentrations are higher than the identified threshold of 3 g/l for the months January to June. Also for July this threshold is exceeded by around 25% of the values.
6. Salinity values have an increasing trend for the dry season (January – June)

Step 4 Future climate analysis



1. Threshold exceedance will increase for the mid-century (until 2059) by 11–20 days (RCP 4.5) and 21–30 days (RCP 8.5)
2. Threshold exceedance will increase for the late century (until 2099) by 21–30 days (RCP 4.5) and 81–90 days (RCP 8.5)
3. The duration of salinity intrusion (> 2 g/l per hour) will increase for the Mekong Delta until 2059.
4. No change for the duration of salinity intrusion is detected for the location of the sluice gate

1. Data basis for temperature and salinity analysis is not robust (T: only one observation station; Salinity: no significant trend)
 - the observation data of Rach Gia station (T) and Xeo Ro (salinity) are representative for the region
2. Relevance of historic climate conditions and climate vulnerability of the gasket
 - a watertight gasket that is exposed to maximum daily temperatures over 35°C by 7.5 days per year has deterioration rates that correspond to a life time of 5–10 years.
 - a watertight gasket that is exposed to salinity concentrations greater than 3 g/l more or less permanently during the dry season (and at some days during the rainy season) has deterioration rates that correspond to a life time of 5–10 years

1. Relevance of projected heat days for deterioration process
 - Near future (until 2035): no statements can be made about the durability of the currently installed watertight gasket
 - Mid-future (until 2059): doubling of heat stress (RCP8.5) with bi-section of gasket life time (based on assumptions in step 1)
 - Far-future (until 2099): triplication (RCP4.5) to quadruplicating (RCP8.5) of heat stress with vanishing of gasket life time (based on assumptions in step 1)
2. Changes for the duration of salinity intrusion (for durations > 3 months) are not detectable in the provided figure
 - trend for the Mekong Delta is valid for the location of the sluice gate which rises an increase of salinity (but unknown value)



Figure 16
 An Overview of the vulnerability-related values of the analysed climate thresholds



The capacity of the infrastructure component (green beam) and the current (designed) load (orange beam) and the future load in the context of a changing climate (red beam). The out fading colouring indicates an uncertain limit. Dashed colouring indicates a range of possible values.

5.6.1. Summary of Results and synopsis of uncertainties

The provided climate information products indicate an increase of climate stress on the watertight gasket. That increase is clear referring to hot days and not detectable (but suggested) for salinity intrusion. However, the relevance of the future change of climate stressors for the climate vulnerability of the watertight gasket is accompanied by a bunch of uncertainties and requires therefore some fundamental assumptions that are partly not plausible. Referring to the results of the climate data, an increase of deterioration rates can be expected, however, a statement if and to what extent the lifetime of the watertight gasket is affected is not possible.

Major uncertainty refers to step 1 and step 2, which refers to the characterization of vulnerability and threshold definition. No detailed causal relationship between climate and the process of deterioration could be defined, which does not allow the determination of an impact-related climate threshold. Therefore, it is not possible to determine a capacity of the watertight gasket with respect to the load provided by the climate stressors (i.e. how much load provided by climate stressors is tolerated by a lifetime of 5–10 years? [Green beams in Figure 16]); and it is not possible to assess the current vulnerability of the watertight gasket to climate stressors (i.e. how much of the current capacity is already exploited under current climate conditions? [orange beam in Figure 16]). Consequently, it is also not possible to assess the relevance of the future change in the climate stressor (i.e. how much more can the load provided by the climate stressors increase before the lifetime of the watertight gasket is significantly diminished below 5–10 years? [red beam in Figure 16]). In this context, the provided climate information provides little added value for the decision-maker to answer these questions irrespective of any uncertainties of numbers.

In addition, major uncertainties refer to the relevance of the gasket's vulnerability. The identified life-time of the gasket as well as prevalent adaptation options suggest that no climate projections are necessarily required in order to make decision on adaptation options: the gasket's lifetime is not in the range of climate projections (< 10 years) and some adaptation options (replacement of gasket) do not require a lead time beyond a similar range. A detailed analysis on the possible decision-making options (i.e. which [climate] information do I need in order to do implement the adaptation option?) as well as a criticality analysis (i.e. how relevant is the gasket for the service provided by the sluice gate?) would help to decide on the relevance and urgency of the vulnerability of concern. Such analysis would help to assess the benefit of a detailed climate risk assessment, to set priorities and thus to save resources.

Minor uncertainties refer to the data robustness: the data basis is not ideal for perfectly reliable results (e.g. data from only one observation station; limited length of time series / projected time slice; expert judgement). Consequences of this uncertainty may affect absolute numbers (e.g. range of heat days in the future) but less the direction of change.

In addition, minor uncertainties refer to the method of data analysis and presentation: climate data analysis that do not refer to the determined threshold or that provide different outputs for historic and future climate do complicate an adequate interpretation regarding the determination of (changing) risk. E.g. historic salinity analysis does not refer to the defined threshold but analysis hourly values and provides information on maximum, minimum and mean values and disregards possible relevant parts of the data set (rainy season).



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