FLOOD & DROUGHT MANAGEMENT TOOLS

Technical Training: Volta Basin

Report

8-11 February 2016

Miklin Hotel

Accra, Ghana

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1. Executive summary

There is a growing sense of urgency around the need to improve resilience within river basins, and for this to become a critical part of water management plans. The increased frequency and unpredictability of floods and droughts is a priority concern across scales from transboundary to local, along with the other multiple drivers that cause depletion and degradation of shared water resources.

The Flood and Drought Management Tools (FDMT) project (http://fdmt.iwlearn.org/) is financed by the Global Environment Facility (GEF) International Waters (IW) and implemented by UNEP, with the International Water Association (IWA) and DHI as executing agencies. The project is developing a computer software-based decision support system (DSS) with tools to support planning from the transboundary basin to water utility level by including better information on floods and droughts. The project is being implemented from 2014 - 2018, and 3 pilot basins (Volta, Lake Victoria and Chao Phraya) have been identified for development and testing of the planning DSS.

Understanding how to use the planning DSS is an important aspect of the future operational use and sustainability of the FDMT project, therefore, capacity on the use and application of the DSS, as well as giving stakeholders an opportunity to provide feedback on the functionality of the DSS will go a long way to achieving this.

The project has been holding a series of technical trainings targeting technical staff and junior to senior level water resource professionals from different organisations. Trainings intend to provide a basis for bringing basin organisations, water utilities and other organisations together around a common planning tool, while being able to test and validate the planning DSS. Feedback from these workshops is being gathered and will be included in the further development and refinement of the planning DSS.

The objective of the technical trainings are to:

- Enhance stakeholders understanding of the planning DSS
- Provide stakeholders with an opportunity to give feedback on the functionality of the planning DSS
- Refine the development of the planning DSS based on stakeholder feedback

With support from the Volta Basin Authority (VBA), DHI and the International Water Association (IWA) organised the 4 day technical training in Accra, Ghana from February 8-11, 2016. The training focused on the functionality available at this stage of the project, with a strong emphasis on planning and on information relevant to the stakeholders. This helped clarify the purpose of the training and the role of stakeholders in the project. While participants were given a chance to explore the platform interface consisting of the MIKE Customised platform (the central tool of the planning DSS) and QGIS, day one focussed on planning and on basic QGIS functionality useful for planning. Day two explored functionality for drought management and planning. Day three focused on seasonal forecasting and climate projection and its implications for planning. The final day looked at the planning DSS support for Water Safety Planning (WSP).

2. Project background

The ‘Flood and Drought Management Tool’ (FDMT) project (http://fdmt.iwlearn.org/) is funded by the Global Environment Facility (GEF) International Waters (IW) and implemented by UNEP, with the International Water Association (IWA) and DHI as the executing agencies. The project is developing methodologies and tools within a decision support system (DSS) with tools to support planning from the transboundary basin to water utility level by facilitating the inclusion of information about floods, droughts and future scenarios into Integrated Water Resources Management (IWRM) planning, Water Safety Planning (WSP), Transboundary Diagnostic Analyses (TDA) and Strategic Action Plans (SAP). The project is being implemented from 2014 - 2018, and 3 pilot basins (Volta, Lake Victoria and Chao Phraya) have been identified for development and testing of the planning DSS.

The project responds to a growing sense of urgency around the need to improve resilience within river basins, and for this to become a critical part of water management plans. Consequently, the IW focal area of the GEF has identified the increased frequency and unpredictability of floods and droughts as a priority concern in transboundary contexts, along with the other multiple drivers that cause depletion and degradation of shared water resources.

The project is integrating information on climate including floods and droughts for planning at both transboundary and national basin and local (specifically water utilities) levels by providing tools for both scales within a single planning DSS. There are also supporting tools such as QGIS and a web portal for downloading climate data under development.

The planning DSS is a computer-based decision support system (or piece of software) containing various technical functionality in the form of ‘tools’ to integrate information on climate including floods and droughts for planning at both transboundary and national basin and local (specifically water utilities) levels by providing tools for both scales within a single planning DSS. Although the planning DSS is being tested and validated with available data at both basin and local levels in the 3 pilot basins, the tool is intended for all other GEF IW basins. This also includes training modules available at the end of the project to ensure that methods can be applied to other basins. The aim is to develop an approach that interfaces with existing planning practices; e.g. TDA/SAP, IWRM or WSP, but will not necessarily embrace all activities within the planning methods. The outcome will enable stakeholders to compile information, from models, indicators and existing planning approaches, so as to develop future planning scenarios that are robust, resilient and pragmatic.

3. Technical training

3.1 Overview of training

Technical training on the use of the planning DSS is scheduled on a yearly basis within each of the pilot basins. The technical training intends to provide capacity building as well as an opportunity for stakeholders to give feedback on the functionality and use of the planning DSS. The feedback will be included in the further development and refinement of the planning DSS and is of great value for the project.

