On behalf of:

Federal Ministry
for the Environment, Nature Conservation,
Building and Nuclear Safety

of the Federal Republic of Germany

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

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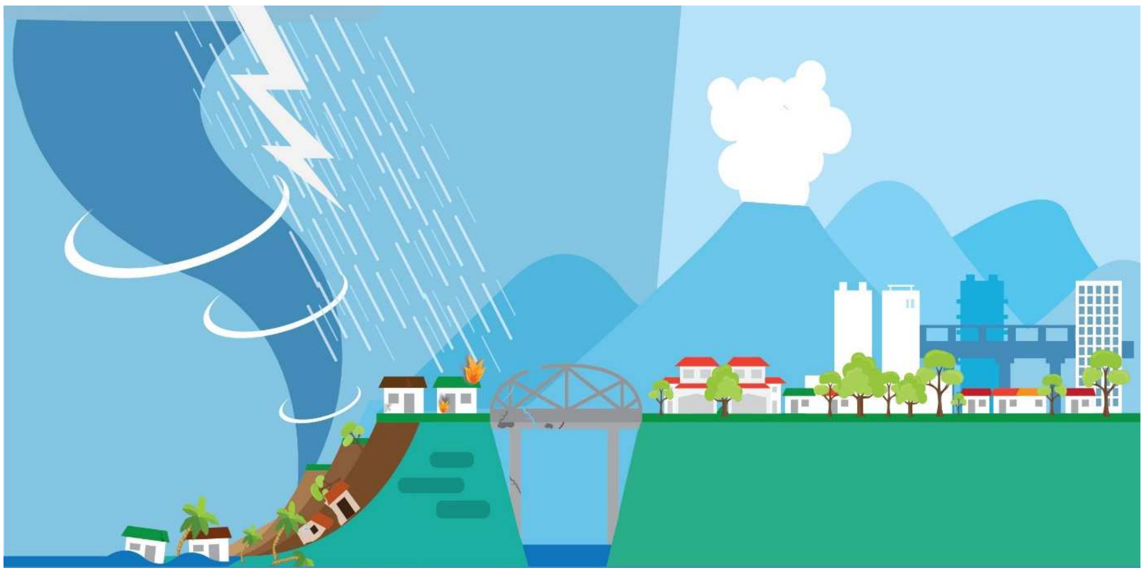
End-to-End Training on Public Infrastructure Climate Risk Assessment



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As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

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1. Background, Objective and Methods of the Training Course

Developing countries and emerging economies are investing billions in durable infrastructure every year. However, they often fail to take account of future climate change in their planning. As a result, new infrastructure projects are being implemented without consideration of their vulnerability to climate change. This leads to high risks of damage, loss and misguided investment with potentially serious consequences for the economy and society.

Therefore, infrastructure adapted to the impacts of climate change is one of the United Nations Sustainable Development Goals. A number of countries, including Brazil, Costa Rica and Viet Nam, have already launched efforts to increase the resilience of their infrastructure and have included infrastructure climate risk management in their National Adaptation Plans (NAP). But until now, little experience has been gained worldwide how to consider climate change risks in the planning, design, implementation and operation of infrastructures investments.

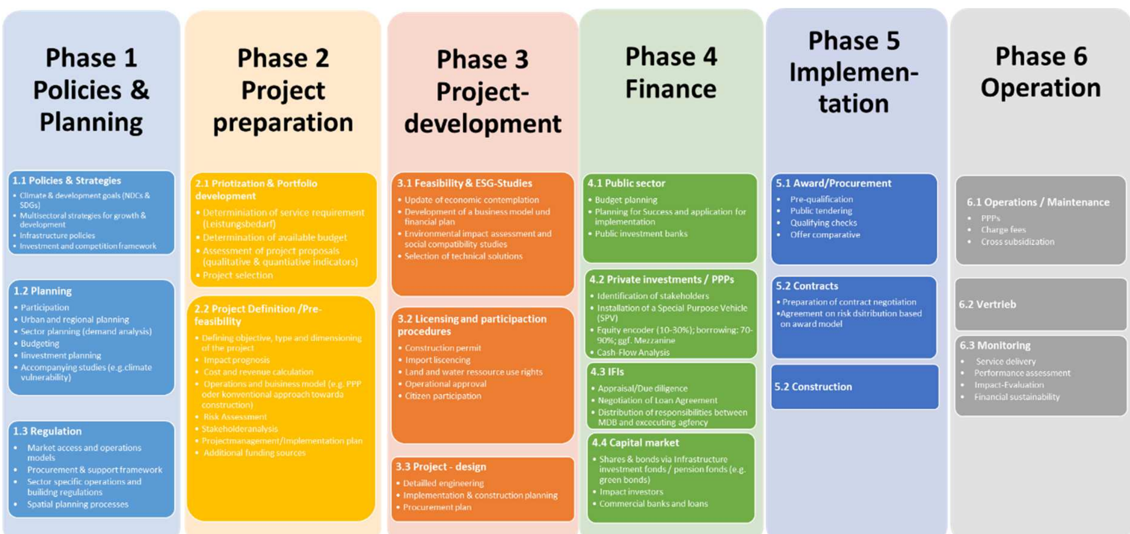


Figure 1: Project cycle of Infrastructure investments: from the policy to the project level

From 2017 – 2019, the global project on Climate Services for Infrastructure Investments (CSI), funded by the German Ministry of the Environment (BMU), together with Engineers Canada has piloted climate risk assessments of bridges (Costa Rica), power distribution systems and harbors (Brazil), sluice gates (Vietnam) and water resource management related infrastructures (Nile Basin Initiative). These pilot assessments have served discussing the institutionalization of the concept of climate proofing within the infrastructure investment cycle (Figure 1).

Using the method of the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol, the project has built local capacity through an iterative process of training and application. Hence, training and guidance for risk assessments have been provided throughout all steps of the PIEVC protocol.

The training course illustrated in this document had been developed to promote awareness about the topic of infrastructure risk assessments amongst numerous national and local stakeholders such as policy stakeholder and planners from infrastructure sector ministries and authorities. Moreover, it has served as a kick-off training for participants in the pilot risk assessment to receive a comprehensive overview of the PIEVC process and the included infrastructure risk assessment protocol. The training applies a mixed-method approach of experiential learning, composed of short inputs, group work and reflection. Exercises allow for gaining a more in-depth understanding and more insight into the technical prerequisites of the protocol, without getting lost in technical details.

