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ICOLD
27TH CONGRESS
90TH ANNUAL
MEETING



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27^{ÈME} CONGRÈS
90^{ÈME} RÉUNION
ANNUELLE



ICOLD Technical Committee Y « Climate Change »

Workshop « **Climate Change: Risks & Opportunities for Dams, Reservoirs and Hydropower** » - May 28, 2022

Experience by AFRY on the Application of the IHA Climate Resilience Guide

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ICOLD TC Y Workshop 2022-05-28



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Overview

- Introduction to case studies
- Similarities and differences
 - Stakeholder engagement
 - Data availability
 - Baseline definition
 - Climate stress test
- Conclusions

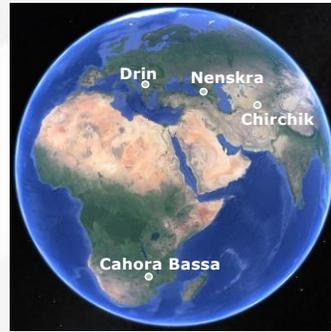
Case studies using IHA Climate Resilience Guide

Selected examples:

- Drin cascade (KESH), Albania
- Chirchik-Boszu (Uzbek Hydro), Uzbekistan
- Cahora Bassa (HCB), Mozambique
- Nenskra HPP, Georgia



Study areas overview

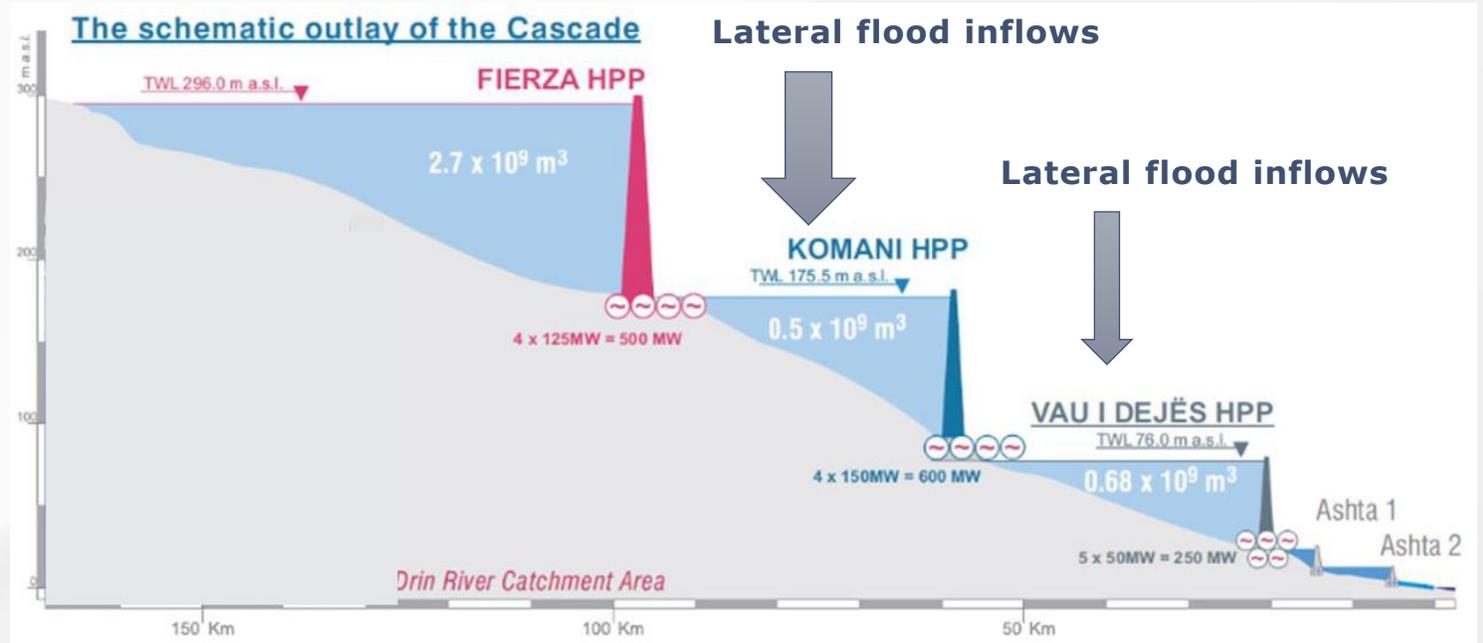


| | KESH | Uzbek | HCB | Nenskra |
|---------------------|-------------------------------|--|--------------------------------------|---------------------------------|
| River basin | Drin | Chirchik-Bozsu | Zambezi | Enguri |
| Country | Albania | Uzbekistan | Mozambique | Georgia |
| Transboundary | Yes (3 countries) | Yes (3 countries) | Yes (6 countries) | No |
| Catchment size | 14 000 km ² | 14 100 km ² | 1 064 400 km ² | 300 km ² |
| Hydropower capacity | 1350 MW | 40 MW | 2075 MW | 280 MW |
| Plant status | Existing | Existing (refurbishment) | Existing | Planned |
| Cascade operation | 1 seasonal, 2 run-of-river | 4 run-of-river, (1 upstream seasonal) | 1 seasonal, (2 upstream seasonal) | 1 seasonal, 1 diversion weir |
| Unique feature | High lateral flood inflows | Complex water allocation | Upstream dam operation | Snow and glacier impacts |
| CRA study status | Finished | Finished | Ongoing | Ongoing |