The technical training provides a basis for bringing basin organisations, water utilities and other organisations together around a common planning tool. The training was organised with a number of sessions some relevant for all stakeholders and other sessions specialised for groups of stakeholders based on the technical areas of expertise and needs.

The technical training was based on real data from the Volta Basin. The WSP session made use of data from the Chao Phraya Basin. The training sessions reflect the developed functionality within the planning DSS, hence the first technical training focused on the functionality available at the time of the training, while later trainings will include the functionality of the full planning DSS.

Objective

The objective of the technical training is to:

- Enhance the stakeholders understanding of the developed planning DSS (which they can eventually use to apply in a specific context)
- Provide the stakeholders with an opportunity to give feedback on the functionality of the planning DSS
- Refine the development of the planning DSS based on the stakeholder feedback

Expected outcome of the workshop

The expected outcome of the technical training is that target stakeholders will understand the developed functionality, how to use the planning DSS, and how the output from the planning DSS can be used in decision making around flood and drought management planning across scales.

For the project, this will be an opportunity to get valuable feedback from the stakeholders on the functionality and how the developed planning DSS could be used in decision-making.

Target group

The target group of the technical training is the technical staff within the project stakeholders, junior to senior level water resource professionals as recommended by key stakeholders. The training in Accra focused on staff from the basin organisations – Volta Basin Authority (VBA) – water utilities – Ghana Water Company Limited (GWCL) and National Office for Water and Sanitation (ONEA) – catchment and national level representatives (e.g. national water agencies in Burkina Faso and Ghana, disaster management organisations) and other relevant organisations and institutes (see Annex 3 for full participant list).

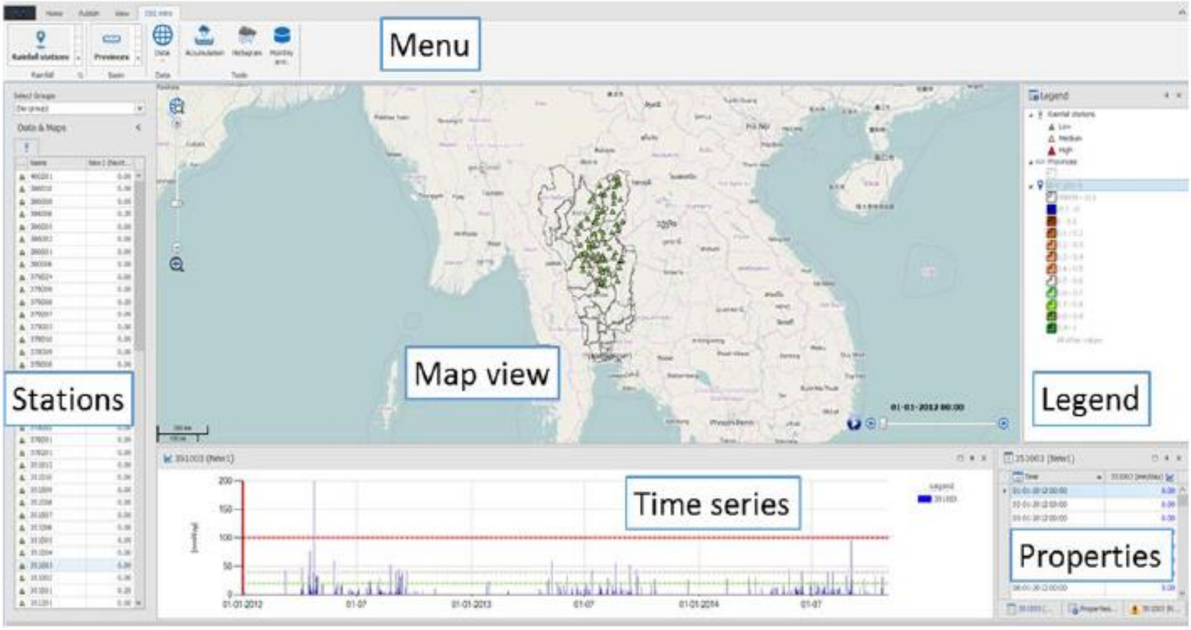
3.2 Technical training

From February 8-11, 2016, the FDMT project held a 4 day technical training with support from VBA at the Miklin Hotel, Accra, Ghana.

The FDMT project is developing a computer-based decision support system (based on MIKE Customised and QGIS) containing various technical functionality in the form of 'tools'. There are ongoing developments of selected functionality within the DSS. At this point, the developments focused on the:

- Platform and tools for the DSS – containing data with planning workflow
- Drought management[1]
- Support for Water Safety Planning (WSP)
- Seasonal forecasting
- Climate change projections
- Web portal – to view and download data

MIKE Customised is the central platform for the planning DSS integrating all tools in one place (it links GIS, time series, meta data, and other applications such as AquaCrop). QGIS, which is a free and open source GIS tool, has been integrated into the platform and customised for the project enabling users to plan, view and analyse spatial data and temporal data, creating maps (e.g. NDVI maps), graphs and tables for reports. It is used to analyse spatial data as the basis for planning.