The training course shall provide recipients a glimpse overview on the PIEVC process and becoming firm in explaining to others the overall context and scope, resources required, procedures and processes to follow, as well as critical issues to take care of whilst applying the PIEVC protocol. Thereby, participants are supported in their individual development regarding the following competences:

- Ability to describe the fundamental concepts related to climate change, adaptation, risk assessment, climate services
- Ability to explain the relevance of climate services for infrastructure planning
- Ability to explain the PIEVC-process to peers and stakeholders as well as superiors

2. Facilitation Plan

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
DAY 1 (half day)						
OPENING						
60’	**Objectives, scope and context of training**	• Get the big picture • Make contact with overarching strategy of the project (ideally: the partner organization) • Present trainer team	Plenary Speech from GIZ (ideally also partner organization)			Prepare plenary as round of chairs without tables. If no PPT presentation is planned, the circle can be nearly closed with one space for a pinboard in “front”. Bring a “middle piece”, e.g. a bunch of flowers on a small table cloth and place it in the middle of the circle as eyecatcher and place of stillness and beauty (if you wish you can complement the flowers by some items connected to the training, e.g. a small building truck, a rock, pebbles….
	Getting to know each other	• Identify individual and common expectations • Engage in team building • Listen to each voice	1. interview in groups of three: name, organization, specific interest in the workshop and one thing the 3 have in common (3x5’) 2. Mutual presentation in plenary (1’ p.p)	• Pinboard, • Cards (1 rectangular card pP, 1 round card per group) • Markers		0. Prepare board with heading, e.g. “The who’s who” 1. As the trainer team: complete cards as demonstration object: three bullets per person on one card and one additional card for what you have in common and show to group

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
						(Write cards neatly, be a good example for visualization 😉) 2. Invite groups one by one to present each other, do a neat time keeping, be an attentive listener (be a good example again 😉) 3. If possible welcome each participant by name when they go back to their seats (prepare name cards that can be set in front of each chair)
	Training programme, workshop methods, rules of the game	• Receive orientation on contents and methods of the workshop (also: material, documentation) • Discuss how this fits with the interests • Get in touch with the concept of shared responsibility for the workshop	Presentation and discussion	• FC to be filled in "Guidelines for effective learning" • Agenda print-outs, daily agenda on FC • Co-management committee FC		Frame the question of "rules" as "What supports us in effective learning" and ask participants what they need as to learn effectively, add you own needs (sample see Annex) If necessary: explain the workshop's work mode, e.g. in case of strong hierarchies that contributions are taken in order of showing up. Explain how the documentation will be done. Co-management committee*, see Annex*
INTRODUCTION TO INFRASTRUCTURE RISK & ADAPTATION						

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
15’	**Climate change, risks for infrastructure and adaptation opportunities**	• Understand basic concepts: climate change, adaptation • Get to know possible impact of CC on infrastructure and adaptation opportunities • Conclude that adaptation requires a systematic assessment and planning approach	• Input PPT	• Projector, Laptop, file		Keep to ~10 slides In the end make sure that the key conclusion comes across, relate it to participants’ work - and keep repeating it
15’		• Digest, relate to own work context • Sense the opportunities of peer learning	1.Buzz groups among neighbors (10’): • What are key aspects of CC for infrastructure planning in your work context? 2. Share key findings or questions in plenary (10’)	• Board • Cards • Markers		0. Prepare Board 1. Invite participants to share their ideas in buzz groups (2-4 neighbors turning in their chairs for a quick exchange) and provide each group with cards and marker 2. Assist presentation by clustering cards
Break (30’)						
EXERCISE 1: Risk Terminology						
10’	**Background and overview on the PIEVC protocol**	• Understanding the evolution of the Protocol and its context for application	• Input PPT • Flashlight on first impressions from participants	• Projector, Laptop, file • Handout process overview		0. Keep presentation short, use examples to illustrate.

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
1h15	**Elements of engineering vulnerability**	• Understand the Terminology: Risk, Impact, Sensitivity, Vulnerability, Hazard, Threshold, Severity, Probability • Identify possible entry points for "adaptation to CC"	• PIEVC Interactive exercise / action learning	• PPT that builds up during the discussion • Key slides printed out in A0 and posted on pin-boards (6) • Handout glossary		1. Go through the animated PPT and take sufficient time to ask questions before you show slides with the solutions. 2. Use the printed key slides in A0 and build them up after having presented the slides 3. Refer to the slides in the discussion as needed.
5'	Overview of next day, explain reading task			• Handout case		
30'	Co-management Committee	• Navigate to workshop towards these specific participant's needs • Create ownership for the workshop	Reflection with participant representatives and trainers • What went well • What should be differently? Together define programme of day 2			
End of day						

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
DAY 2 (full day)						
WARMING UP						
15’	Opening	• Recap • Joyful start/Energizer	Plenary Done by Co-management Committee			Be in touch with CmC to make sure the workshop starts on time
10’	Recap PIEVC Process	• Remember the PIEVC as key process • Remember the need for systematic procedures	• tbd			Ideally this will be done in a playful way, e.g. prepare cards with the different steps and more detailed of what each steps includes and ask the group to sort them in a chronological order on the floor
20’	Introduction into the exercises	• Familiarize with “experiential learning” • Familiarize with training material • Recap of the story line of the selected case study	• Input • Q&As	• Handout case (shared the evening before)		Use the map from the action learning board Explain why a fictitious case has been chosen
EXERCISE 2: UNDERSTANDING THE RISK MATRIX						
5’	Introduction to exercise 1	• Understand the objective, the tasks and work flow	• Input presentation	• FC objectives, group tasks • Handout instructions Exercise 1		Prepare FC according to exercise instructions Relate the introduction to the action learning board

Kick-off training on the PIEVC Protocol – Generic facilitation plan

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
5’	Setting up of work groups	• Get to know each other • Sense the value of exchange and collaboration, understand the need for rules of cooperation	• Division into groups (e.g. by counting) • Advise on effective group work	• FC instructions for effective group work		Depending on overall group size do 2 groups or 2x2 groups (break out groups should comprise 4-6 participants) Sample orientation for effective group work see Annex
30’	Infrastructure components (y axis)	• Understand PIEVC protocol step 1 • Understand the different infrastructure components	Break out groups • Self-guided exploration of case material • First brainstorming on cards/FC • Selection of priority items on cards	• Flipchart • Pinboard and cards • Markers		
	Climate events (x axis)	• Understand PIEVC protocol step 1 • Understand the different possible climate events/hazards		• Flipchart • Pinboard and cards • Markers		
20’	Presentation	• Learn to communicate using the technical language • Understand differences (if 2x2 groups) • Get feedback from trainers	Plenary • presentation	All groups bring their results		I suggest 3-4’ presentation per group + 5’ feedback/observations from trainer
10’	Reflection	• Relate to own work • Discuss usefulness	• Open discussion	• Flipchart for notes		Take a “good question” that came up during the presentation or a generic one, e.g. how can you use this during your work and ask participants on their ideas. If time is running out, this reflection session can be cut short.

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
Break (30’)						
EXERCISE 3: APPLYING THE RISK MATRIX (PIEVC step 3)						
15’	Introduction into the PIEVC scoring system and scoring process	Probability score • Understand how probability is calculated • Understand the difference between probability of occurrence and statistical confidence Severity (Impact) score • Understand the hierarchy of impacts and the method to assign impact values for specific infrastructure components	• Input presentation + Q&A • Develop some ficticious score with the participants.	• FC severity score • FC probability score		It is very important that the Scoring system and risk evaluation is the skeleton of the PIEVC methodology. To apply it the scoring system needs to be well understood.
5’	Introduction to the exercise	• Understand the objective, the tasks and work flow	• Input presentation	• FC objectives, group tasks Handout instructions Exercise 1 • Prepared Boards with risk matrix axis filled in (see handout exercise)		Sometimes participants may ask why they cannot continue with their own work but to be on the safe side it is helpful to have the boards prepared. Per group 1-2 infrastructure components and 3-5 climate signals. Prepare FC according to exercise instructions Prepare Boards according to exercise instructions Relate the introduction to the action learning board