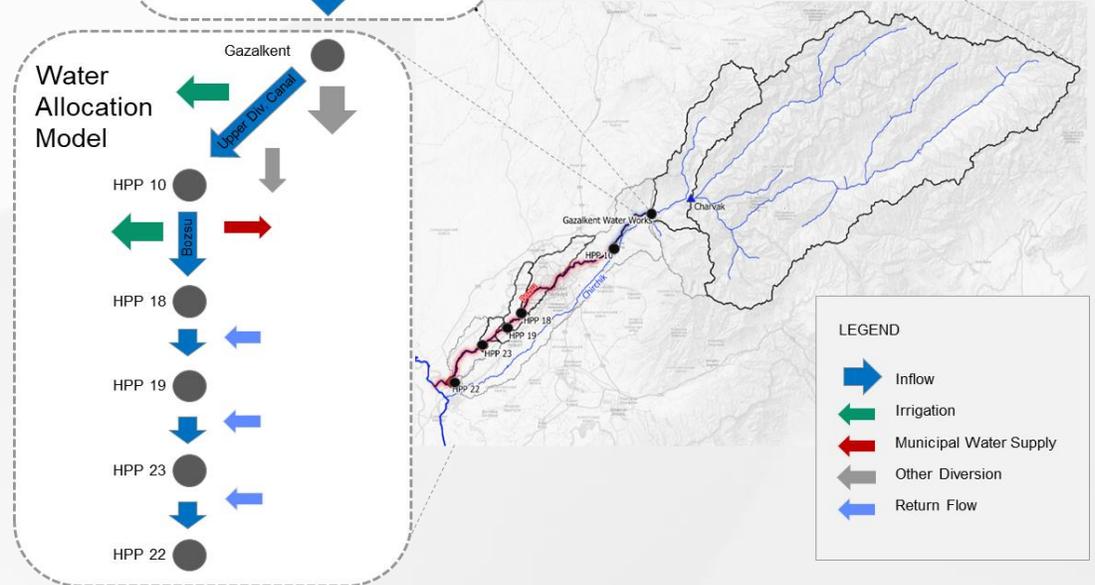
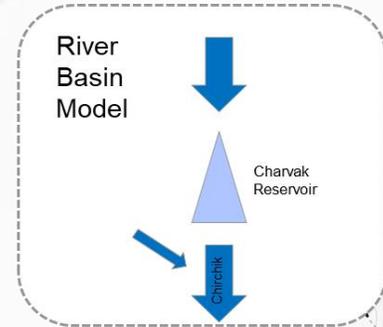
KESH Albania: Lateral flood inflows into the cascade