The DSS platform shows selected data for that station or combination of stations. It enables you to calculate various ranges such as monthly average rainfall, among other functions that can be defined by the user based on the available data and needs.

The training started with a clarification on the objectives of the training and an explanation of the role of stakeholders in the development stages of the planning DSS. The technical trainings throughout the project will help users understand the potential of the DSS to support planning approaches and get stakeholder feedback to help further development and ensure the usability of the end product beyond the project lifetime. The training in Accra gave participants a first impression of the planning DSS in which they could test the functionality of the different components and provide their comments.

Jacob Tumbulto, Director of the Volta basin Observatory, in his opening address, welcomed the efforts by the Flood and Drought Management Tools project in assisting the work done within the basin to plan and better manage for extreme events. In the Volta Basin, there is a growing need for a tool that will assist organisations in their planning for the future of the basin around flood and drought events

Day 1. Planning and basic QGIS functionality

[1] Currently the focus has been on drought management. As the project progresses functionality to address flood issues will be integrated into the DSS.

Monday 8 February 2016

The first session focused on planning in which various decision methods were introduced. This was followed by group work to discuss how planning should be done in the Volta Basin and an introduction to QGIS and how QGIS is being integrated into the planning DSS.

Decision making in Planning

The planning session provided participants with the opportunity to influence the development of the planning DSS by shaping the workflow for how planning should be done.

Planning is the process of deciding how to solve a specific issue and decision making methods help to find the ideal decisions to formulate a plan to address the issue.

Water resource planners (whether basin organisations or utilities) make decisions today without perfect knowledge of the future. The planning DSS will help guide users in a workflow approach through a decision making process by providing the tools to perform the analysis needed in the decision making process taking into account uncertainty

From their own experiences, participants were divided in groups and asked to identify external factors (that cannot be controlled), which hinder the uptake and implementation of interventions. The following table summarises the external factors of each group:

Group 1 (B)	**Group 2 (C)**	**Group 3 (A)**
• Water availability (due to climate change) • Water demand (depends on the population growth as their needs change) • Financial mobilisation (Understanding the changes taking place is important however, money is needed to address the changes)	• Climate change – rainfall patterns are not regular (can be very high or very low) • Political influence • Transboundary issues	• Climate change (will affect water in terms of the availability) • Land use change (degradation of the environmental that is provides the water) • Modernisation and urbanisation (increase demand for water) – population increase

Climate change and population growth are the key external factors identified across the 3 groups. Keeping in mind these external factors, the groups were then asked to identify potential interventions used in planning to meet water demand while minimizing water deficit and maximizing benefits over the next 20 years. The conditions set were as follows:

- Environmental flow requirement for the wetland is just met
- Hydropower demand is just sufficient to meet the demand
- Irrigation demand is just met
- Power and irrigation deficits currently occur every year during the dry season

The following table summarises the main interventions from each group:

Group 1 (B)	**Group 2 (C)**	**Group 3 (A)**
• Building of adaptive dams (multi-purpose dams) (which can take into account all the needs of the city, irrigation sector, energy production) – location is important as this could create conflict with communities • Build tools (e.g. DSS) to share the available water in	• Multi-purpose dams • Information system (climate patterns, etc.) • Storage options – ensure water is available all year round (can be also part of dams) • Education / training • Appropriate technology • Efficient use of water • Provide incentives for good	• Provision of extra dam that is climate resilient in nature • Expand existing water treatment plant • Demand management (sensitisation – reduce the inefficient use of water, even looking at irrigation systems to employ efficient use of water for irrigation)

an equitable way • Having a prediction system about the population growth, about needs, etc.	water storage (e.g. rainwater harvesting) • Sustainable urban drainage systems	

All 3 groups identified the construction of a dam as a good intervention mechanism; however there is a long list of intervention methods that can be implemented. Models can be used and integrated in the planning DSS to observe different scenarios and compare. What is important is to see what the more efficient scenarios are that will yield better results.

Using the common interventions and external factors identified by the groups, the participants were asked how to evaluate the impact of the interventions and external factors, looking at tools to evaluate the impact and indicators to show the impacts.