Kick-off training on the PIEVC Protocol – Generic facilitation plan

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
5’	Setting up of work groups	• Understand the quality of bringing together different expertise	• Division into groups (e.g. forming a line given names from a-z and then bundle groups) • Advise on effective group work	• Boards with the scoring system		Depending on overall group size 2-4 groups (break out groups should comprise 4-6 participants) Depending on the timing, you can decide to let each group work on 1-3 infrastructure components (if you allow at least 2, there will be some learning from repetition)
60’	Applying the risk matrix	• Understand PIEVC protocol step 3 • Understanding that not all infrastructure components are at equally risk • Conclude that in time of scare resources and capacities prioritization is absolutely necessary	Break out groups • Case work (Participants shall agree on the values they want to give)	• Boards with matrix • Print-outs with matrix		Let participants work through the case study description first and advise to search for probability and severity scoring information in the case study description. Take your time to engage participants in discussions so that they can follow the tasks easily.
Lunch break (90’)						
20’	Presentation of results and conducting the risk evaluation	• Make communication experience • Understanding the role of risk evaluation based on the calculated risk values calculated from probability and severity scores.	Plenary • 4x5’ facilitated presentation in plenary on results • Comparison of risk values assigned and exemplification of debate on	• Board with the risk evaluation matrix		3-4’ presentation per group + 5’ feedback/observations from trainer

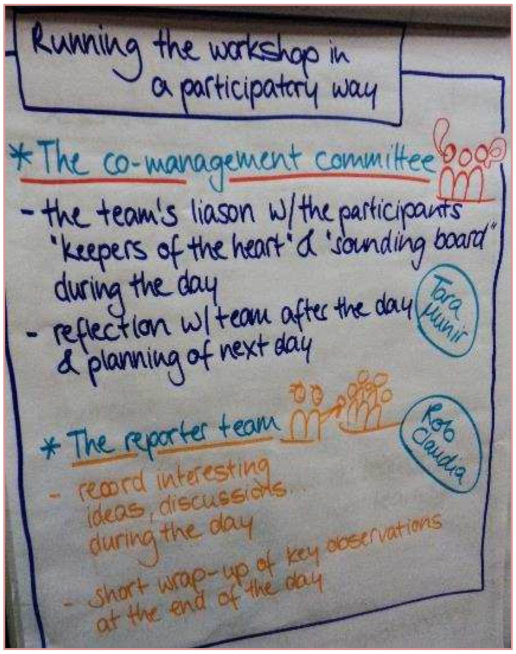
Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
			assigning risk values • Discuss the result of the risk evaluation (risk acceptability)			
15’	Reflection	• Make connection with work place	• Open discussion	• Flipchart for notes		Take a “good question” that came up during the presentation or a generic one, e.g. linking to the issue of data availability or acceptability of risk level. Even if time is running out, this reflection session should be kept in.
REFLECTION 1: Data availability (PIEVC step 2)						
20’	The big issue: data and where to find appropriate information	• Get an idea of PIEVC protocol step 2 • Understand uncertainty as a management challenge and discover tools that help dealing with it (and that you use them already) • Conclude that in-action is not an option because it includes more risks than going into the right direction	• Reflection in buzz groups on participants’ experiences: how do people, organisations and systems deal with uncertainty • Sharing in plenary	• FC for notes		You could find a few examples from daily life and gather “tools” and then reframe them in official language. E.g. “Should I take an umbrella with me, I don’t know if it’s gonna rain”: use a weather app (=go with existing knowledge), ask your granny (=expert judgement), take it anyway (=contingency planning) Possibly you can discover a few traits why people feel so reluctant, and most likely not all of them are related to sufficient information.

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
Coffee break (15’)						
REFLECTION 2: Adaptation options/recommendations (PIEVC step 5)						
30’	Defining adaptation options/ step 5 “recommendations”	• Get an idea of PIEVC protocol step 5	• Recap adaptation options • Breakout groups stand at their boards (in conference room) and discuss different options • Sharing in plenary	• FC adaptation options (day 1)		Ask participants to look at the board the worked on in exercise 2 and elaborate a few recommendations. For the sharing in plenary try not to discuss the options themselves but ask participants what the think is relevant to guide such a process in their context (meta level questions).
CLOSURE						
15’	Evaluation	• Judge own learning progress • Give constructive feedback	Individual assessment on boards • Progress tracking • What I take home • What could be done differently? Appreciation by trainers	• Boards prepared, cards, markers		For possible evaluation questions see in Annex
10’	Next steps	• Understand how the new insights relate to the PIEVC-process being kick-started	• Open discussion	• If possible FC process overview		
20’	Closure	• Vote of thanks, appreciation for what has	• A few warm words from the trainers,	• Certificates?		

Time	Topic	Learning objectives	Method	Material	Who	Suggestions for facilitation
		been achieved in the last days	possibly also from partner organisation and participants • Certificates			
End of training						

3. Guideline for facilitation

Participatory course management - the Co-management committee



The participants' committee works on a daily basis. It will take a critical review of what has happened during that particular day. This is a precious opportunity for the trainers to get first hand feedback from the group, and for the group to influence the training process likewise. Membership of the participants' committee rotate in order to give all participants this unique learning experience. In the context of this training, one committee will serve for the 1.5 days, with 2-4 participants' committee members. You should try to make it a voluntary task. I usually prepare a Flipchart explaining the role and tasks – you can add the names of the committee members (see picture).

CMC meetings can be time consuming, but evidence shows that the time invested will have clear benefits in terms of more ownership as well as feedback to the trainers (very important in a kick-off phase). Often, I announce that we take 30' all in all, which normally is enough time.

Tasks of the Co-management committee

Support during the day: Participants' committee members can be invited to take an active role during the day of their "duty". This may cover co-facilitation at a certain time, time-keeping, energising the group and questioning the participants individually on their impressions as well as being the team's sounding board.

- Recap session: The committee members and the trainers convene after the end of the training day and
  1. Discuss the day: what went well, what could/should be done differently
  2. Discuss and, if necessary amend, the agenda planned by the trainer team (e.g. less PPT, longer/shorter breaks…)
- Next day: The CMC is given 15' time first thing in the morning, they welcome the participants, do a short recap of the day before and a small energizer. Creative methods for the recap should be encouraged, e.g. interviews, radio/TV show, game. Recap and energizer can be combined.

Participants' CMC can be time consuming. Trainers may be worried that that they do not have sufficient time to prepare for the following day. But evidence shows that the time invested in a participants' committee session will have clear benefits in terms of more ownership. This is the case when participants take an active role in shaping the following day's training. While trainers should not cut the committee members short, they don't have to invite participants again and again to make suggestions. It may be that they are just fine with what you have suggested.

How to work together in a beneficial way?

- Learning means: "exploring the unknown" and "everybody has something to learn"
- There are no faults, but a worthy try and a chance to understand a different approach – and questions that come from the true interest cannot be silly.

- Everybody is responsible for his*her own learning.
- Everybody makes an effort to support the learning of others.

Guidelines for effective learning

There are different ways of framing what has been called “rules of the game” before.

1. You can elaborate rules together with the group (neatly visualised on FC and then stuck to the wall for transparency). In this case I recommend to choose a heading like “for effective learning and exchange we agree to…”
2. You can explain that effective learning depends on the entire group’s common effort, based on a “contract”. You can prepare the Fc (sse picture) beforehand and then ask participants to add. Depending on the situation, I sometime ask participants to sign the contract during the first break, which I feel makes a huge difference in liability.