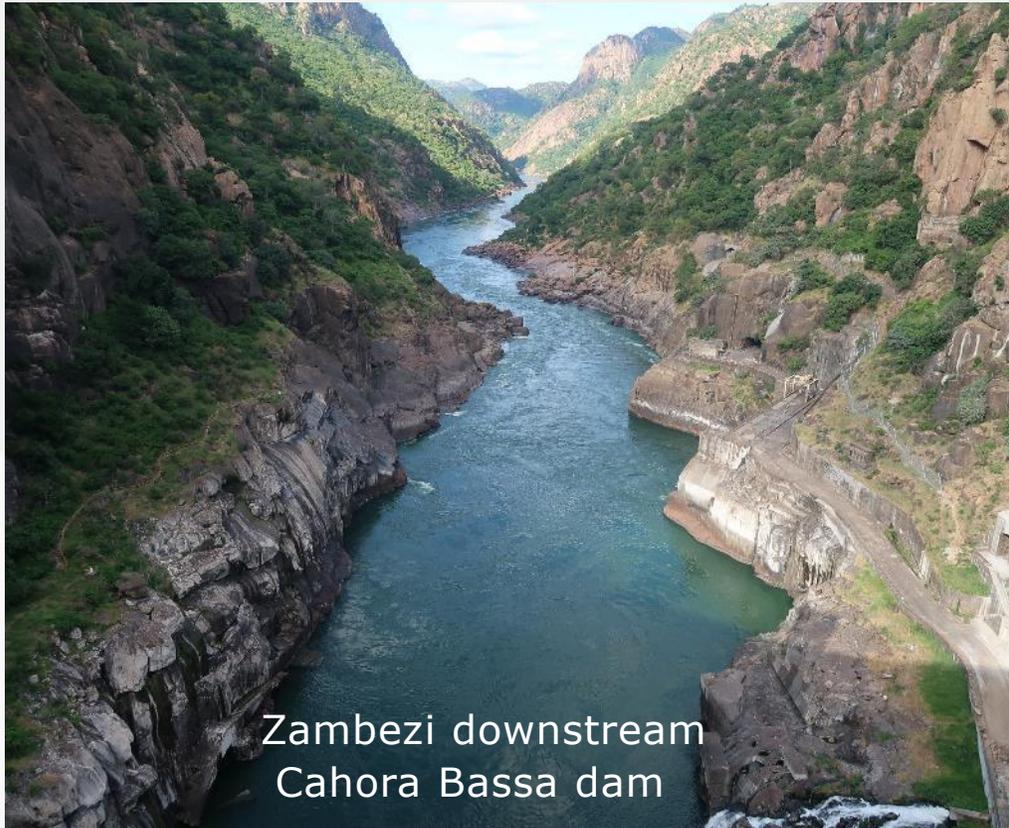
Komani reservoir



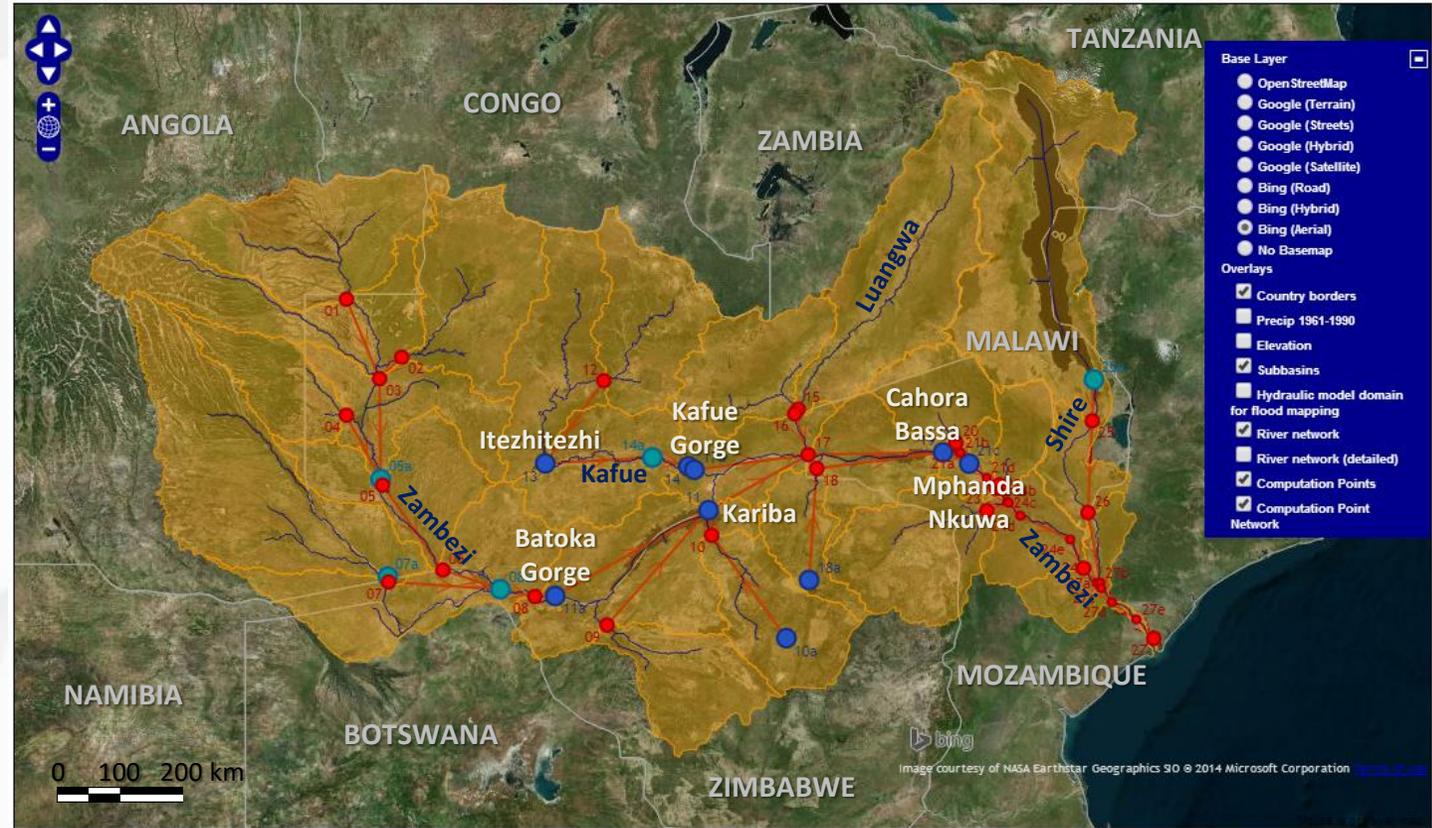
Uzbek Hydro, Uzbekistan: Water allocation and irrigation withdrawals