The following lists the tools (e.g. models, spreadsheets, etc.) to evaluate the impact of the interventions and external factors:

Item	**Group 1 (B)**	**Group 2 (C)**	**Group 3 (A)**
Dam construction under climate change and changing population	• Water availability (improvement of livelihood of inhabitants) • Water demand (national survey institutes in each country that carries out a survey about population, about agriculture production, etc.) • Hydrological models • Assessing conflicts (number of conflicts) – evaluate impact	• Climate models (GSM) • Population census – annual growth rates • Socio-economic surveys (at household level to assess the impact of the dam) • Hydrological models ○ Mostly used by Ghana Water to extrapolate population growth to estimate demand	• Expert opinion (to understand impacts) • Scientific models (WEAP) • Comparing data, based on differences you can see if there is an impact or not

The following table list some indicators:

Item	**Group 1 (B)**	**Group 2 (C)**	**Group 3 (A)**
Dam construction under climate change and changing population	• Percentage of water access • Rate of production • WRIS (socio-economic data also included) • Water pollution around the river (not always the priority of countries, first priority is making water available for agriculture)	• Reduction in waterborne diseases • Improvement in yields from irrigation (farm produce) and fishery • Percentage of coverage of potable water • Increased capacity of power generation • Pumping test (ground water recharge) • Flow rate (measurement upstream and downstream)	• Total production (of water) • Annual expected demand (consumption) of water • Frequency of water shortages • Cost (Net Present Value) • Water levels (total volume of source water) • Environmental flows (measure with stream flow measurements) *Ghana water mostly*

		• Water level in the dam *These indicators are used by the basin organisation and some other organisations such as Ghana Water*	*uses these indicators*

The objective of the exercise was to hear from the groups the most relevant external factors (and related uncertainties) and interventions (decisions), and identifying the evaluation methods/indicators to evaluating the performance of intervention plans. This helped to understand what they consider to be relevant for decision making and to help them define a solution to a problem through a decision making framework.

Introduction to QGIS

Why use QGIS?

- Essential for planning, in particular for viewing and analysing spatial and temporal data; creating maps, graphs and tables for reports; to maintain spatial data.
- Free and open source product – anyone can download it and it is very close to being as good as ArcGIS, as it is open source (no license required), there are bugs, but these can be reported and you can also see how to fix these (these can be found on forums, for example).
- Useful for professional application.
- The field of remote sensing is improving.
- Accepts a variety of data sets (data formats); data conversion is better with QGIS (compared to ArcGIS, which is also not a free and open source product).

Participants explored the functionality of QGIS for processing satellite based data. The exercises helped participants understand how to set up a QGIS project, from adding, modifying and analysing data to mapping, grouping and ordering of data, layer styling and labelling, mapping (create maps), importing and creating and editing GIS layers. This exercise was to get familiar with the basic functionality of QGIS and how it could be used in planning.

Day 2. Drought management

Tuesday 9th February2016

Day two focused on drought management and what functionality has been developed in the planning DSS as well as a web portal and what information is made available (e.g. climate data) to support planning around drought management.

Drought management and remote sensing

The first step within drought management is to get an overview of the current drought status/impact. There are two options to access remote sensing data. The first is to work with QGIS, execute the necessary scripts and download the data. The second is through a recently developed web portal which allows users to access selected satellite based data. Once the processed information is downloaded (as a csv file) it can be easily used in the planning DSS. Every second day the portal downloads the data from the web server. As the web portal is developed, data will be available for a selected basin including SWI, TRMM, seasonal forecast, NDVI, Water extent. These are not all currently available as the web portal is still under development.

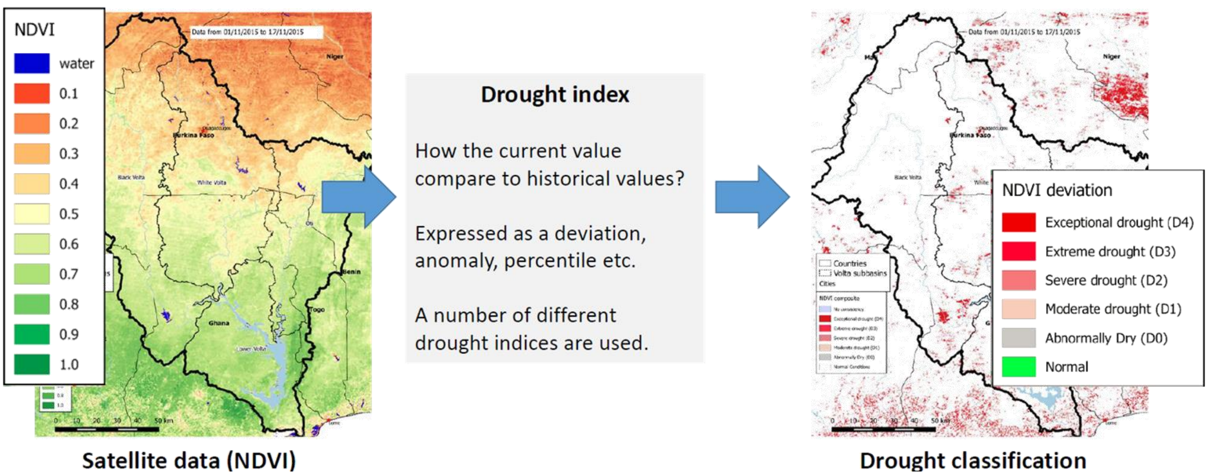
The portal has only raw data, no models, requires no license and does not have any maintenance cost for the user. The source of the data can also be viewed. To look at more detailed processes such as flows from different countries then need to use hydrological models. Links to the modelling can be supported by planning DSS but the model needs to be provided by the organisations using the planning DSS and there would need to be some work to make the linkage. To see more details in sub-basins, the approach would to download the relevant raster file and overlay with shape file in QGIS for further analysis at the local level.

