Localization of water resources management technology to adapt to climate change in Hong-Thai Binh River basin

Activity 2.1 Stakeholder Consultation Report
Request ID# AF-2021000099

12th October 2022

Prepared for UNFCCC Climate Technology Centre and Network, CTCN, as part of the Adaptation Fund Climate Innovation Accelerator Programme

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Contents

Figures

Tables

Appendices

Acronyms

CTCN	Climate Technology Centre Network
DCC	Department of Climate Change
DWRM	Department of Water Resources Management
IMHEN	Vietnam Institute of Meteorology, Hydrology and Climate Change
KLORCE	Key Laboratory of River and Coastal Engineering – Vietnam Academy for Water Resources
MONRE	Ministry of Natural Resources and Environment
NAWAPI	National Center for Water Resources Planning and Investigation
NCHMF	National Center Hydro-met Forecasting Centre
NDC	Nationally Determined Contribution
NVWATER	North Division for Water Resources Planning and Investigation
TA	Technical Assistance (TA)
WRI	Institute for Water Resources Science

Executive Summary

This report is the written deliverable of Activity 2.1 of the Climate Technology Centre Network (CTCN) technical assistance (TA) to Viet Nam entitled 'Localization of water resources management technology to adapt to climate change in Hong-Thai Binh River basin' (reference number AF-2021000099). The beneficiaries of the TA are the National Center for Water Resources Planning and Investigation (NAWAPI) and its Northern Division (NVWATER), and the main outcomes are:

- Identification of climate change risk and challenges to transboundary water resource management in the Hong-Thai Binh River basin
- Identification of the most appropriate technology to provide science-based information on transboundary water resources
- Customization of the selected technology
- Capacity building in relation to the selected technology

This report describes the stakeholder consultation process which took place from the 22nd to the 30th of August 2022 and consisted of several meetings with NVWATER and NAWAPI as well as the following institutions:

- National Hydro-met Forecasting Centre (NCHMF)
- Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN)
- Institute for Water Resources Science (WRI)
- Key Laboratory of River and Coastal Engineering – Vietnam Academy for Water Resources (KLORCE)

The purpose of the consultation meetings was to align expectations and collect information from NAWAPI/NVWATER, introduce the TA to a wider range of stakeholders selected by NVWATER and to gather information with respect to management of the transboundary water resources of the Hong-Thai Binh River basin.

After the week of consultation, a final technical meeting was held at NAWAPI with decision-makers and technical experts. The meeting was focused on introducing the key NAWAPI technical experts from the Planning and Forecasting Departments that DHI will be working directly with, presenting the findings of the stakeholder consultation presenting an overview of the proposed methodology and obtaining a preliminary approval of the development proposed.

This report provides background to the technical assistance in section 1, a description of the approach for consultation and of each meeting held in sections 2 and 3, the final meeting with NAWAPI is captured n section 4 and section 5 list the next steps to follow in the implementation.

1 Background

The United Nations has awarded funding to a technical assistance (TA) request to the Climate Technology Centre Network (CTCN1) to select and customize technologies that can provide science-based information on transboundary water resources in the Hong-Thai Binh River basin in Viet Nam, to ensure more accurate and integrated planning. The main anchor for the technical assistance is the National Center for Water Resources Planning and Investigation (NAWAPI) and its Northen Division (NVWATER). The organization delivering the technical assistance is DHI.

The duration of the TA is from April 2022 to October 2023 and the main objectives and outcomes are:

- Identification of climate change risk and challenges to transboundary water resource management in the Hong-Thai Binh River basin
- Identification of the most appropriate technology to provide science-based information on transboundary water resources
- Customization of the selected technology
- Capacity building in relation to the selected technology

Output 1 of the TA was completed in the end of July 2022 corresponding to the preparation of the “Detailed work plan” and “Monitoring & evaluation (M&E) plan and impact statement”. These are TA management and monitoring instruments required by the CTCN.

Figure 1.1 overleaf outlines the remainder of the scope of work.

Activity 2.1, “A kick-off meeting, stakeholder consultations and site visit”, is the subject of this report and was the first step in the identification of climate change risk and challenges to transboundary Water Resource Management (WRM) in the Hong-Thai Binh River basin. It presented the opportunity for face-to-face meetings in Hanoi where the broader group of TA stakeholders were consulted. The visit was also an information and data collection effort to inform the remaining activities.