Guidance for effective group work

- For effective and efficient work, a working group should select a facilitator, a time keeper and a presenter.
- Take your time to read through the task description and see of everybody is on board
- The working groups work independently
- Trainers can be asked for advice
- The main learning objective is to learn about the systematic approach and not to be comprehensive in the task

Evaluation

The objectives of an evaluation are

1. Receive feedback as trainer team, training managers/conveners
    - In rating questions
        i. On the contents of the different sessions, and their usefulness for participant’s work
        ii. If the methodological approach supported their learning
        iii. If trainer team’s approach supported their learning
    - In open questions for general feedback
        iv. What do I take home?
        v. What could be done differently

2. Give participants the opportunity for an auto-evaluation as a feedback to their own learning process
    - A suitable approach is e.g. a progress tracking

Material requirements

Ideally this training is equipped by

- 1 large workshop room with day light (>80m^2)
- Depending on the size of the workshop room and the surroundings up to 4 break out rooms
- 6 pinboards, brown paper, pins
- 5 Flipchart stands, paper
- Cards of all sorts
- Markers of all sorts

4. Case Study Description for the Climate Risk Assessment of the Millennium Bridge of the City of Metropolis

Setting the Scene – The Karibu River and the city of Metropolis

1.1 Environment

The Karibu River Watershed lies in the Eastern Province of South Country. The Northern parts of the catchment are characterized by the high Upper Mountains, gently sloping south. The Upper Mountains have been classified an Area of Extraordinary Beauty and they a renowned destination for ambitious hikers and climbers in summer. However, in the past years much of the forests had been degraded due to rapid urbanization and uncontrolled land-use changes. In the rainy season, the peaks of the mountains are often covered in clouds with intense rains occurring every afternoon causing tremendous water discharges. Two tributaries add their waters before Karibu River reaches the major bridge connecting both parts of the city accessible for vehicles.

1.2 The city of Metropolis

Metropolis has about 6 Million inhabitants. A mega city in the Eastern Province, and an area of major importance for economic activity and social life throughout the country. Metropolis is equipped with residential and commercial / industrial areas, green spaces for recreation, hospitals, schools and universities, as well as vast shopping facilities covering all needs. Thereby, the city is of major importance for the surrounding region, especially the smaller villages and dwellings who benefit from the services and facilities offered by the city. With having a harbor, the city receives importance as a gateway for the trade of goods and commodities within the region. The roads leading across the bridge is of crucial importance for traffic, transport and overall mobility.

1.3 The Millennium Bridge

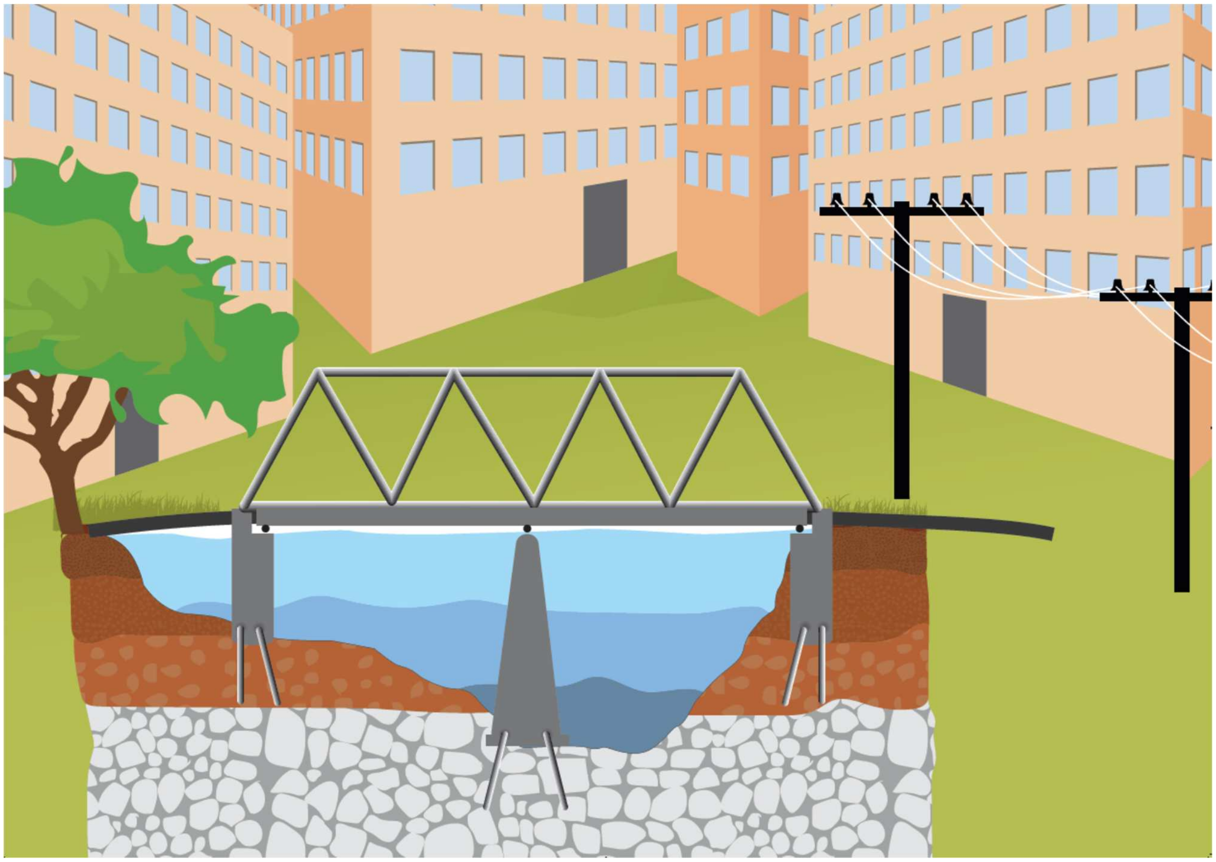
The Millenium Bridge has been rebuilt, after the last bridge was severely damaged during a so-called centennial flood in 1998 and had to be taken down due to safety reasons.

Outline of socio-economic consequences due to the bridge failure

The socio-economic impacts of this event were severe, beyond the costs of the new bridge. During the reconstruction phase, the river crossing of people and smaller vehicles was provided by a ferry service, but larger vehicles had to do a long detour of approx. 80 km to the next bridge further south. Commuting pupils and students from the Western banks had to leave their school buses at one side of the river, take the ferry and then climb on the next bus at the other side. The education statistics show a decrease in the final exam grades of commuting pupils. The health statistics of this time show a significant increase in pulmonary diseases among schoolchildren, especially in elementary school. Medical services had to operate by helicopter if there was an emergency case at the Western banks of Karibu River. Longer travel times of every day commuters from their apartments on the one side of the river to their offices on the other side of the river has caused reduced performance of companies limiting their annual turnover. The intra-regional as well as the inter-regional trade suffered from additional costs for transport as well as from a loss of customers due to vast delays in service delivery. In the second year of reconstruction, the local traditional market, as well as several restaurants at the river banks that represent important touristic places, had to be closed as the expected number of tourists had dramatically fallen the year before causing a dramatic decrease of number of overnight stays and has only recovered since a few years.