The downloaded data is used to identify areas where there might be a water deficit or a drought impacted area by comparing the deviations between historical information and current status. The deviation is converted into drought categories, so an exceptional drought would have a large difference compared to previous years. The comparison will be looking at the same month and season in different years (rather than days as there will be changes over a month or season). This information can be used in management and planning around drought impacts.

The project addresses three types of drought:

- Meteorological drought: Rainfall and potential evaporation using Tropical Rainfall Measuring Mission (TRMM) to estimate the change in rainfall – the use of GPM will replace TRMM once there is sufficient historical data (this has a higher resolution)
- Hydrological drought: using Soil Water Index (SWI) to estimate changes to the moisture content in the upper soil layers – data indicates the water availability in the root zone. The data (spatially distributed) is updated every other day.
- Agricultural drought: Vegetation cover using Normalized Difference Vegetation Index (NDVI) to estimate the vegetation growth – data is updated every 16 days (16 passes within a 16 day period, providing the best data). NDVI deviation map; the analysis of the NDVI map, shows how the current situation is normal or different to the normal situation, or what is expected

The above indices are used to categorise the climate conditions or situations; in this case for drought classification. NDVI indicates vegetation cover[2] and analyses how the current situation compares to the normal (or average) historical condition; comparing whether the conditions over time are above or below the normal mean. If vegetation is low, this will be flagged with a red colour indicating a certain level of drought (there are 5 classes of drought from abnormally dry to exceptional drought – the assessment looks at what is normal (what you expect the situation to be) to understand the extent of the deviation from what is expected). A similar process is done with SWI and TRMM data. The information obtained can be used for operational drought planning, for example.



The project looks at all three indices because vegetation cover can be lower than usual due to a farmer deciding to grow less, which would not be an indication of a drought. Therefore, it is best to combine more than one indicator for drought analysis. Also, ground-truthing of the data should also take place, which means checking the satellite data with measured rainfall on the ground.

[2] USGS, IP DAAC - source of data for vegetation cover

The drought functionality within the planning DSS should enable users to look at drought indices, and then use this information in planning around the management of the situation.

Not yet a focus in the project, but the same approach will be used for flood management using satellite data to produce flood maps using the MODIS 500 meter 8 day reflectance product. The combination of NDVI and SWIR (shortwave infrared) values extracted by the product ensures the best approach for capturing a water extent (2 independent parameters). One of the challenges is that the satellites are cloud sensitive which is an issue when collecting information on heavy rainfall and flooding. The project would like to use a radar based satellite product, currently Sentinel 1 has limited bandwidth, but using data from Sentinel 3[3] is planned and should be more effective.

The groups were given the opportunity to explore the web portal. Exercises using the web portal served two purposes: to let the participants use the tool and to get feedback on the usability or the way in which data is being downloaded and viewed. Using the portal they were asked to analyse rainfall data for the Oti sub-basin; calculating the monthly average, the driest month and the wettest month.

Item	**Group 1 (B)**	**Group 2 (C)**	**Group 3 (A)**
Monthly average	74.3691	74.3691	74.36
Two ways to calculate • *monthly average of the mean column* • *average of the data column*	*Does the answer received make sense?* Looking at the mean for the whole year does not make sense, it is better to look at the mean per month (you can multiply the mean by 12 to get 892 mm – this calculation makes sense, but the amount is not good, the yearly average is too low. It is important to look at the data to see why this is the case. You can use TRMM data to correct this and keep in mind we are interested in the deviations and not the absolute data. However, verified data is needed to ensure that decisions are based on sound information No matter the type of data, it is always important to do a quality check		
Driest month	December 2010	December 2010	December 2010
	How do you calculate this? -Filtering (group 1) -Sorted the table (group 3) and use this to find the highest and the lowest value		
Wettest month	August 2009	August 2009	August 2009
	How do you calculate this? Same as above		

Focusing again on the Oti sub-basin and looking at TRMM, SWI and NDVI data, the groups were asked to look at the dry season in 2015 and to observe how the values were compared to the long term mean. They were then asked whether the dry season was drier or was it wetter.

Item	**Group 1 (B)**	**Group 2 (C)**	**Group 3 (A)**
Rainfall (TRMM)	-	-	-
	Rainfall was low and it delayed		
SWI			Dry season longer than the mean (that what we normally notice) the Soil moisture recovers a bit later
	Largest deviation of rainfall was also around April, so this makes sense the at soil moisture recovers later.		
NDVI	Similar trend as before.		