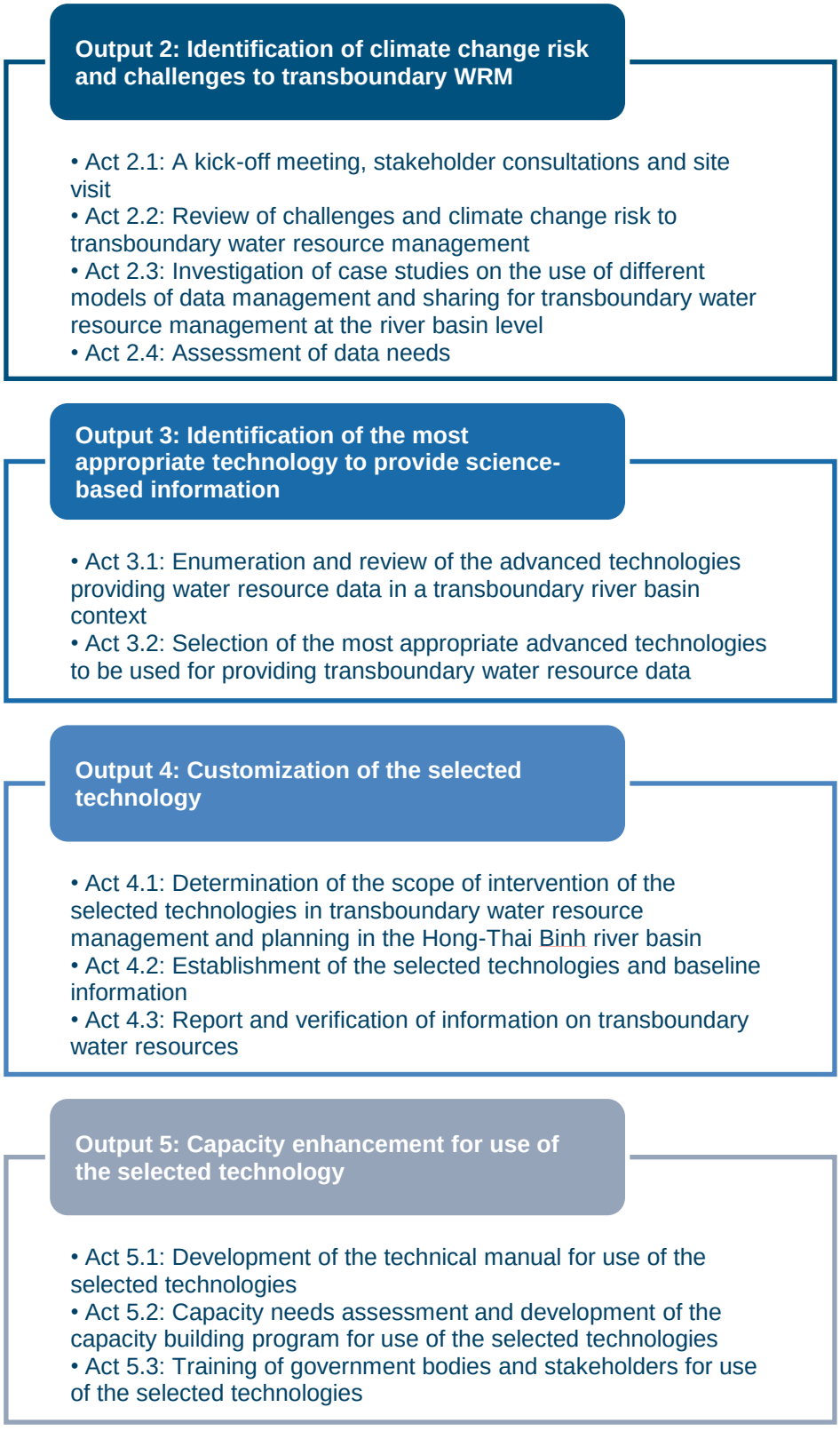

Figure 1.1 Outline of the scope of work and outputs of the technical assistance.

2 Participation and Approach

During preparatory meetings between NVWATER, NAWAPI and DHI, the expectations about the TA were understood and a list of broader stakeholder institutions and respective contact persons was drawn. A round of consultation meetings was held with each individual institution followed by a final consultation with NAWAPI and NVWATER at both technical and decision-making levels.

The selected list of institutions was composed of 6 government and research institutions is presented below, contact details are included in Appendix A.

- National Hydro-met Forecasting Centre (NCHMF)
- Department of Water Resources Management (DWRM)
- Department of Climate Change (DCC)
- Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN)
- Institute for Water Resources Science (WRI)
- Key Laboratory of River and Coastal Engineering – Vietnam Academy for Water Resources (KLORCE)

Out of the 6, two were not available, the DCC and DWRM. The purpose of the meetings was to introduce the technical assistance team and scope to the broader group of stakeholders and also to obtain an understanding of their role within the transboundary WRM framework for the Hong-Thai Binh River basin. Specifically, the DHI team focused on covering the following topics:

A. Describing the current processes/protocols for the generation, provision, management and sharing arrangements of data.

B. Identifying what information/data (e.g., rainfall, river water flow and river water level) is used at the basin and national levels by which institutions, including current access and quality control of water data in the field.

C. Identifying gaps and needs not forgetting the context of climate change.

D. Identifying water governance, including data collection and sharing, challenges/issues.

E. Identifying results and lessons learned from completed and ongoing projects to collect/generate and provide similar data.

F. Identifying previous and ongoing climate change impacts, technology/measures to address risk and efforts for its management and/or reduction.

It was found that during this activity, a visit to the border areas between Viet Nam and China would not be needed because it would not add any significant substance to the data and information collected in Hanoi. It was also decided by NAWAPI, that a larger workshop would not be required but instead a technical meeting with NAWAPI experts only should be held after the first consultation, to make sure that the required level of detail is reached, and a methodology and way forward could be discussed.

3 Stakeholder Consultation

NVWATER and DHI co-hosted the consultation meetings with the identified key stakeholders within transboundary water resources management and specifically transboundary flow estimation in the Hong-Thai Binh basin. The consultation calendar is presented in Table 3-1.

Table 3-1 Consultation calendar displaying the day and time of meetings from the 23rd to the 26th of August 2022.

Title	TUE, 23/8	WED, 24/8	THU, 25/8	FRI, 26/8
National Center for Water Resources Planning and Investigation (NAWAPI) Northern Division for Water Resources Planning and Investigation (NVWATER)	NVWATER 14:00-16:00	NAWAPI 14:00-16:00		NAWAPI 13:30-14:30
Department of Climate Change (DCC)				Not available
National Center Hydro-met Forecasting (NCHMF)	09:00-11:00			
Institute of Meteorology, Hydrology and Climate Change (IMHEN)			13:00-15:00	
Department of Water Resources Management (DWRM)				Not available
Institute for Water Resources Science		09-10:00		
Key Laboratory of River and Coastal Engineering (KLOCE)			09:30-11:00	

3.1 Northern Division for Water Resources Planning and Investigation

Date: 23rd August 2022, 14:00 – 17:00

To kick off the round of meetings, the DHI technical assistance team met with Mr Nghia the Director General and representative of the TA request proponent NVWATER. The DHI team had prepared a questionnaire (available in Appendix B) which had been submitted in advance via the TA contact at NVWATER. We were informed that specific answers would not be provided but that it would be possible to use the questionnaire as an overall guide for the meeting.

NVWATER is responsible for basic investigation involving water resources monitoring, planning and forecasting. NVWATER investigates flow for segments of the national river systems. They provide cross-sectional flow area information to DWRM for their flow calculations. NVWATER uses population data and water use data to carry out inter-province allocation of water. They also manage inter-reservoir operations and water storage for different purposes such as agriculture or industry.

In addition, NVWATER produces monthly flow forecasts but currently the models are not providing accurate estimates for the transboundary flow entering Viet Nam from China. Therefore, the TA request came about, to improve the reliability of transboundary flow estimates for use in planning and decision making.

Though they are responsible for domestic water resources investigations transboundary flow is an input and currently NVWATER do not have this information, which was the l basic reason for the request to the CTCN for this TA. All that is available to them are the flow monitoring stations at the border in the Hong-Thai Binh basin, climate data from the NCHMF and reservoir operational data from the DWRM.

When asked about the key water resources challenges in the basin, they mentioned that although there seems to be no shortage when comparing available resources with the demand on an annual basis, temporally and spatially there are problems as the water availability is not evenly distributed monthly and over seasons. There is not an even distribution between mountain areas and lower downstream areas. These are the types of issues NVWATER works to solve.

Next, the broader consultation schedule of meetings was discussed, specifically the fact that some of the institutions on the list might not be available to meet with the team. The reason being mobilization via official letters from NAWAPI had not been possible to do within the timeframe. NAWAPI is NVWATER's parent institution within the Ministry of Natural Resources and Environment, MONRE.