The new bridge spanning Karibu River that was built after the disastrous flood in 1998 was opened in 2000, thus dubbed the Millennium Bridge. Financing the new bridge was shared by the city administration of Metropolis and the Eastern Province. The bridge was built in adherence to the existing building codes. In 2001, it was nominated for the prize “Innovative infrastructure of the year” by the National Engineering Society of South State. The technical details include (bridge components illustration courtesy of Alberta Transportation):

Road surface (asphalt cement pavement)	Design temperatures: Superpave Performance Grading (PG) 64-22 (highest temperature of asphalt of 64 deg. C) Design life= 15 years
Bridge deck	Carbon fiber reinforced concrete; design life 75 years Drainage system Guard rails and signage
Expansion joints	Designed for 30 deg. Celsius
Piers and abutments	Designed to resist scouring of 100-year flow (equivalent to 4.300 m3/s)
Clearance of bridge deck above high-water level	Designed for 100-year (for a design flood of 6.5m above sea level = +4.5m above average)



The Millennium Bridge is managed by the Metropolis City Infrastructure Authority in cooperation with the Province's Road Maintenance Department. The bridge will be examined concerning functionality and maintenance in a through check-up in 2020. In this process, possible repairs or refurbishments can be programmed.

3. Climate Information

2.1 Current climate and hydrology

The following graph shows the current climate conditions in the catchment on a monthly basis for precipitation and on a daily basis for temperature.

The recent climate for Metropolis, South State & the Karibu River Hydrology

Month	Average Monthly Precipitation [mm]	Average Daily Temperature [° C]
Jan	252	22,3
Feb	193	24,1
Mar	120	21,3
Apr	52	20,5
May	33	19,1
Jun	16	18,3
Jul	8	18,1
Aug	7	19,8
Sep	22	23,1
Oct	253	24,5
Nov	298	24,3
Dec	280	23,7
Annual mean	**1534 mm**	**21,6°C**

(Mean climate parameters 1981-2010)

The Karibu's River flow is determined by the precipitation patterns in the catchment - in normal years: majority of rainfall in November to February, negligible rainfall during the rest of the year.

The normal level of the river is at 2m (measure point: +1.5m above sea level), with a mean annual discharge pf 250m^3/s. The highest recorded water level was 8.43m, the highest recorded discharge 4.300m^3/s (1998).

Besides the natural pastures at the Eastern & Western Bank there are no flood control/defence mechanisms in place.

2.2 Recent observed changes in climate and hydrology

The observed changes in annual mean temperature are +0,8°C since 1970. The lower parts of the Karibu River catchment regularly experience high water levels from December to February, due to the seasonal intensive rains. Overall, the frequency of strong rainfall events has increased. Although, the average amount of annual rainfall is largely unchanged, especially during El-Nino years, more precipitation in the rainy season (more rainfall and torrential rains) has been experienced in the past decade. The bridge had been partly damaged by flooding in the past, however, the last severe damage before the one leading to the reconstruction in 1998 had been before the beginning of the 20th century (had to be looked up at the town's archives). Thus, the flood in 1998 was called a centennial flood. However, the frequency of such disruptive high water levels appears to be increasing and a severe flood – similar to the one in 1998 – has reoccurred once since.

A relatively new feature are random thunderstorms accompanied by strong rains in the northern part of the watershed, where steep, bare rock slopes are common, leading to extraordinary high water levels, and eventually causing flooding of the cities original flood plain, that is now urbanized.

The other experienced extremes in recent years have mainly occurred during La-Nina, where precipitation has decreased accompanied by drought conditions and heat waves.

2.3 Climate projections in the Karibu River Catchment

Temperature

- Annual mean temperature rising by 2-3°C in the Upper Mountains and 1-3°C in the river valley by the 2050s (compared to the 1970 to 2000 average).
- Increase in heat waves in summer and during La-Nina years with
    - Likely occurrence of temperatures exceeding 35 degrees in three consecutive days
    - Probable occurrence of temperature exceeding 40 degrees in five consecutive days leading to asphalt temperatures exceeding 64° Celsius.

Precipitation

- Slight increase in mean annual precipitation by the 2050s (compared to the 1970 to 2000 average).
- More intense precipitation in the rainy season and more intense El-Nino related rains.
- Precipitation focused on shorter periods.
- Increase in thunderstorms with high intensity rainfall events in summer (short and heavy rains with up to 35l/m^2 in 6h).

Wind and storms

- Increase in thunderstorms with increased average and top wind speed.

Surface hydrology

- More variable river flows.
- Likely more frequent floods exceeding discharge of 4.300m^3/s and exceeding 6.5m water level above sea level.
- Longer periods without significant precipitation (dry spell)
- Lower late summer river flows.
- Increased erosion of sloping land and reservoir catchments.
- Larger sediment loads in lower Karibu River.

5. Exercises

Exercise 2a - Scoping the system of interest

Learning objective

In exercise 2a you will learn about how to scope your system of interest that will be subject to risk assessment. This means identifying and agreeing on the infrastructure components considered in the assessment. Scoping your system of interest is a crucial first step in risk assessment.

Method

You will work together in mixed teams. Please find some hints for a fruitful cooperation in the box below.

Guidance for effective group work

- For effective and efficient work, a working group should select a facilitator, a time keeper and a presenter.
- Take your time to read through the task description and see if everybody is on board.
- The working groups work independently.
- Trainers can be asked for advice.
- The main learning objective is to learn about the systematic approach and not to be comprehensive in the task

Instructions / What to prepare

You are part of the expert team, preparing the check-up mission for the Metropolis Millennium Bridge, South State. You and your colleagues bring in the engineering expertise.

- Together review the case description.
- Use a flipchart
    - List all infrastructure components that you find in the case description and add from your own experience.
    - Ideally cluster the components, e.g. according to different aspects of the bridge management or construction.
    - If possible, give indications for the design load for each component (in case you can identify them in the case description: watch out for them).
- Prepare your presentation to the plenary

Exercise 2b – Definition of Critical Climate Events

Learning objective

In exercise 2b you will learn about the key features of the PIEVC risk matrix: Identifying and agreeing on the climate signals and the critical climate events to be considered in the assessment.

Method

You will work together in mixed teams. Please find some hints for a fruitful cooperation in the box below.

Guidance for effective group work

- For effective and efficient work, a working group should select a facilitator, a time keeper and a presenter.
- Take your time to read through the task description and see if everybody is on board.
- The working groups work independently.
- Trainers can be asked for advice.
- The main learning objective is to learn about the systematic approach and not to be comprehensive in the task

Instructions / What to prepare

You are part of the expert team, preparing the check-up mission for the Metropolis Millennium Bridge South State. You and you colleagues bring in the meteorological and climate change expertise.

- Together review the case description.
- Use a flipchart
    - Based on the case, list all relevant climate parameters (historic, recent and projected) and add from your own experience. Moreover, define the critical climate events related to the sensitivity of the infrastructure components.
    - Ideally cluster the different climatic factors that relate to each other
- Prepare your presentation to the plenary

Product of Exercise 1 & 2

Infrastructure components	Climate Variable: e.g. Temperature								Climate Variable: e.g. Precipitation							
	Critical climate event				Critical climate event				Critical climate event				Critical climate event			
	yes/ no?	P	S	R	yes/ no?	P	S	R	yes/ no?	P	S	R	yes/ no?	P	S	R
1 …………	no	-	-	-	yes	4	2	**8**								
2 …………	yes	2	8	**16**	no	-	-	-								
3 …………																
4 …………																

Exercise 3 – Assessing and evaluation of the risk

Learning objective

In exercise 3 you will learn to apply the PIEVC risk matrix, considering

- the relevance of a climate parameter for a certain infrastructure component (Exposure yes / no)
- its probability of occurrence
- the severity of the possible consequences
- and finally conclude a risk score.