3 http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-3

	However, there is no major time lag that was		
	Lack of rainfall in April has affected vegetation. What could be another reason for the deviation in vegetation? Fire, deforestation, farming practices, could be the data		

All 3 groups observed that the 3 indices were all in agreement. Participants were told when looking at the charts, if a larger deviation was observed, this is an indication of a more severe drought category and less deviation a less severe category.

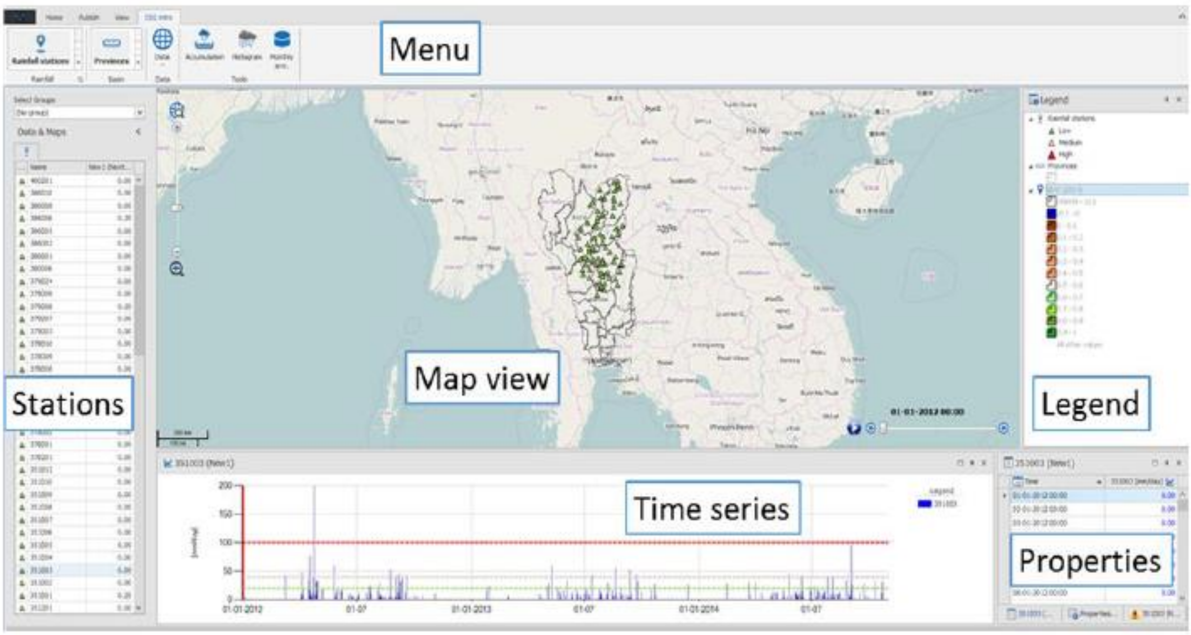
The groups were also able plot the historical ensembles for rainfall and use this to evaluate the risk of drought, identify which months are critical for drought and observe the difference between the sub-basins.

Day 3. Climate in the DSS
Wednesday 10th February 2016

Day 3 focused on the objectives of climate data in the planning DSS looking at seasonal forecasting and climate change projections.

DSS planning introduction
The planning DSS allows you to both view data but also analyse data. System and data visualisation and analysis in the planning DSS consists of:

- Map views
- GIS layers
- Station lists
- Observation times
- Time series



There are two key parts of the planning DSS; configuration and the system interface. The configuration option provides the user with different options to configure the DSS and define specific setups. This section, for example, enables the user to define functionality (e.g. tools to calculate monthly average rainfall, etc. – this can be user specific as there is no limit to the additional functionality that can be defined by the user) or defining stations, attributing data (can associate more data information to one station, e.g. turbidity, salinity, water level, etc.) and defining thresholds, among other options. The system interface is used to view and analyse the data.

The planning DSS can link to a system database on a central server to which you log on to. Inputting data can be itemised by importing a script into the DSS system, however, this would need to be done by an IT person.

Other functionality of the planning DSS includes the possibility to link to web pages or spreadsheet interfaces. For example creating a tab for the project website or integrating the AquaCrop model from the Land and Water Division of FAO.

Information in the form of seasonal forecasting and climate change projects can provide a general expectation of possible futures and associated impacts. This information can help determine what the right actions are needed, which can ensure the sustainability of the basin and its resources.

Functionality to model climate change projects and seasonal forecasting are being developed in the planning DSS.

Seasonal forecasting

Functionality for seasonal forecasting has been developed to forecast drought impact. Currently the Climate Forecasting System version 2 (CFSv2) developed and published by NOAA is used because it has global coverage and is publically available. The seasonal forecast is based on a global climate model, using satellite based information updated daily, providing 20 ensemble members of forecasted climate . What this means is that no one future is predicted but several futures all equal in terms of probability (they have all the same probability of happening, one is not more likely than the other), this enables you to study multiple scenarios.