NVWATER mentioned that the departments involved in water resources planning, had to prioritize work on the update process for the "Integrated river basin planning project for the Hong-Thai Binh river basin" to be finalized and presented to the office of the Prime Minister on the 30th of October 2022. This work included infrastructure and water resources planning studies for the whole country.

NVWATER is mandated to carry out basic investigation studies to be used in planning of water resources in the Hong-Thai Binh basin, including carrying out flow measurement and estimating transboundary water flow. NVWATER uses data from the monitoring stations, operated and managed uniformly by National Center Hydro-met Forecasting, and from forecasting models as input for their water resources planning activities.

It was agreed to take up detailed technical questions in the consultation meeting with NAWAPI, because it is the parent institution, the responsible for the technical works and the host of the technological resources.

3.2 National Center for Water Resources Planning and Investigation

Date: 24th August 2022, 14:00 – 16:00

The DHI technical assistance team, accompanied by NVWATER's team met with Mr Do Truong Sinh, Head of Water Resource Planning Division on behalf of the Director General, who invited to the meeting the following the Department of Water Resources Planning, the Department of Water Resources Monitoring, and the Center for Water Resources Warning and Forecast (CEWAFO).

Firstly, the TA requirements were discussed. This TA must benefit the departments of Planning and Forecasting, meaning these departments would be the main recipients of the technology to be developed. Mr Do Truong Sinh mentioned that technical staff would be appointed to work with DHI in the development of the technology to support transboundary flow calculations. The hope is that what is developed for the Hong-Thai Binh may then be replicated in the future within other basins in the country.

Concerns were expressed regarding the fact that Viet Nam requested this technical assistance to support their planning study two years before, meaning, it is coming too late to assist in the preparation of this year's study. NAWAPI's team is focusing on the "Integrated river basin planning project for the Hong-Thai Binh river basin" in main river basins in Vietnam, a draft is being finalized on the 30th of August 2022, which will be followed by a complex process of review towards the final version which must be submitted to the office of the Prime Minister on the 30th of

October 2022. During the review NAWAPI receives comments from different ministries by conducting inter-disciplinary council meetings.

DHI acknowledged that the concerns are understandable, however, the technology developed will only be available for the next planning cycle. In addition, the subject of this TA is transboundary flow estimation only and a full review of the “Integrated river basin planning project for the Hong-Thai Binh river basin” is entirely out of scope of the technical assistance. What would be possible, would be to provide general comments to the way in which transboundary flow is being estimated currently by the NAWAPI team, since in order to propose an enhancement, the current methodology needs to be understood in any case. Therefore, although the timing is not as intended by NAWAPI, the DHI team would make an effort to provide such comments as early as possible during the month of September.

Mr Do Truong Sinh acknowledged this discrepancy and pointed the DHI team to the NAWAPI leaders and that this support to the current planning study would need to be further discussed with them.

The main challenge that NAWAPI is facing is lack of water resources data from the international area of the transboundary river basin.

The Water Resources Monitoring Department has benefitted from a project funded by Sweden, where a method to estimate transboundary flow has been established. From this technical assistance the Water Resources Monitoring Department expressed they expected to improve their incoming water flow calculations to have higher accuracy in the future. Their technology uses remote sensing data for land cover, topography and water surface measurements that they validate with ground-based information. This is then fed into hydrological models to come up with transboundary flow predictions.

Rainfall forecasts are used from international sources - EMWP, GPM, Japanese, Swedish - because of high uncertainty and errors with prediction, different rainfall datasets are used. By using a combination of different sources, they come up with probabilistic forecasts. Ensembles of predictions are created with up to 50 members to calculate weighted average probability.

Physically based hydrological models are applied to generate hydrological forecasts, combined with deep learning technology to improve the uncertainty of the calculation. To assess the forecast performance multiple criteria such as the Nash coefficient are used, depending on the type of scenario (wet, dry, flood conditions, etc.).

They use these calculations to produce newsletters where they inform different sectors on the state of water resources, by providing daily, monthly and quarterly forecasts. They use monitoring station data at the border for flow and rainfall measurements, as well a rainfall data shared by their Chinese counterpart.

When asked about Chinese reservoirs, it was explained that the source of data is satellite imagery, to calculate different parameters for the reservoirs. An algorithm has been developed and the main challenge being faced is the timeliness of the satellite data and finding a way to integrate it with the rainfall and flow data. Difficulties with integrating the data into the models were also mentioned as well as the overall uncertainty of the results.

These resources are available at: http://waterdata.dawapi.gov.vn/mohinh.php

It is important to highlight that these resources are available to the Water Resources Monitoring Department only and hence are not used by the NAWAPI departments who are the beneficiaries of this technical assistance – Planning and Forecasting.

In addition, the methodologies used are currently being developed and hence more details cannot be made available to the technical assistance team at that point.

Finally, when asked about climate change for the Hong-Thai Binh basin, precipitation and temperature data for RCP 4.5 and 8.5 scenarios were mentioned as the scenarios used for planning for 2025 or 2030 horizons.

The National Center for Hydrometeorological Forecasting (NCHMF) downscale climate change data for Viet Nam and publish it for use by Vietnamese institutions, however, this downscaled information is not available for China therefore global data is used. Should it be found that there is an increase or decrease in projected rainfall, the flow calculations would be affected by this.

Next, it was the turns of the Departments of Water Resources Planning and the Center for Water Resources Warning and Forecasting to present what methodology and tools are used as well as what are the challenges faced.

Hydrological models and hydraulic models are used by the Departments of Water Resources Planning as general working tools. These have been set up for the different river basins in Viet Nam.

To calculate transboundary flows particularly, the department experts have only rainfall data from a few monitoring stations in China that do not reflect the amount of water that is available due to their geographical location and to the fact that the rivers are regulated by reservoirs. They do not have the real river flow discharge information, nor the operation rules of the Chinese upstream reservoirs.

Although the department has access to other rainfall-runoff models and water balance models, in particular they utilize MIKE by DHI software suite MIKE HYDRO Basin and MIKE 11. They need an integrated solution to predict flows coming to Viet Nam from China.

When questioned about the main gaps and sources of error, the experts mentioned that not having observed flow and rainfall data at the required level of coverage and detail on the international side of the basin is the challenge. They also have no experience with the use of remote sensing data.

In terms of water resources issues in the basin and main problems faced in planning, it was mentioned that shortages exist. The biggest problem is water shortage at the downstream region. This is related to the lowering of the red riverbed, due to degradation of the sediment supply from upstream. Sedimentation of reservoirs, and lower riverbed causing lower water level in rivers, results in a situation that Along the river at the main extract points of irrigation system and at the river mouth it becomes harder to extract water for irrigation and farmers cannot get enough. Not only irrigation but power generation is affected.