Method

You will work together in mixed teams. Please look at the description of exercise 1 to find some hints for a fruitful cooperation.

Your task

You are part of the expert team, involved in the check-up mission for the Metropolis Millennium Bridge, South State. Finally, this process aims at making the Millennium Bridge “climate proof”.

At this point of the process, after much preparation has been done, you are asked to participate in the risk assessment – the result of the risk assessment shall guide the next steps. As the detailed analysis is quite costly, is shall be carried out for priority aspects.

The steps of the risk assessment you need to follow:

<u>A. Preparation</u>

1. Have your case description at hand and carefully look at the risk assessment spreadsheet (Exercise materials A). --> Read the following task description carefully.
2. Discuss possible procedural questions with your team colleagues and make sure everyone is on-board.

<u>B. Assess the relevance</u>

3. Evaluate the criticality (importance of the component for the entire infrastructure) of each component on a scale between 1 and 5 (1= not critical, 5= highly critical)
4. Yes/no analysis: Mark a checkmark where you believe a Climate Event could have an interaction with each infrastructure component (exposure assessment).

<u>C. Define the probability</u>

5. Using the Probability Score (Exercise materials B) please fill in column “P” (= **P**robability) for each climate variable defined. Based on the climate descriptions in the case study, please decide upon which method (A or B) of the probability scoring you would like to apply. This would normally also be done by the experts. However, please try it. Carefully read all details in the case study description.

<u>D. Define the severity</u>

6. Elaborate for each climate variable and infrastructure component an “impact chain”: What is the cascade of impacts in a situation where a climate event triggers the threshold of a selected infrastructure component.
7. Based on the impact chains develop apply the Severity Score (Exercise materials C) and fill in column “S” (= **S**everity) for each infrastructure component. Please decide upon which method (A

or B) of the severity scoring you would like to apply. Rethink again what the different methods mean.

E. Do the risk scoring

8. Do the maths: Risk (R)=Probability (P)*Severity (S)
9. Align the values calculated with those in the risk matrix (Exercise materials D) and cross the respective boxes in the matrix.
10. Look at the suggested risk thresholds – does this judgement seem reasonable to you? Is this prioritisation of risks acceptable?
11. What do you think are the implications for risk reduction, please discuss
12. Prepare your presentation in plenary

Product

THE RISK MATRIX

Severity							
7	7	14	21	28	35	42	49
6	6	12	18	24	30	36	42
5	5	10	15	20	25	30	35
4	4	8	12	16	20	24	28
3	3	6	9	12	15	18	21
2	2	4	6	8	10	12	14
1	1	2	3	4	5	6	7
	1	2	3	4	5	6	7

Probability of Occurrence

6. Glossary of key terms[1]

TERM	DEFINITION
HAZARD / CLIMATE EVENT / CLIMATE VARIABLE	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts. (IPCC AR5)
CLIMATE	Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. (IPCC AR5)
CLIMATE CHANGE	Climate change refers to a change in the state of the Climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes. (IPCC AR5)
EXPOSURE	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. (IPCC AR5)
CRITICAL CLIMATE EVENT	A critical climate event is defined as a climate condition that exceeds the identified load capacity of an infrastructure component leading to an impact on the component.

[1] Sources
- IPCC AR5: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_Glossary.pdf
- GIZ Risk Supplement to the Vulnerability Sourcebook https://www.adaptationcommunity.net/wp-content/uploads/2017/10/GIZ-2017_Risk-Supplement-to-the-Vulnerability-Sourcebook.pdf

PROBABILITY / LIKELIHOOD	The chance of a specific outcome occurring, where this might be estimated probabilistically. (IPCC AR5) Note: In the IPCC AR5 likelihood is expressed using a standard terminology.
CLIMATE PROJECTION	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized. (IPCC AR5)
DESIGN LOAD	The design load is the maximum load (or force) a system (or its individual components) is designed to sustain.
THRESHOLD	In the context of a PIEVC Protocol assessment, Threshold relates to the intensity (magnitude) of a climate event that affects the performance of the asset or its components. → "Performance Considerations"
VULNERABILITY / SENSITIVITY	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. (IPCC AR5) Vulnerability has two relevant elements: 1. Sensitivity is determined by those factors that directly affect the consequences of a hazard. Sensitivity may include physical attributes of a system (e.g. building material of houses, type of soil on agriculture fields), social, economic and cultural attributes (e.g. age structure, income structure). 2. Capacity in the context of climate risk assessments refers to the ability of societies and communities to prepare for and respond to current and future climate impacts. It comprises: a. Coping capacity: The ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term (e.g. early warning systems in place). b. Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (e.g. knowledge to introduce new farming methods). (GIZ Risk Supplement to the Vulnerability Sourcebook)
PERFORMANCE RESPONSE CONSIDERATIONS	Also referred to as "Infrastructure Response Considerations" in the PIEVC Protocol, infrastructure response criteria establish a range of outcomes of climate-infrastructure-interaction outcomes that are tailored to the specific assessment and provide a basis for the → severity scoring. These may include performance considerations such as structural (e.g., will the asset or component fail?), functional/capacity (e.g., is the capacity of the asset or

	component to provide the service as designed affected?), or operations and maintenance (e.g., does the climate event affect access to the asset or component? Is the service life of the asset or component reduced due to the event?)
IMPACT	Effects on natural and human systems. In the AR5, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and sea level rise, are a subset of impacts called physical impacts. (IPCC AR5)
SEVERITY (SCORE)	In the context of a PIEVC Protocol assessment, the Severity score (or rating) relates to the gravity (seriousness) of the effects and consequences a climate event occurring at the selected intensity threshold on the assets or components.
RISK	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. (IPCC AR5) Risk results from the interaction of vulnerability, exposure, and hazard. (GIZ Risk Supplement to the Vulnerability Sourcebook) The easy risk formula is Risk=probability*severity
ADAPTATION	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. (IPCC AR5)