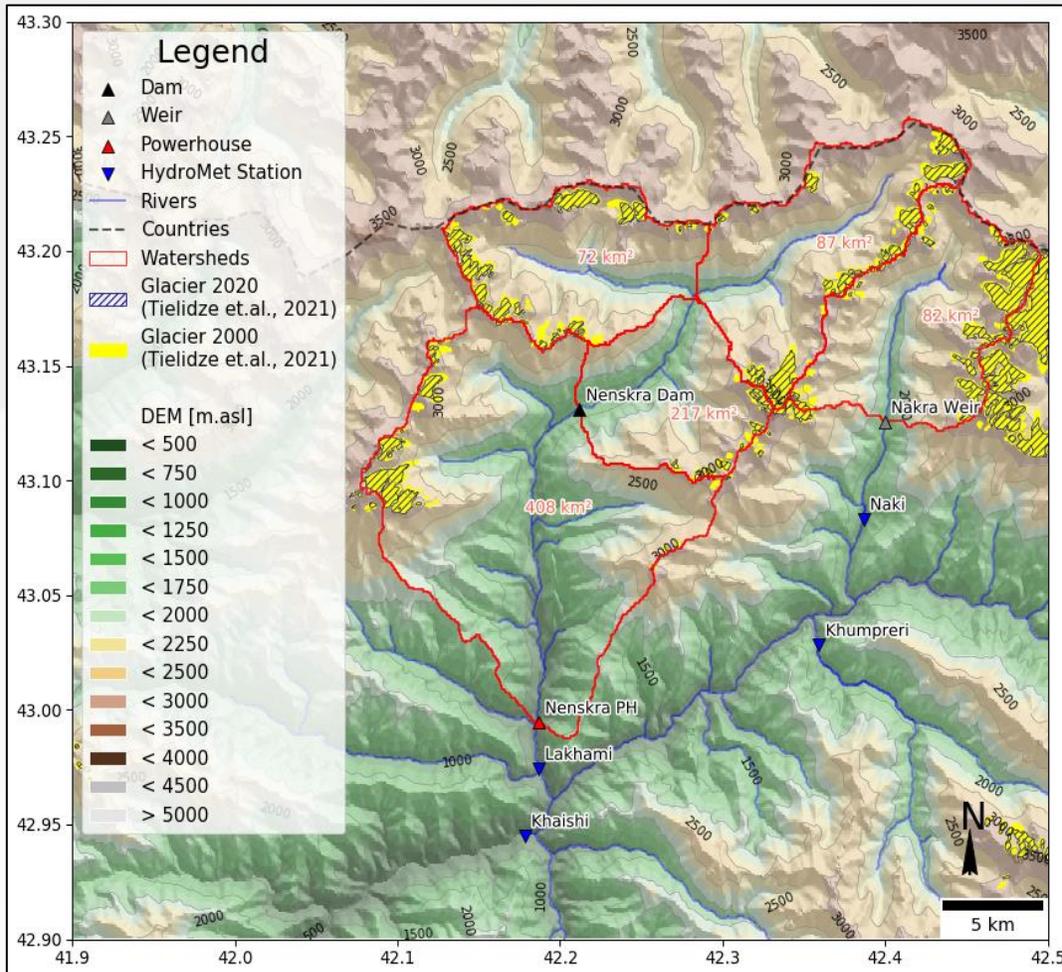
Cahora Bassa, Mozambique: Upstream dam operation