However, when surface water cannot meet demands, groundwater is available for use. Sea water intrusion into groundwater has therefore become a problem, though supply from surface water sources has a higher priority than groundwater.

Quality and quantity of the flow is reduced, so NAWAPI searches for solutions. In the case of the Hong-Thai Binh and the transboundary water flow calculation, it was referred that 40% of the water comes from China. Solutions used by NAWAPI includes adjusting operational procedure of upstream reservoirs, use of pumping technology to increase water levels, transfer water from Hong River to other polluted rivers, construct barrages to increase the water levels upstream

It is found that the total variation of water availability is not very significant, however during the dry season, it becomes a problem putting stress on irrigation and energy production. Various papers expose reasons: mineral exploitation in the rivers, reservoirs upstream reducing available flow downstream.

NAWAPI seeks to address these problems by more efficient water use. This means operating flow distribution in between rivers, to carry out revitalization and recovery. Transboundary flow provides an important contribution to the total water availability in the Vietnamese part of the basin and therefore also and information on this resource is therefore an important input to the

hydrological and water allocation models applied by the experts. The lack of reliable transboundary flow data makes it difficult to plan and execute efficient water management in the lower part of the Basin, I.e. when trying to include inter-reservoir operation data in the models and use them for water management in the national river basins. Water quality becomes a relevant factor as well, since if some of the water sources are heavily polluted, these cannot be employed anymore for basin transfers and meet the demands.

When estimating transboundary water for long-term planning purposes, the accuracy of predictions is low. To deal with uncertainty, the experts use 3 scenarios: business as usual, extreme scenarios, corresponding to 50%, 85% and 95% reliability of supply. These are generated based on the monitoring station data. These scenarios are reviewed and re-run every 5 years.

When estimating transboundary water for short and seasonal planning purposes, they use forecasts for 10 days, monthly and seasonal for both wet and dry seasons. They publish bulletins where it water resources information is reported including if there will be water shortage. They provide monthly bulletins to different authorities such as the DWRM, MONRE and to local governments. These bulletins are done manually, which is something they would like to automate in the future.

When asked what they would you like to see at the end of the TA, the response was having set of tools for transboundary water flow prediction to be used for planning of river basin. It was expected that global rainfall data sources are used for calculation of transboundary water flows, and that these tools are integrated into their exiting operational platform MIKE OPERATIONS. The intention is to calculate transboundary water flow in an operational way.

In terms of relation with the National Center for Hydrometeorological Forecasting (NCHMF), there is no data sharing protocol where data is given freely to NAWAPI. Currently NAWAPI downloads the free bulletins NCHMF publish on their website. However, it was mentioned that efforts are being made in the direction of establishing such an arrangement.

Date: 26th August 2022, 13:30 – 15:00

In the consultation meeting with NAWAPI's Director General, the main objective was to discuss the expectations and scope of the technical assistance.

It was explained that NAWAPI is currently engaged in the finalization and approval of the "Integrated river basin planning project for the Hong-Thai Binh river basin". It was mentioned that Viet Nam requested CTCN for support several years ago so that it could assist with the "Integrated river basin planning project for the Hong-Thai Binh river basin", however, the TA came too late.

It was clarified that this CTCN technical assistance only focuses on the transboundary flow calculation of the Hong-Thai Binh river basin, and that any involvement or review of the "Integrated river basin planning project for the Hong-Thai Binh river basin" is out of scope. Also due to the timeframe the technology developed for transboundary flow calculation will only be available for the next planning cycle.

It was agreed that DHI should prioritize looking at the current way transboundary flow is being calculated and provide general comments. This would be useful to the NAWAPI team, and in any case, in order to propose an improvement to the calculations of transboundary flow, the current approach being used needs to be understood. Therefore, the DHI team should make an effort to provide such comments as early as possible during the month of September once the information is shared by NAWAPI.

A technical meeting was scheduled to the 30th of August, to officially appoint technical experts to work with the DHI team as well as discuss the outcomes of the stakeholder consultation in terms of preliminary proposed methodology for the technology to be delivered by the TA.

3.3 Department of Climate Change

This institution was unavailable for a consultation meeting. However, they agreed to receive questions in writing. These are presented in Appendix B, at the time of submission of this report, the responses have not been received and have therefore not been incorporated.

3.4 National Center for Hydrometeorological Forecasting

Date: 23rd August 2022, 09:00 – 11:00

The Deputy Director and a technical expert of the National Center for Hydrometeorological Forecasting (NCHMF) were in attendance.

An introduction to the technical assistance was provided by the NVWATER and DHI consultation delegation. Next the Deputy Director informed on the functions and responsibilities of the NCHMF and responded to the questions of the consultation team.

This center has an operational function at the national level for hydrometeorological forecasting. It is responsible also for the coordination and management of the centers at regional level. The center uses an integrated forecasting supporting system that results in the production of monthly newsletters that are published on their website. Information is also disseminated to specific offices of government via email or text message.

The center also produces water resources forecast with lead times of 5, 7, 10 and 15 days, and 1-3 months. These are included in the newsletters that are provided for free on Center's website, NAWAPI downloads these bulletins for use in their water resources management modeling. The Center's transboundary flow calculations are used as input to the results presented in these newsletters.

This data collected and produced by the center is of the highest national importance, used to support socio-economic development of the country.

Regarding transboundary flow specifically, MONRE has been working with their Chinese counterpart, and have Terms of Reference for a data sharing under legalization.

Regarding data sharing with NAWAPI, it was mentioned that it is improving. In the past data sharing was strictly prohibited, but recently leaders are committed to a more open process.

The NVWATER representative mentioned that NAWAPI is open for more data sharing. However, a high-level executive permission is needed to do so. From their perspective, they require investment in hardware for storage, and procedures to send data from the center's centralized warehouse to NAWAPI's system. In terms data transfer, NAWAPI has certain requirements regarding the data formats. It is understood that different measuring technology uses different formats, therefore harmonization of the formats would also need investigation.

For the time being and until there is an agreement at the leadership level, the only readily available data is on the newsletter published in the Center's website, available at https://nchmf.gov.vn/Kttv/vi-VN/1/nguon-nuoc-21-18.html

When asked about the main sources of error in the station data, the response was that error could be human, when carrying out monitoring activities. There are stations that are privately owned and however the data cannot be used as it is not considered to be accurate enough, and data cannot be trusted. From a forecasting point of view, it could be an equipment error, or errors with using different measuring technologies in the equipment, or errors connected to the installation, location of stations as well as the surrounding environment leading to leaves in trees covering the sensors.

One of their main challenges is the low resolution of satellite data. Though they have an advanced remote sensing department, they struggle with the frequency of imagery does not capture flood events and flow peaks.