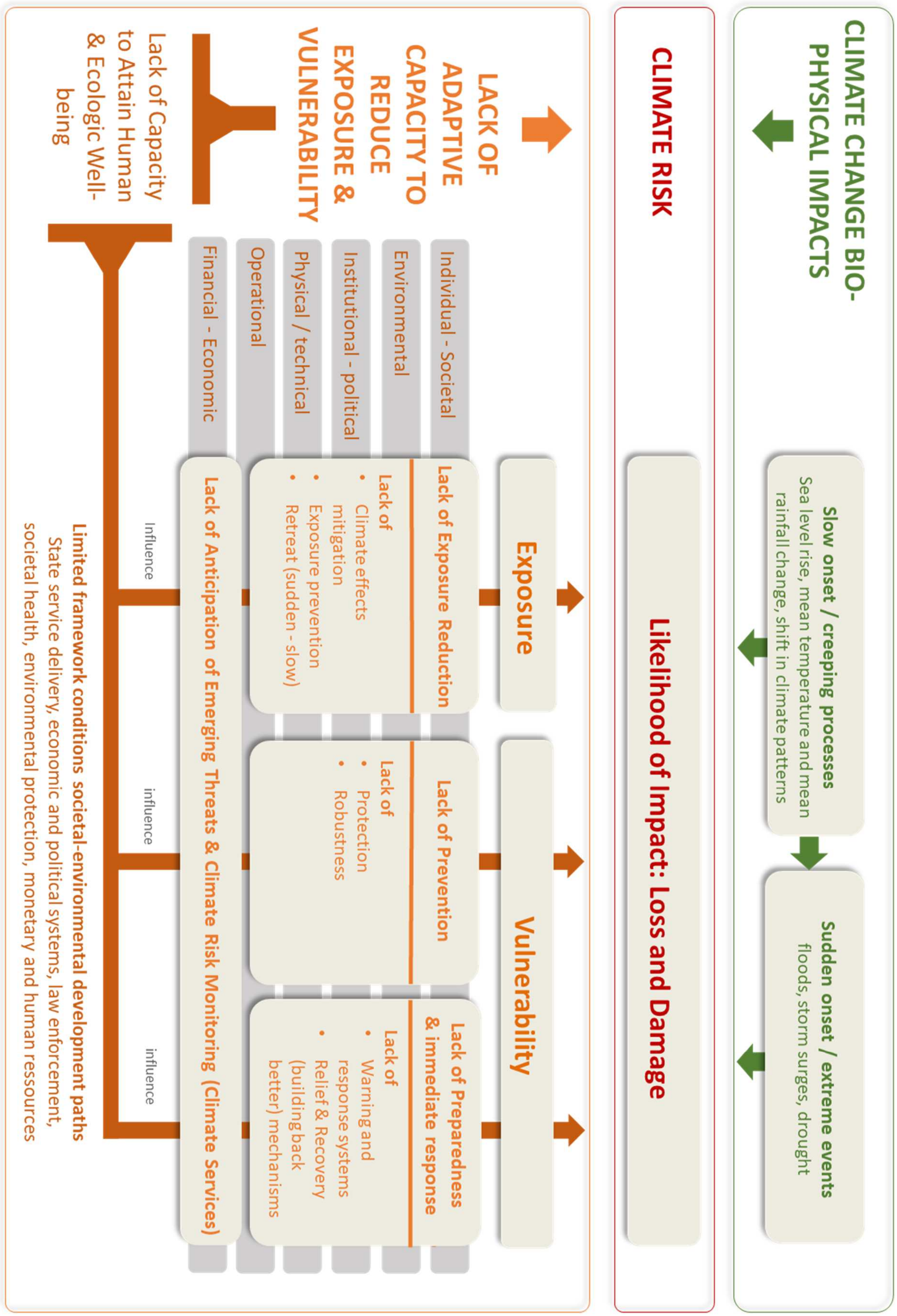
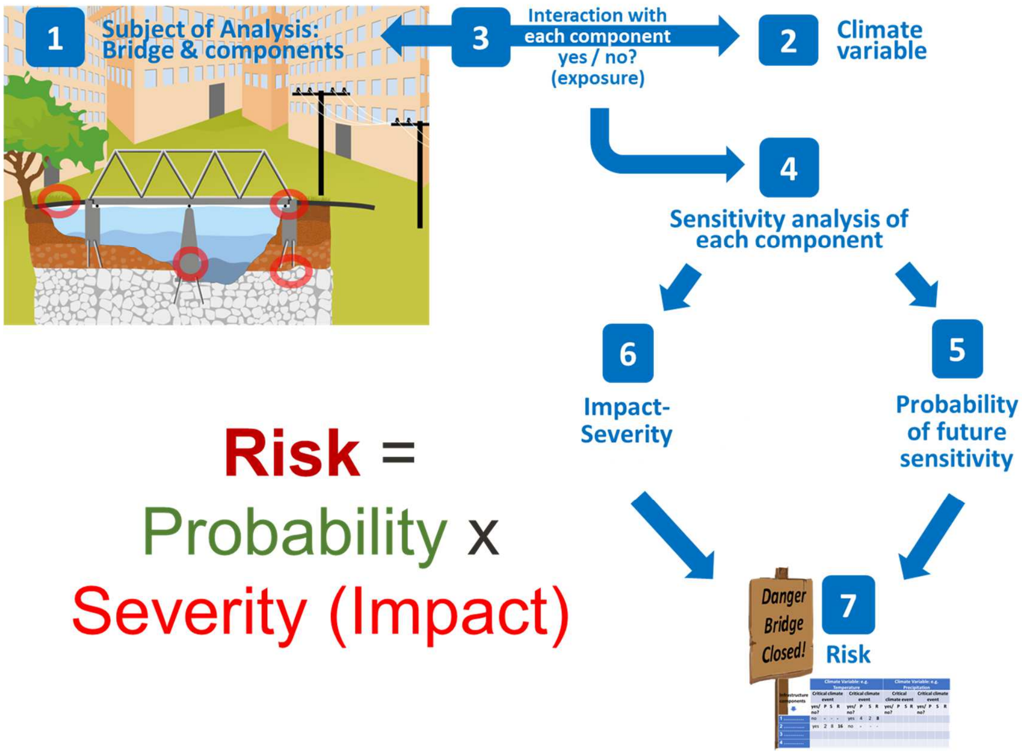
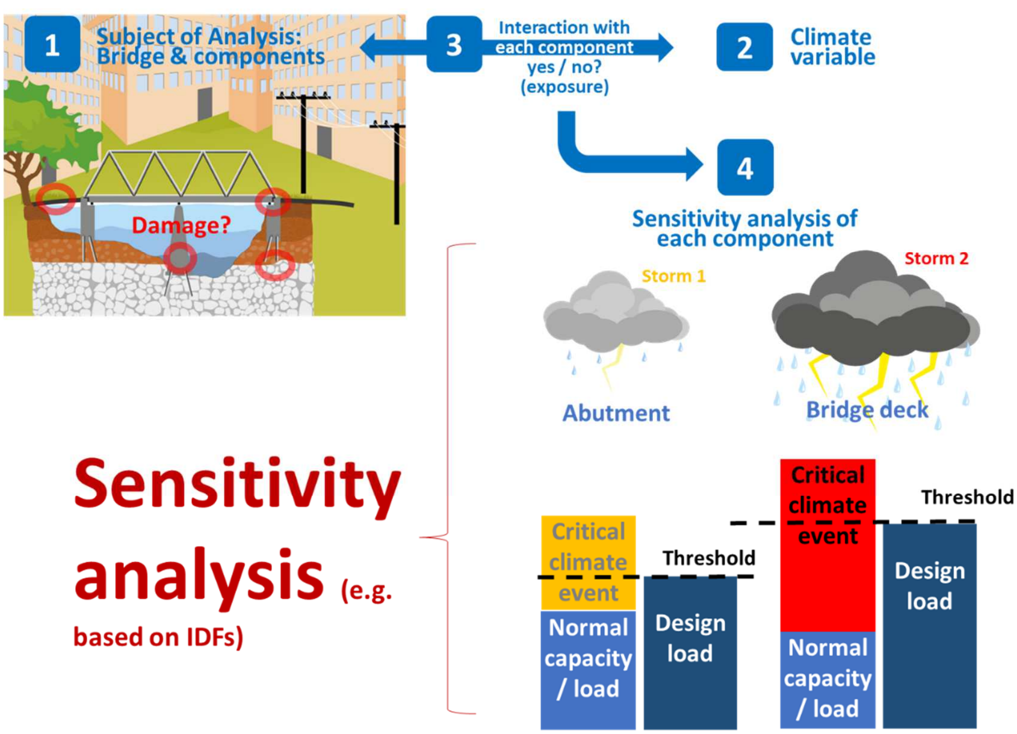
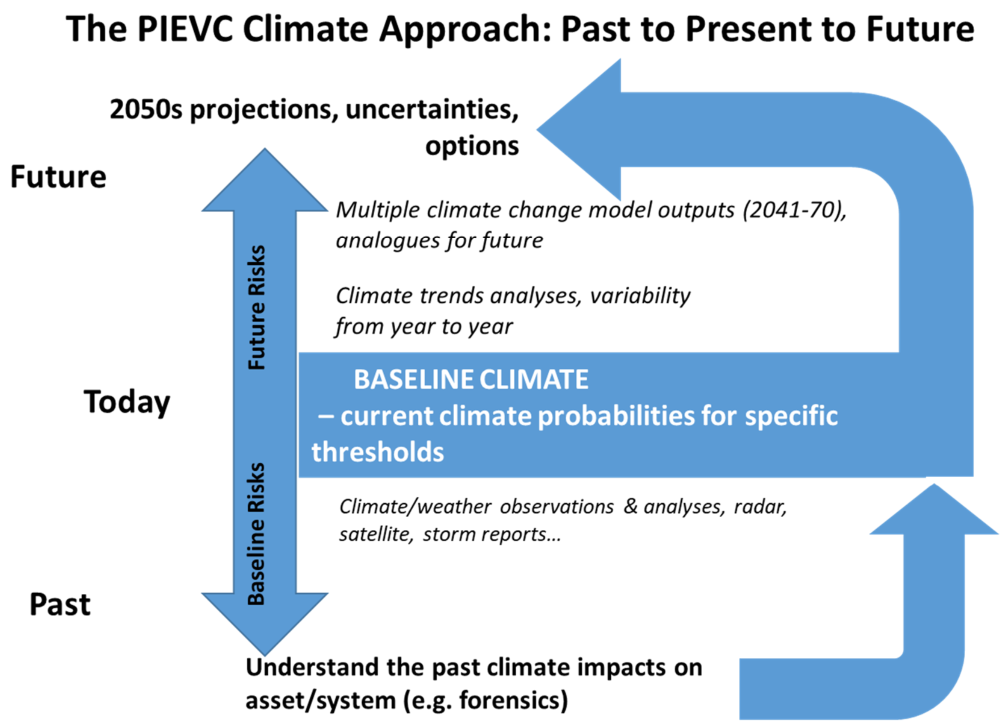