Zambezi downstream
Cahora Bassa dam

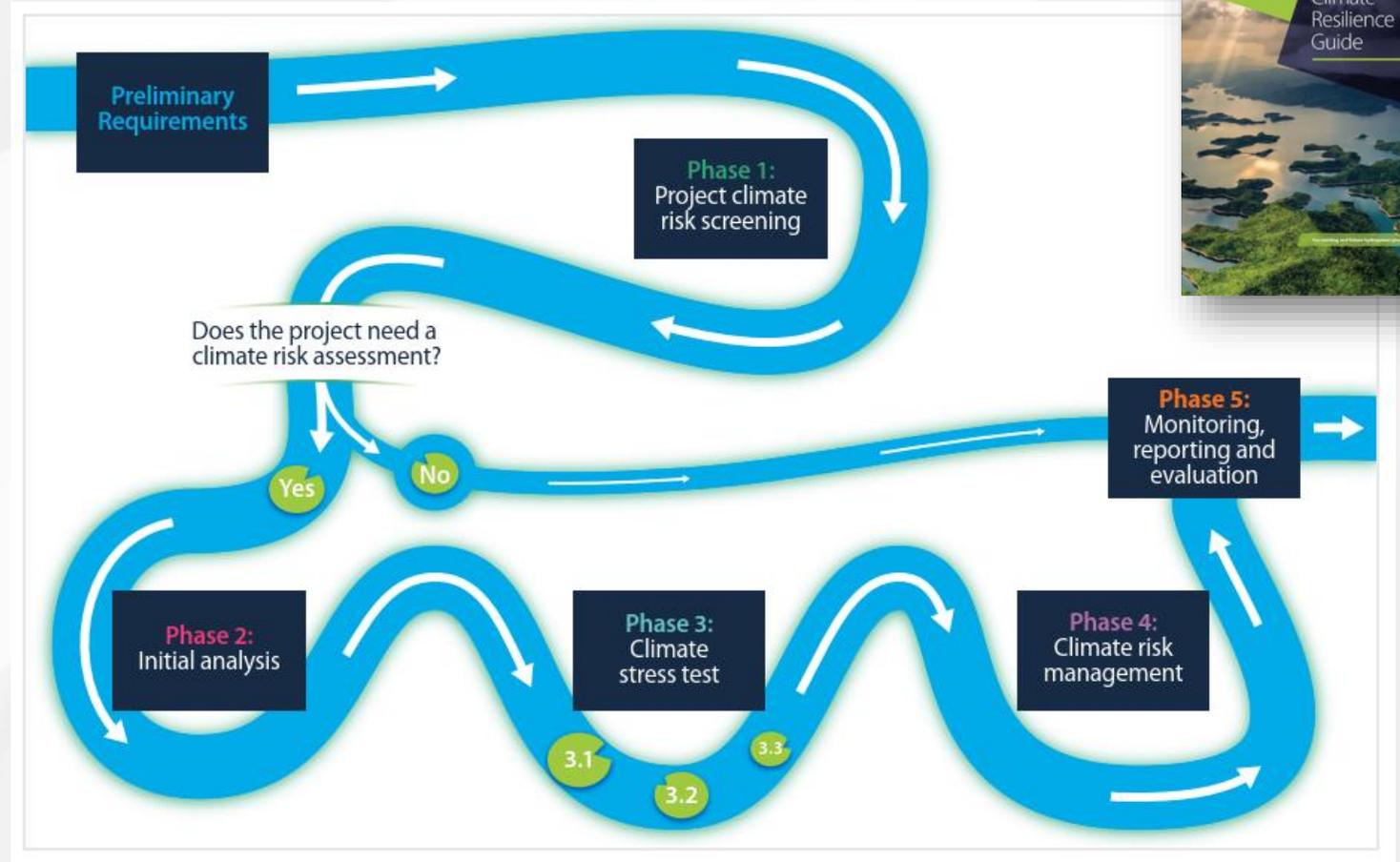


Nenskra HPP, Georgia: Snow and glacier impacts



Similarities and Differences in the Case Studies

- Stakeholder engagement
- Data availability
- Baseline definition
- Climate stress test