When asked about the TA outcome, they mentioned that forecasting in general is difficult and that transboundary forecasting is quite challenging, therefore they find it will be very meaningful to improve these estimates and that they see the Center becoming a beneficiary of the outcomes. However, if the Center was to use data produced by NAWAPI, it would have to pass reliability assessments.

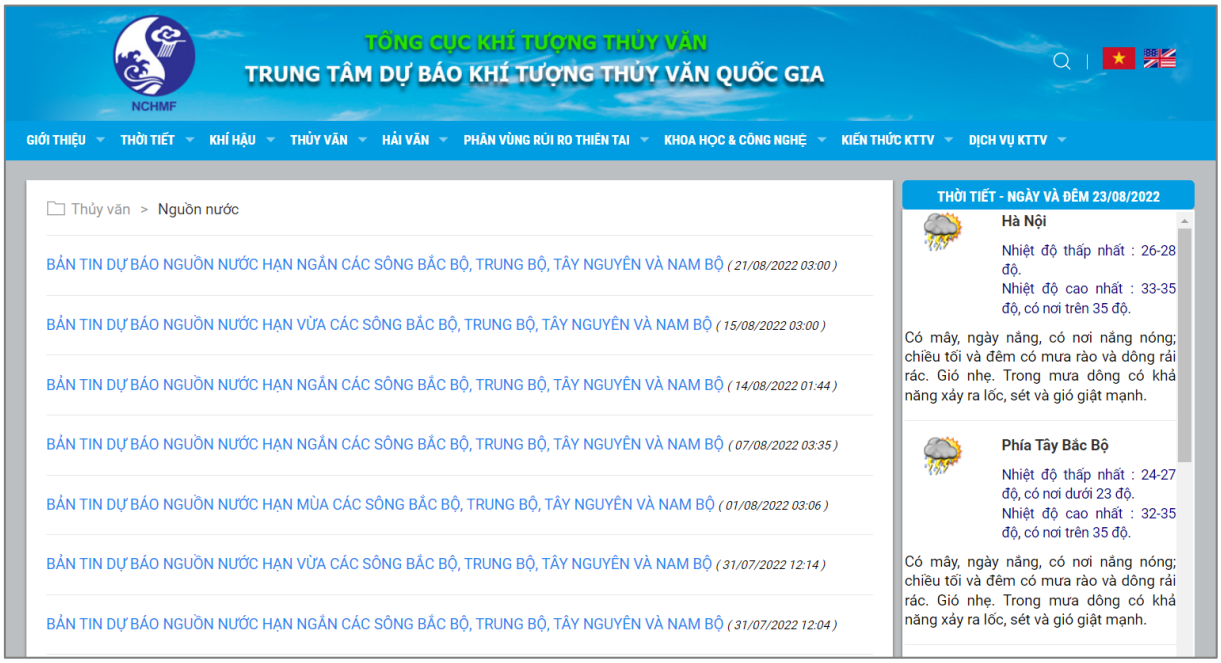

Figure 3.1 The NCHMF's website where the newsletters downloaded and used by national institutions such as NAWAPI are published.

3.5 Institute of Meteorology, Hydrology and Climate Change

Date: 25th August 2022, 13:00 – 15:00

The TA team was received by hydrology and forecasting experts of the Institute of Meteorology, Hydrology and Climate Change (IMHEN). An introduction to the technical assistance implementation was provided. The IMHEN experts were asked about the institute's connection to NAWAPI, existing data and Climate Change (CC) impacts related to the Hong-Thai Binh basin.

When asked what the latest climate change assessments were made for the Hong-Thai Binh basin and what were the results, the experts responded that in the past many projects related to the Hong River were done including CC scenarios concerning sea level rise, rainfall and temperature, and estimated the impacts of climate change in water resources. However, the last published assessment is 5 years old and not at the basin but at provincial level.

Currently the IMHEN is developing CC scenarios in detail for Hong River basin. They have found striking differences based on the new climate modelling data available, the main one being the fact that flow is expected to increase both in the flood and dry seasons.

As tools for these assessments, the experts utilize monthly data from ground-based monitoring stations, together with dynamic downscaling methods versus the statistical downscaling methods used in the past.

At IMHEN, experts work in developing climate change scenarios (4.5 and 8.5 RCP), following the publications by IPCC and using the method of applying monthly delta change factors to baseline (1986-2005) scenario climate variables thus obtaining their projected values (2015-2035, 2046-2065, 2080-2099). When analysing the projected climate variables, the experts also consider the number of dry days, changes in trends and assessing how some months are wetter/dryer.

They are currently working on the lates published scenarios by the IPCC (AR6) to produce a report which is then published and in it, the delta change factors. This is how data is exchanged with other institutions. IMHEN also publishes scientific papers and reports at the provincial level.

IMHEN pointed out that flooding is considered to be most critical impact for the Hong River Basin with the added impact of tidal increase, as registered by the water level monitoring station located on the delta. In addition, other impacts are drought, salinity intrusion, storm surges, high waves, sea temperature increase, and typhoons.

In terms of climate change risk management and reduction, IMHEN mostly focuses on research and carrying out risk management and warning, coming to the proposal of adaptation measures.

These are considered to be general ones, for example: how to improve forecasting capacity, improve flood control infrastructure, develop a system to assess risk for infrastructure.

Finally, with regards to transboundary flow assessment in particular, the experts mentioned there is rainfall from the NCHMF service. They use rainfall-runoff modelling as a tool (NAM model by DHI), and rainfall forecasted for stations near the Chinese border inside Viet Nam, assuming that across the Chinese border the rainfall forecast is the same. Using the model, they simulate inflow to Viet Nam. A recent improvement is to use spatially distributed rainfall forecast (1 km resolution) to produce catchment rainfall forecast. The model is validated with NCHMF observed data.

3.6 Department of Water Resources Management

This institution was unavailable at the time for a consultation meeting.

3.7 Institute for Water Resources Science

Date: 24th August 2022, 09:00 – 10:00

The Institute for Water Resources Science (WRI) carries out a variety of studies in the development of water technologies, to inform the setting of regulations, amongst others. The WRI bulletin is used by other entities to support NCHMF activities and support decision-making particularly the DWRM.

WRI builds on data from previous research and buy from other sources. In terms of technology, the WRI use models and observed and forecasted precipitation data, they also use remote sensing data, as it is hard to get data from other countries.

An important part of their research is on flooding, where they estimate flood flows in the Mekong delta. They also estimate dry season flows in the Mekong. This is done by their Water Resources Forecasting Department, that publishes a monthly bulletin on their website, from where it is available for download. When other organizations need information upon request, they would also be able to provide, for example to the NCHMF or to the flood and drought council.