An ensemble forecasting system samples the uncertainty inherent in weather prediction to provide more information about possible future weather conditions. Rather than producing a single forecast with a model, multiple forecasts are produced by making small alterations either to the starting conditions or to the forecast model itself, or both.

The functionality for seasonal forecast is used to describe how the drought is expected to evolve over the coming weeks to months (information needed for the drought indices) or to analyse crop production (using AquaCrop). The goal is to use the planning DSS to operationalise – downloading forecasting to processing, extracting relevant time series and generating products, and reporting and dissemination.

This information is useful for asset management, for example to optimise the management of a dam in relation to the agriculture sector. However, the information would be more valuable if linked to a hydrological model. Just forecasting rainfall is not enough.

In the groups, participants were asked what kind of information can be used to analyse what the chance of rainfall to be above or below the long term mean in March 2016. The use of historical data can help suggest if rainfall should be above or below, but there is no certainty. With functionality to forecast, this can easily be addressed. What the exercise showed was that without information on forecasting, it is hard to tell if the rainfall would be above or below normal (or normal).

The groups were asked to download seasonal forecast from the web portal and us the data to calculate the average, median, min and max of the ensembles for the forecast for March 2016. Once calculated, they were asked to compare the median to the long term mean for March and indicate if the observation is above or below the normal. The long term mean is based on the historical data.

All groups agreed that the median was below the normal long term mean (historical mean). The analysis showed the number of ensembles above and below the historical mean to establish the probability that the forecast will be below the mean (60% more likely to be below the historical mean). Even though the median is below, it is almost 50%, so it is not a clear forecast.

When using forecast, you need to also assess the skill of a forecast; reliability of the system – seasonal forecast model. The skill of a forecast describes the performance of the forecast compared to observations. Past forecast runs or so-called reforecast datasets are used to compare forecast ensemble with historic data. As an example, the figure below shows how reliable the ECMWF System 4 forecasts dry and wet conditions for winter and summer on a global scale[4].

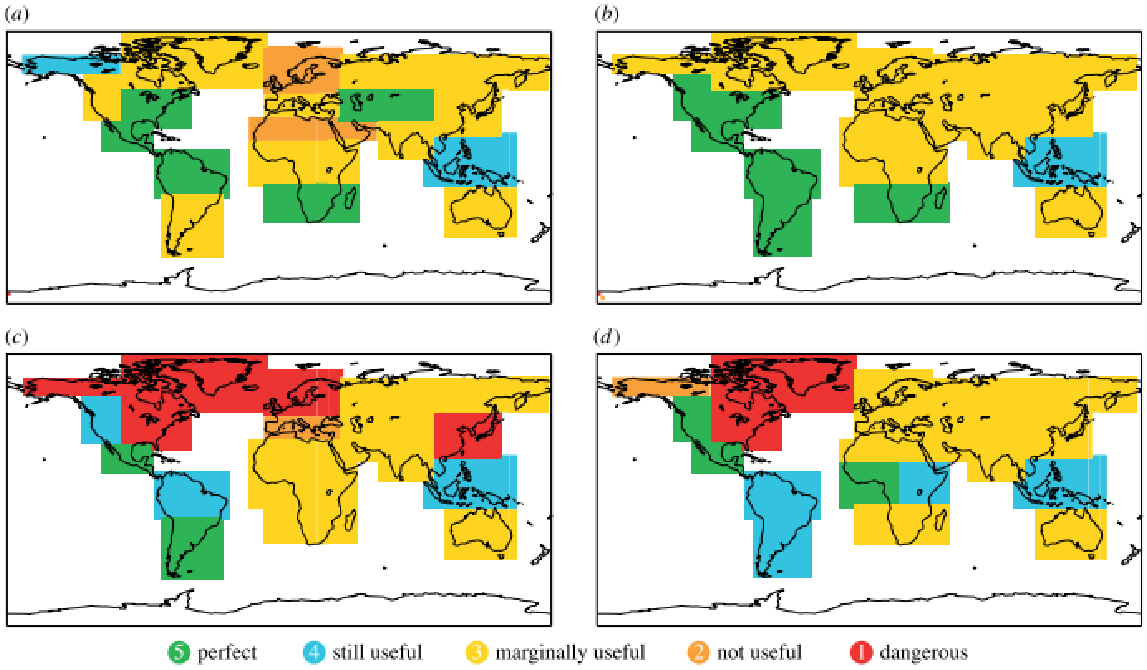


Figure 5. Reliability of System 4 seasonal forecasts for precipitation. (*a*) Dry DJF, (*b*) wet DJF, (*c*) dry JJA and (*d*) wet JJA.