Stakeholder engagement

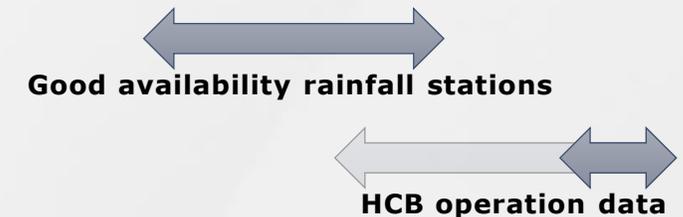
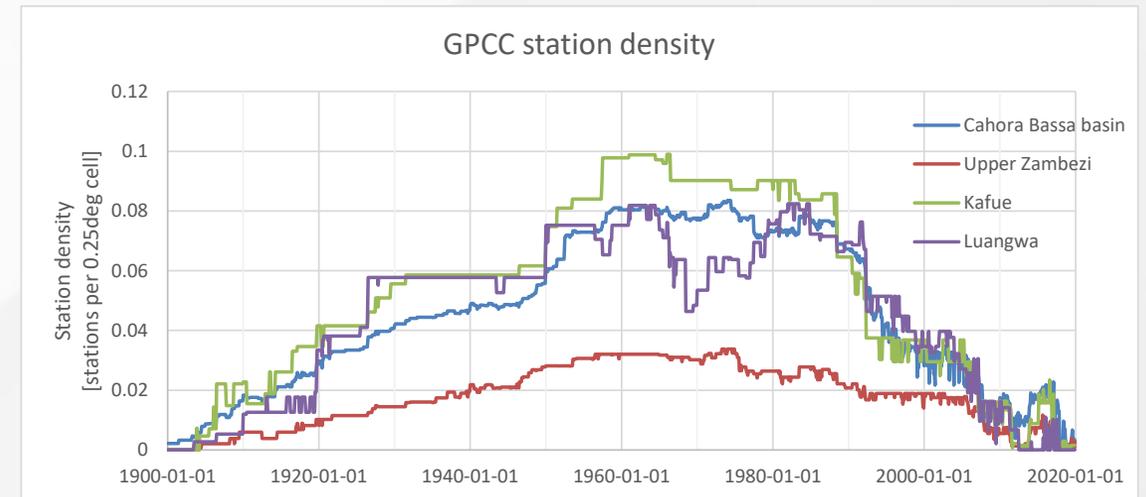
- AFRY's approach for stakeholder engagement:
 - Level of detail is a decision by the Client
 - Sensitive information
 - AFRY supports clients with outreach activities
- Capacity building and training
 - Some clients are mainly interested in the CRA results, not capacity building
 - For other clients close cooperation in all phases of CRA, including:
 - Interactive workshops
 - Hands-on training for key experts



Data availability

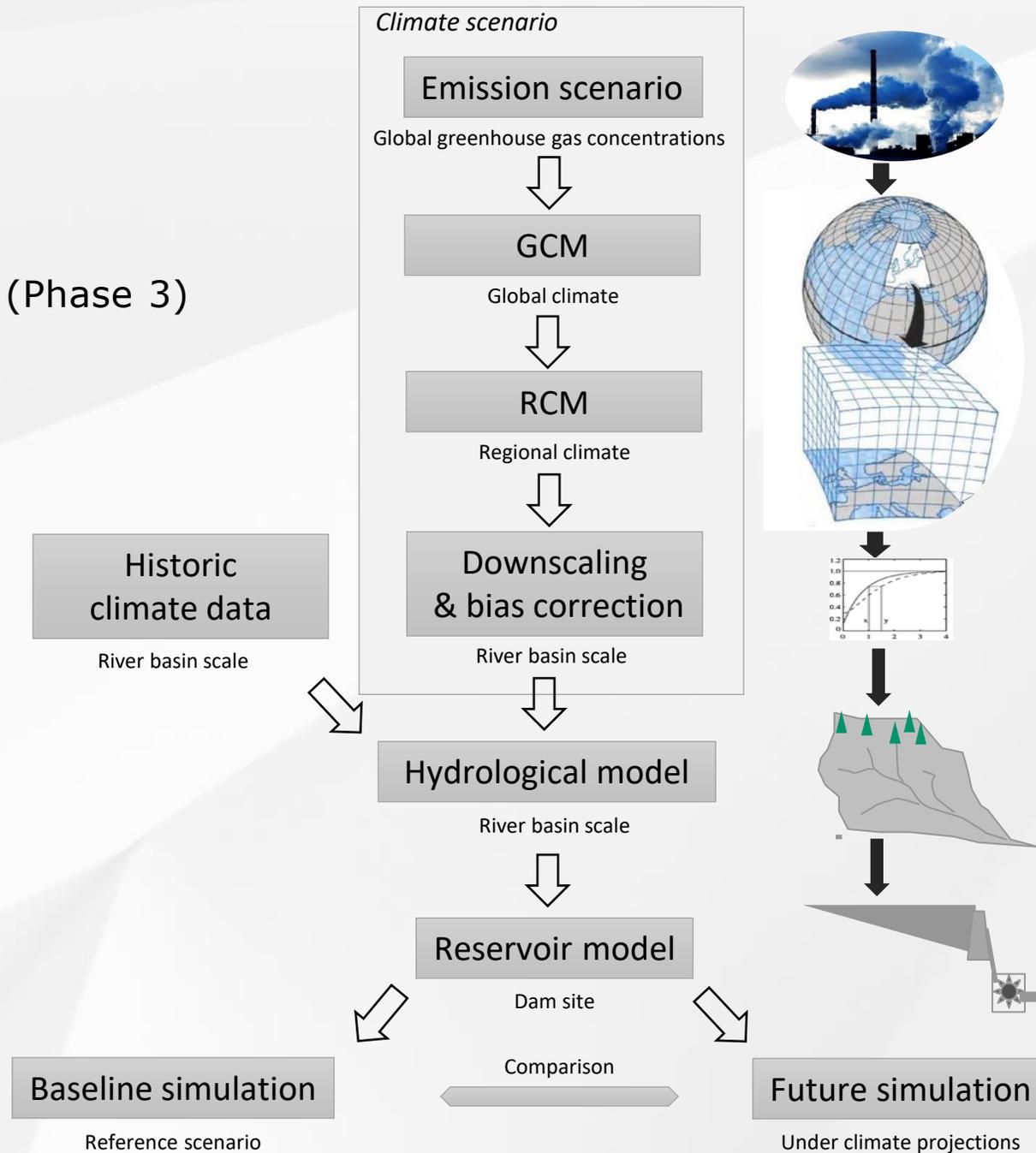
- Hydro-meteorological data (precipitation, air temperature)
 - Station data availability good until ~1990 (e.g. GPCC, WMO)
 - Satellite rainfall available since ~2000, but bias can be large
 - Summary:
 - Better quality ~1950-1990
 - Poorer quality ~1991-now
- Discharge data
 - Flow gauge data:
 - Gauges are available, but data access sometimes difficult
 - Deteriorating quality due to outdated rating curves
 - Existing HPPs:
 - Best data source
 - Outflow, water level, back-calculated reservoir inflow
 - Smoothing of inflow data required
- Climate model projections
 - Good availability (CORDEX ESGF, CMIP6 Copernicus)
 - Bias correction required, with good quality observations