The WRI produces two bulletins a year, every 6 months with seasonal forecasts, one flow forecast for dry season and one for the wet.

However, the WRI does not have the responsibility of the utilization of the information, as it is up to the users to use the website information, it is meant to be for research purposes not for operational purposes.

The consultation team introduced the technical assistance and its purpose. The researcher explained that the WRI is currently conducting a project mandated by MONRE to assess national inter reservoir operations.

When asked about transboundary flow estimation, the researcher mentioned they are using models in combination with observed data from stations around the border and remote sensing data in the Chinese territory. The researcher confirmed that remote sensing is the only source of data for the Chinese basin area.

Key challenges pointed out were the following: incidence of drought events is more frequent on the Mekong; in North Viet Nam lack of data, particularly on reservoir operation outside the Vietnamese borders where the flood season and its economic and societal impacts are critical.

The researcher mentioned that the most challenging task is flood forecasting, yet if they could predict precisely impacts would be overcome. The difficulty lies in the fact that they are missing observed rainfall, water sources, evaporation, temperature data, as input to their assessments. Currently they are using remote sensing data, but find the resolution is not so good. The experts apply multiple sources, depending on specific scenarios they use different sources with different resolution of images. For the transboundary basin areas, they are not sure on different accuracies.

Impacts of climate change are most pronounced in central and south Viet Nam according to the WRI researcher.

3.8 Key Laboratory of River and Coastal Engineering

Date: 25th August 2022, 09:30 – 11:00

NVWATER and DHI team kicked off the meeting by introducing the CTCN technical assistance.

The Key Laboratory of River and Coastal Engineering (KLOCE), conduct hydraulic and water resources studies. They are a user of MIKE 11, know DHI and expressed high interest in technology DHI will develop with NAWAPI.

Following a request by the Ministry of Science and Technology, KLOCE presented the status of their ongoing project in disaster management in the Hong River, brought about due to the 2017 flood event. During this event, there was a lot of incoming water flow from lateral catchment areas and the measurements from the ground stations proved not to be very useful. Reservoirs operations became an important factor and based on that problem; the Ministry of Science ordered the study. Hence KLOCE experts are building technology to forecast inflow to Vietnamese reservoirs for hydropower production and improve quality of calculation of flood flow from upstream in the Da river for dam safety purposes.

For the hydropower reservoirs in Viet Nam area the experts can count on observed of inflow and outflow. The frequency of observation is 15 min, 30min and hourly. In addition, global rainfall data and observations inside Viet Nam is used as input. Based on the understanding of the operation they can apply forecasted inflow and then calculate forecasted outflow. Currently, they are developing the tools for Chinese basin area.

3.9 Gender Sensitivity

Gender Expert participated in NVWATER and NAWAPI consultation meetings. Gender issues were discussed with members attending the meeting of NAWAPI when they were assigned by MONRE to develop a Master Plan on Water Resources for the Red - Thai Binh river basin and also will take over to use the technology provided by DHI. The number of women accounts for

35% of the total number of employees of NAWAPI, of which the leadership and department heads account for about 45%. NAWAPI established the Committee for the Advancement of Women. For the takeover and use of DHI's technology, female leaders/staffs who are qualified from NAWAPI are willing to participate in the project without any hindrance or restriction on them.

When asked about gender mainstreaming in this plan, the response was that gender issues have not been really focused, but only criteria for regions (such as ethnic minority areas, areas of water scarcity for living and production, etc…). Up to now, the master plans on water resources have not addressed gender issues (for example demand for water use by men and women, both for daily life and production; the role of women in management and protection of water resources, etc…).

Located in Southeast Asia, with medium-high water resources in the world, Viet Nam has more than 2,360 rivers with a length of 10 km or more, including 109 main rivers. Besides the benefits gained from water of the main rivers, Viet Nam also faces different types of natural disasters and extreme weather events that lead to drought, flooding, salinization, etc. Agriculture, including forestry and fisheries, is the sector with the largest number of workers, of which over 50% are female, and is also the sector that depends heavily on the reserves and quality of water resources. Therefore, sustainable management, utilization and protection of water resources is of great significance in maintaining and ensuring the quality of human lives and food security, especially in communities with livelihood from water-based production activities.

In recent decades, especially in the 2000-2020 period, the participation of the community in water resource management has gained attention from and been promoted by many development organizations and countries. However, the participation of the community, especially women, is still not widely spread and approach of community-based water resource management is quite different in projects that related to water resource management and exploitation such as the clean water supply and rural environmental sanitation program, irrigation works, monitoring and warning systems for natural disasters and so on. Many studies have shown that women are one of the most vulnerable groups to the impacts of climate change and the disadvantaged group in water resource management.

Vietnam has a relatively complete system of policies on gender equality, but policies on management and protection of water resources do not have many regulations related to the role of women as well as gender equality, such as:

Table 3-2 Legal documentation related to water resources and gender

No.	Legal documents related to Water Resources	Legal documents related to Gender and Women
1	1994, Ordinance of exploitation and protection of irrigation structure (No.36-L/CTN)	2002, National Strategy Plan for Vietnamese's Women Development until 2010
2	1998, Water resource law (No.08/1998/NA10)	2008, Gender equality law (No.73 /2006/NA11)
3	2000, Ordinance of dykes (No.26/2000/ SCNA10)	2010, National Strategy Plan for Gender Equality for the 2011 – 2020 period
4	2001, Ordinace of exploitation and protection of irrigation structure (No.32/2001/SCNA10)	2011, National Target Program on Gender Equality for the 2011-2015 period
5	2006, Dykes law (No.79/2006/ NA11)	2020, Resolution on Sustainable Development (No.136/GOV). Target no.5: "Achieving gender equality empowering and giving opportunities for women and girls"
6	2012, Water resource law (No.17/2012 /NA13)	2021, Resolution on National Strategy Plan for Gender Equality for the 2021-2030 period (No.28/GOV)

No.	Legal documents related to Water Resources	Legal documents related to Gender and Women
7	2013, Natural disasters prevention and control law (No.33/2013 /NA13)	
8	2017, Irrigation law (No.08/2017 /NA14)	

In terms of legal regulations, all acts of discrimination against women, offending women's dignity are prohibited. The State commits to creating conditions for women to exercise their equal rights in the areas of social and family life. However, there are not any specific regulations on the participation of women in the management and protection of water resources. The relevant legal documents, while emphasizing the importance of gender equality and women's participation in programs in general and irrigation constructions in particular. However, these legal documents only refer to the concept of community, instead of specifying women's participation as part of planning and promoting decision-making in water resource management. For example, in the Law on Water Resources, the Law on Irrigation as well as the documents related to the implementation of these two laws, there are no specific contents and regulations on the role of women as well as the role of women in the water resources management and protection.