Figure: The causal structure of Risk (Source: Baumert, N.; adapted from Baumert N (2016)

7. Annex: Key slides from Action learning exercise







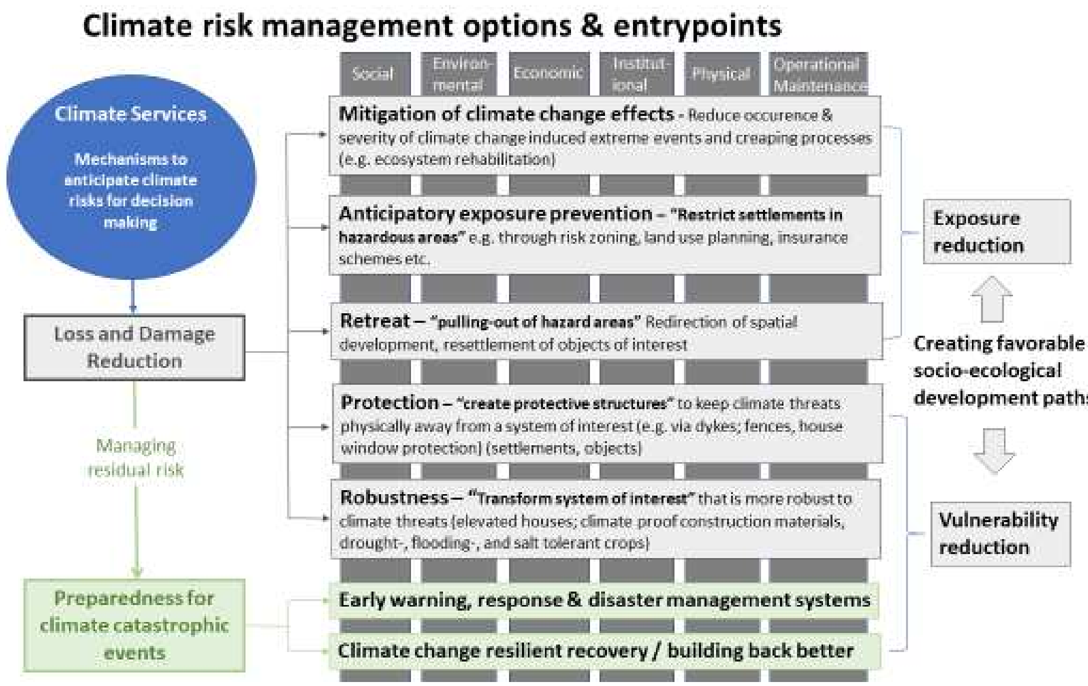
Score	Probability Scoring	
	Method A	**Method B**
0	Negligible Not Applicable	< 0.1 % < 1 in 1,000
1	Highly Unlikely Improbable	1 % 1 in 100
2	Remotely Possible	5 % 1 in 20
3	Possible Occasional	10 % 1 in 10
4	Somewhat Likely Normal	20 % 1 in 5
5	Likely Frequent	40 % 1 in 2.5
6	Probable Very Frequent	70 % 1 in 1.4
7	Highly Probable Approaching Certainty	> 99 % > 1 in 1.01

Score	Severity / impact scoring	
	Method A	Method B
0	No effect	Negligible Not applicable
1	measurable	Very low Some measurable change
2	minor	Low Slight loss of severiability
3	Moderate	Moderate loss of serviceability
4	Major	Major loss of serviceability Some loss of capacity
5	Serious	Loss of capacity Some loss of function
6	Hazardous	Major Loss of function
7	Catastrophic	Extreme Loss of Asset

THE RISK MATRIX

Severity							
7	7	14	21	28	35	42	49
6	6	12	18	24	30	36	42
5	5	10	15	20	25	30	35
4	4	8	12	16	20	24	28
3	3	6	9	12	15	18	21
2	2	4	6	8	10	12	14
1	1	2	3	4	5	6	7
	1	2	3	4	5	6	7

Probability of Occurrence


Climate risk management options & entrypoints
Social
Environ-mental
Economic
Institut-ional
Physical
Operational Maintenance
Climate Services
Mechanisms to anticipate climate risks for decision making
Loss and Damage Reduction
Managing residual risk
Preparedness for climate catastrophic events
Mitigation of climate change effects - Reduce occurence & severity of climate change induced extreme events and creaping processes (e.g. ecosystem rehabilitation)
Anticipatory exposure prevention – "Restrict settlements in hazardous areas" e.g. through risk zoning, land use planning, insurance schemes etc.
Retreat – "pulling-out of hazard areas" Redirection of spatial development, resettlement of objects of interest
Protection – "create protective structures" to keep climate threats physically away from a system of interest (e.g. via dykes; fences, house window protection) (settlements, objects)
Robustness – "Transform system of interest" that is more robust to climate threats (elevated houses; climate proof construction materials, drought-, flooding-, and salt tolerant crops)
Early warning, response & disaster management systems
Climate change resilient recovery / building back better
Exposure reduction
Creating favorable socio-ecological development paths
Vulnerability reduction