**Example Cahora Bassa CRA:
Availability rainfall stations**



Baseline

- Required for climate stress test (Phase 3)
- Baseline should consider:
 - Data availability
 - WMO standard periods
 - Recent period
 - Comparability to other studies
 - Current conditions:
 - New dams
 - Irrigation withdrawals
 - Current operation rules
- Baseline \neq Historic

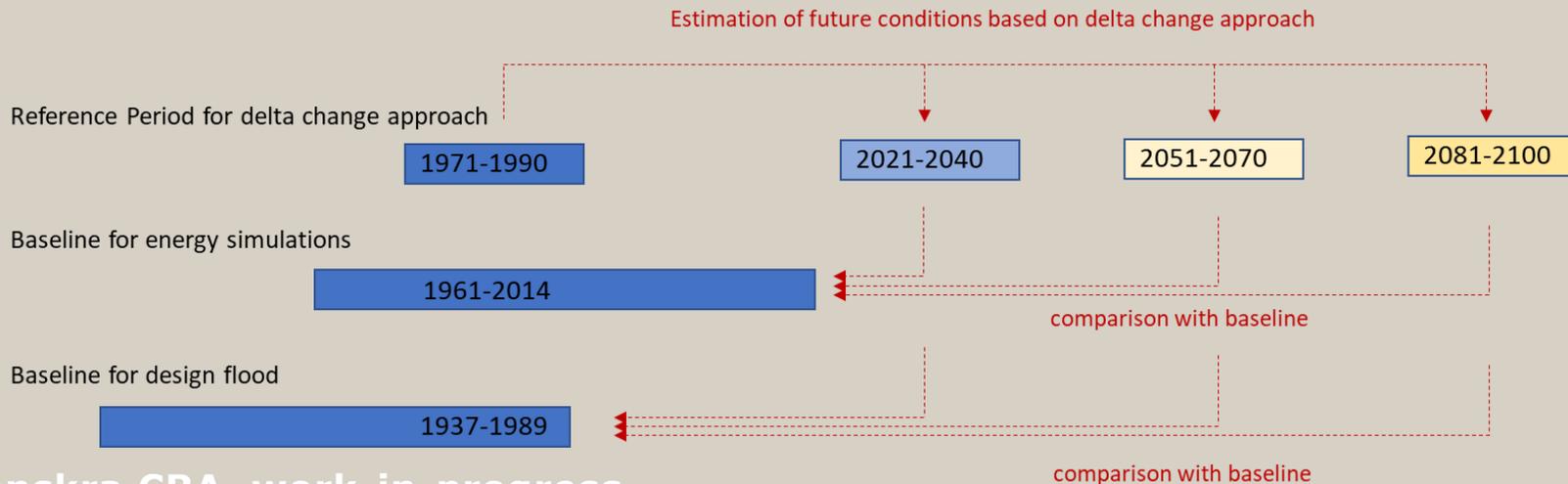


Baseline and future periods, examples



- 1961-1990: **Reference period** for observed, historic climate. Suitable for evaluation of climate models and subsequent bias correction. Commonly used WMO standard period.
- 1991-2020: **Baseline period** for simulation of Cahora Bassa hydropower operation.
- 2021-2050: **Near future period** for simulation of climate change impacts in the next three decades.
- 2071-2100: **Far future period** for simulation of long-term climate change impacts