Some policies refer to the Women's Union with the role of participating in propaganda movements and activities, but not the role of representing women's voices in policy decision-making. The terms gender or women are completely absent from the reviewed policies on water resources management and access to water resources. Gender-blind viewpoints will not respond effectively to the varying effects of water scarcity on women and men and, ultimately, these gender-blind policies may exacerbate existing inequality, particularly in water stressed regions.

There are not many studies on the role of women in water resource management in Vietnam as of now, there are only a few studies on women and climate change, women in disaster risk reduction, or women and poverty. Most studies emphasize the need for women's participation as part of vulnerable groups in the formulation and implementation of water resources management policies and in access to water, promoting the implementation of the United Nations' Sustainable Development Goals. Even if national policies recognize the importance of gender equality in the design of climate change responses and water management programs, in practice the effectiveness of gender mainstreaming is still limited. Provincial Disaster Risk Reduction and Climate Change Action Plans have little to no gender analysis, making it difficult to identify specific actions to address gender inequalities, which in turn results in mandates and solutions often being generic or gender-blind.

4 Technical Meeting at NAWAPI

Date: 30th August 2022, 09:00 – 13:00

After the week of consultation, a final technical meeting was held at NAWAPI with decision-makers and technical experts from NAWAPI, including Mr. Tong Ngoc Thanh, General Director of NAWAPI, Mr. Nguyen Ngoc Ha, Deputy General Director of NAWAPI, and the key contact point and proponent for this TA, Mr. Nguyen Chi Nghia, Director General of NVWATER.

The TA objectives and work plan are well known and had already been approved, hence the meeting was focused on three key aspects:

- Introducing the key NAWAPI technical experts from the Planning and Forecasting Departments that DHI will be working directly with
- Presenting the findings of the stakeholder consultation
- Presenting an overview of the proposed methodology to be developed in this TA based on the data and technology needs assessment
- Obtaining a preliminary approval of the development proposed.

The Director General (DG) of NAWAPI, introduced the preparation of the “Integrated river basin planning project for the Hong-Thai Binh river basin”, which is being finalized in August, revised by the other ministries in September and delivered in October to the Office of the Prime-Minister. This crucial instrument of national importance will not be able to benefit from the technological enhancement that this TA will deliver to NAWAPI, this is due to the discrepancy in timing of when the request was submitted, and when the TA started. Nonetheless, NAWAPI welcomes the deliverables for their seasonal planning but also the following planning cycle.

Figure 4.1 Photograph of the meeting with the director generals of NAWAPI and NVWATER, the head of the forecasting center and a group of experts of the modelling unit, the planning and forecasting departments.

Key challenges to address are the issues of flooding, water shortage in the dry season, seasonal discharge of inter-reservoir operations, of increasing water quality and of efficient planning water for irrigation at the delta region of the basin and energy production.

A vision and ambition for the future was also shared: that the Plan currently being finalized will be revised after 5 years of implementation and that they are aiming to have a dynamic planning approach, complete with forecasting planning models, and facilities to disseminate warning messages to different stakeholders, to regulate their water utilization.

The users of the technology to be developed are:

- Department of Water resources planning
- Department of Water resources monitoring
- Center for Water Resources Warning and Forecast (CEWAFO)

All these units are under NAWAPI. It will be installed at CEWAFO.

Finally, the DG pointed out the key contact people involved in the TA (details enclosed in Appendix A): Mr Ha will lead on the technical development, Dr Van head of the Forecasting Centre will assist with data collection, Mr Dung will continue as a fay-to-day contact point for NAWAPI, while Ms Thu maintains the same role from NVWATER's perspective.

DHI presented a summary of the consultation, described in detail in section 3 of this report, especially the fact that transboundary flow estimation methods are already being researched simultaneously by different institutions, namely: NCHMF, WRI, IMHEN, and KLOCE. The fact that there is little sharing of information amongst them if any and that slightly different approaches were being used was noted.

DHI presented the preliminary approach to the technology development based on the needs assessment carried out during consultation meetings. This approach was agreed upon with NAWAPI, with the understanding that in Output 3 and 4 reports the details would be further developed. The preliminary approach can be summarized by the following three essential elements:

1. Generate water resources model for the international catchment areas, because transboundary flow assessments need hydrological and regulation modelling of the upstream catchment area
2. Develop routine to estimate unknown upstream reservoir operations and subsequently transboundary flow
3. Integrate routine within operational system at NAWAPI

Next, Mr Dung provided an introduction to the Hong-Thai Binh river basin and an overview of the masterplan related assessments they have carried out. In his presentation, it was stated that 40% of the water in the basin flows from China.

Key problems to address are:

- Total water volume needs to be balanced for different water uses in the basin.
- Water shortage in the delta region due to lowering water level (caused by lowering river bed). Adjusting upstream reservoirs' operation is one of the solutions.
- Restoration of heavy polluted rivers by water diversion and other solutions.
- Focus on improvement of water volume and quality in the basin.

Main tools utilized are MIKE by DHI, namely: NAM, MIKE HYDRO Basin, MIKE HYDRO River and FEFLOW. Currently their water resources assessment tool, is a model using MIKE HYDRO Basi software with 108 subcatchments that produces estimates for daily flow covering the period from 1990 to 2020. The period for forecasting and planning is from 2021 to 2030. The model is used to produce inter-reservoir operations to be included in the Masterplan and subsequently approved by the Office of the Prime-Minister.

The experts stated that it is necessary to include the impacts of climate change of relevance to MONRE, they are considering scenarios for incoming water flow for the following projection periods: 2021-2030 and 2031-2050.

The planning team also focuses on other specific planning investigations such as how much water can be diverted from one river to another to improve quality and estimate the impact of construction works.

Amongst other needs for NAWAPI's modelling system, the expert emphasized the estimation of upstream transboundary flows in Vietnam, a need to have daily downscaled data.

Models developed already meet requirements, but miss integration, synchronizing together the upstream flow estimation and the whole national basin. The expectation is that they would have the full basin captures, once the transboundary part is there.

The meeting ended with the DG's closing remarks, that NAWAPI is looking forward to the collaboration to develop the product for transboundary flow, related data and information for the Hong-Thai Binh basin. The introduced contact persons were once more pointed out, and their role highlighted. A very close connection and the best cooperation is expected with DHI throughout the TA duration. Finally, after the meeting, the team was given a tour of the operational forecasting centre.

5 Next Steps

The next steps are Activities 2.2, 2.3 and 2.4. These correspond respectively to review of challenges and climate change risk to transboundary water resource management; the investigation of case studies on the use of different models of data management and sharing for transboundary water resource management at the river basin level; and a data needs assessment. During these activities, online meetings will be held with the stakeholders as needed under NVWATER's advice. The outputs of these activities will be presented in the 'Activities 2.2, 2.3 and 2.4 Report'.

Appendix A Stakeholder Contacts

The following list presents the contacts of the representatives of the selected stakeholder institutions involved in the consultation process.

Institution	Title	Name	Position	Email
NAWAPI And NVWATER	Ms	Chu Minh Thu	Acting Head of Division of Water Resource Planning, NVWATER	chuminhthu82@gmail.com
	Ms	Pham Thi Mai Thanh	Officer, NVWATER	thanh6778b@gmail.com
	Mr	Do Truong Sinh	Head of Water Resource Planning Division, NAWAPI	dotruongsinh@gmail.com
	Ms	Le Mai Van	Head of Water Resource Warning and Forecasting Center, NAWAPI	lethimaivantnn@gmail.com
	Mr	Dinh Tien Dung	Officer at Water Resource Planning Division, NAWAPI	dungdt812@gmail.com
	Mr	Tong Ngoc Thanh	Director General, NAWAPI	thanhqhtnn@gmail.com
National Hydro-met Forecasting Centre	Mr	Hoang Van Dai	Vice director of National Hydro-met Forecasting Centre	daihydro2003@gmail.com
	Mr	Bui Dinh Lap	Deputy of Northern Hydrological Forecasting Division	lapbuidinh@gmail.com
Vietnam Institute of Meteorology, Hydrology and Climate Change	Mr	Luong Huu Dung	Director of Center for Hydrology and Oceanography	dungluonghuu@gmail.com
	Mr	Nguyen Van Dai	Head of Division for Climate Change Adaptation Research, Climate Change Research Center	nguyendai.tv@gmail.com
Institute for Water Resources Science	Mr	Tran Manh Cuong	Researcher	manhcuongkt11@gmail.com
Key Laboratory of River and Coastal Engineering – Vietnam Academy for Water Resources	Mr	Le Van Nghi	Director of the Key Laboratory for River and Coastal Engineering	levannghi@gmail.com
	Mr	Nguyen Dang Giap	Head of Disaster Management Center	
Vietnam National Mekong Committee	Ms	Nguyen Thi Thu Linh	Acting Director General	vnmc@monre.gov.vn

Appendix B Questionnaire

Appendix B.1 NVWATER and NAWAPI

Introduction

1. What does your organization do and what is your specific role within it?
2. What kinds of water availability assessments and forecasts are made, by whom and at what frequency?
3. What transboundary water inflow from China estimates are produced and why?
4. How are they used in the assessments for allocation of water to the different uses?
5. To your knowledge, how many departments are involved and how many people are occupied with making these assessments currently?
6. How is long term investment planning made, by whom and at what frequency? Who uses the plans produced?
7. How are seasonal forecasts produced and in what format? Could you show us?
8. How are they used and by whom?
9. How are short-term forecasts made and how many days ahead? Who is using them?

Making an assessment

10. Currently what are the most valuable data and tools for you to calculate inflow from China?
11. What sources of data are used for the calculation?
12. Would you have a description of the methodology or tool, and could you show us?
13. What different tools and data are being used?
14. What kinds of performance criteria do you use to guide the assessment?
15. How are the departments under NAWAPI cooperating in these processes?
16. How about other ministries?

Communication of the assessment

17. How are the transboundary inflows calculations/results being shared currently and with whom?
18. In what format?
19. To your knowledge how is the information used?
20. Which reports are distributed to whom and with what frequency?

21. In your experience, what information is missing currently when assessing and reporting on transboundary water resources?

22. Do you calculate any specific indicators/statistics for specific people? What are these and for whom? Could you show us examples?

Revising the assessment

23. What process is in place to review the transboundary inflow data estimation?

24. How is it reported?

25. What kinds of performance criteria are used that guide the revision of the calculations?

Similar projects

26. Think of the last projects that were carried out to improve transboundary flow assessments. What were the outputs?

27. Describe your experience with those results/tools?

28. What was useful and what did not work for you?

Downstream impacts of NVWATER/NAWAPI transborder flows calculations

29. What is the role of transboundary water flow in the day to day / seasonal management of water resources?

30. How is water allocation carried out?

31. How frequently are water licenses analysed according to actual water availability?

32. How are these analyses (if any) incorporated in the regulation of water resources?

33. Are there any areas in which users are frequently in deficit of water?

34. How is prioritisation between domestic, electricity, industry, agriculture, and nature made in general and during times of deficits?

35. What kinds of insurance are offered to farmers in case there is deficit in their supply?

36. What kinds of other insurance are offered?

37. What is the frequency of pay out from such insurances?

38. Do you calculate estimates of CC impacts for the DCC?

Appendix B.2 Department of Climate Change

Introduction

1. What does your organization do and what is your specific role within it?
2. How do you believe it relates to what IMHEN is doing?

3. In your experience, what is the reasonable temporal range of climate change scenarios applicable to practical climate change adaptation in the Basin (10-20 years ahead, 20-40years, 40-60 years, >60 years?)

4. What were the latest climate change assessments made for the Hong-Thai Binh basin and where could we have access to them?

    - What were the results?

    - What are the main findings on temperature and precipitation?

5. Which institutions make the assessments and which institutions are responsible for responding?

6. How are the assessments used in practice?

7. What are the predicted impacts on water availability by sector?

8. In which report could we find this information?

9. How are you involved in seasonal water resources planning?

10. How are you involved in short term flood forecasting?

11. How are you involved in the assessment long-term predictions of the development of floods and droughts?

12. How are such predictions being used and by which institutions?

Information and data flows

13. Please describe the interactions with other departments particularly NVWATER and NAWAPI.

14. What types of tools are being used for climate change impact assessment on water resources and the Hong-Thai Binh basin?

15. In which report could we find their technical specifications?

16. How are climate change impacts on transborder flows from China being calculated currently?

17. Describe what is your experience of how climate change data is exchanged.

18. Please provide the format and list of data.

19. How is DCC consulted as to the use and conclusions on climate change impacts it produces?

Climate change risk management and reduction

20. How is DCC involved in risk management and or risk reduction related to the predicted Climate Change impacts on water resources in the Hong Thai Binh basin?

21. Which measures are proposed to cope with those impacts?

22. Which of these have been implemented?

23. Which institutions are responsible for the implementation?

24. Where do the funds for the implementation come from?

25. Please share the results /successes / lessons learned from these measures.

26. How are adaptation projects monitored?