Cahora Bassa CRA, work-in-progress



Nenskra CRA, work-in-progress

Approach for Climate Stress Test

| Approach | Method - hydrological model Model | Method - modelling extreme flood events Floods | Future climate scenarios choice Climate scn | Stress test Stress test |
|---------------------------|---|---|---|--|
| Comprehensive | Hydrological model with daily time steps; direct approach | <ul style="list-style-type: none"> Flood frequency analyses supported by numerical modelling PMF simulation based on statistical or meteorological PMP approach | Ensemble of GCM or RCM-based climate projections | Multi-variate sensitivity analyses of (at least) precipitation and temperature in mean and extremes |
| Semi-comprehensive | Hydrological model with at least monthly time steps; delta change or direct approach | <ul style="list-style-type: none"> Flood frequency analyses PMF simulation, as in comprehensive approach, or Clausius-Clapeyron equation approximation | Observed trends and at least three locally-credible GCM or RCM-based climate projections (optimistic, central, pessimistic); as discussed in Step 2.2., the 10 th , 50 th , and 90 th percentile change values are recommended | Uni- or bivariate sensitivity analyses of precipitation and temperature; for PMF with PMP variations |
| Limited | <ul style="list-style-type: none"> Regression Models Budyko-type Models Historical climate analogies model | <ul style="list-style-type: none"> Empirical methods Flood frequency analyses | Observed trends and centroid of the current GCM ensemble | Uni- or bivariate sensitivity analyses of precipitation and temperature |

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11 GCM
30 RCM
53 RCM

Zambezi DSS
West Africa
Danube

selected previous studies of AFRY



Approach for Climate Stress Test

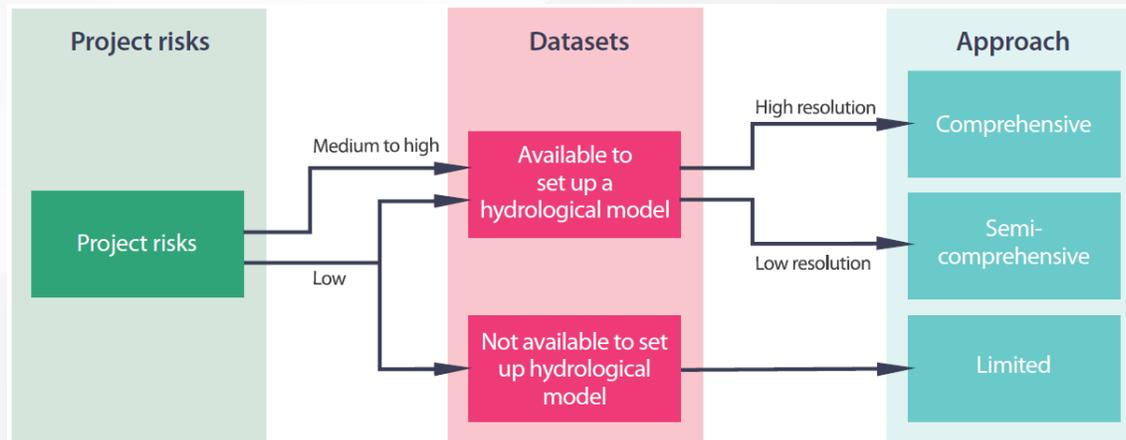
AFRY's case studies based on IHA CRG

| Approach | Method - hydrological model Model | Method - modelling extreme flood events Floods | Future climate scenarios choice Climate scn | Stress test Stress test |
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| Comprehensive | Hydrological model with daily time steps; direct approach Uzbek Nenskra KESH | <ul style="list-style-type: none"> Flood frequency analyses supported by numerical modelling PMF simulation based on statistical or meteorological PMP approach | Ensemble of GCM or RCM-based climate projections 30 RCM 40 RCM 11 GCM 30 RCM 53 RCM | Multi-variate sensitivity analyses of (at least) precipitation and temperature in mean and extremes |
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| Limited | <ul style="list-style-type: none"> Regression Models Budyko-type Models Historical climate analogies model | <ul style="list-style-type: none"> Empirical methods Flood frequency analyses | Observed trends and centroid of the current GCM ensemble 1 GCM | Uni- or bivariate sensitivity analyses of precipitation and temperature Zambezi DSS West Africa Danube |

selected previous studies of AFRY

Conclusions

- IHA Climate Resilience Guide
 - Good guiding document for Consultant and Client
 - Not too detailed, enables to adapt to the peculiarities of individual case studies
- Stakeholder engagement differs greatly between studies
- Historic data availability and definition of baseline is critical
- Approach for Climate Stress Test
 - Combination of different levels of detail
 - Difficult to plan for required budget, if Approach is not known in advance
 - > As a result the Approach is already pre-defined in the Consultant's proposal.





Thank you!



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