When red, this is an indication that it is dangerous to use the forecast model. It is then better to use historical observed data to make a forecast.

There are different figures for different conditions, the above figure is for rainfall. Temperature has its own reliability test – this example is not a reflection of the model we are using but it is to show the reliability of models for the various regions and how it is done. As the FDMT is a global project, a model that looks at global levels is needed. However, as the planning DSS will be flexible, users can integrate models that are more skilled in their region to forecast, however the data integration process would require an IT person/expert user to enable this.

Climate change

As identified in the decision making group activity, climate change is an external factor. The objective is to develop functionality supporting climate processing seamlessly across different temporal scales, from short to seasonal to decadal climate processing.

The current status is:

- Functionality for automated download and processing of seasonal forecast is implanted (global 9 month daily forecast updated every 5 day)
- Seamless climate processing across different temporal scales

Climate predictions are based on Global Climate Models (GCM), which have a spatial resolution of about 100km, this is too coarse so needs to be downscaled. One way is dynamic downscaling to Regional Climate Models (RCM). It takes the boundary levels of the global model to the regional level. Resolutions are then 10 to 50 km. This is often not enough so statistical downscaling or bias correction is used.

[4] The Figure is taken from the following reference which describes in more detail a skill assessment of the seasonal ensemble forecast ECMWF System 4: Weisheimer A, and Palmer TN. 2014 On the reliability of seasonal climate forecasts. *J. R. Soc. Interfaces* **11**: 20131162. http://dx.doi.org/10.1098/rsif.2013.1162

The RCM ensembles and different downscaling methods are used to produce input to (hydrological) impact models. Ensemble of projected impacts are used as input to decision making methods and the output of decision making methods can be used to formulate adaptation strategies.

Data is used from the CORDEX project – the project coordinates regional climate data for the whole world, using various climate models (see map from presentation). For Africa, currently 10 models are available. The information on climate projections can be used in strategic planning to plan around infrastructure development, investments, policies and operating guidelines.

After individually exploring the functionality in the planning DSS around climate change, the groups were asked, using ensemble information, to identify the median monthly precipitation change for April within the Volta Basin under different climate forcing scenarios[5]: RCP45 and RCP85. Additionally, the Planning DSS could be used to indicate how many models agree on an increase in precipitation for April.

The groups discussed how the uncertainty on climate information could be considered in a planning case. Conditions were defined as follows:

- Environmental flow for wetland is equal to the current dry season flow
- Hydropower demand is just sufficient to meet the demand
- Irrigation demand is just met
- Power and irrigation deficits currently occur every year during the dry season

Unfortunately, these conditions are not sustainable in the future and a basin and its cities need to decide on investments. The groups discussed long term planning for required investment to ensure a sustainable power and water supply.

Item	**Group 1 (B)2**	**Group 2 (C) 1**	**Group 3 (A)3**
Step 1 *Discuss what the time scale for needed investments would e (10, 20 or 50 years)?*	20 years	Depending on the type of dam you can plan and develop a dam between 2-5 years and for a big one between 5-10 years	20 years
Step 2 *Discuss which organisation would be responsible for making these long term plans*	Everyone makes their own investment plan (VBA, Water Utilities, WRC, HSD, etc.). National Development Planning Commission for long term planning.	For the purpose of reservoir Irrigation Development Authority (IDA) is usually leading but they do this with other stakeholder institutions such as the Water Resources Commission (WRC) or the District Assembly (consists of WRC, HDS, VBA) If it is a transboundary river system, then it is the duty of the WRC to write to VBA to inform	Those in charge of the water resources such as the government institutes.

[5] The new generation representative concentration pathway (RCP) scenarios represent one of many possible pathways in radiative forcing, i. e. the difference between sunlight absorbed by the Earth and energy radiated back to space. Differences in the radiative forcing impact the Earth's climate dynamics which is modelled by global and regional climate models. It is commonly known that a main driver of changes in radiative forcing are changes in greenhouse gas concentrations in the atmosphere.

RCP45 and RCP85 project a concentration of 650 ppm and 1370 ppm CO_2 equivalent in the atmosphere by the end of this century.

		them about an intention. If there are problems then VBA will take it up and monitor the process Need accurate data including flow data so Hydrological Services Department (HSD) is important. Ministry of finance and other ministries are relevant as well.	
Step 3 *How would you include climate change information (ensembles) into a decision process?*	Take reports from the hydrological services department – they write a report on how climate change will affect water availability and use this in their plan – e.g. water demand management strategies based on the climate change projections, sensitising populations on the needs to preserve water, changing behaviours. HSD makes the reports based on water levels, using historical data (using this as a baseline). For climate change, information is based on models to do forecasting.	WRC setting up dam safety unit guideline. Climate change has been captured into this guideline. You can no longer go and just design but it must fit into the guidelines – ecological flow, etc. They also consider the uncertainty of the climate change in the guidelines, such as potential areas for reservoir construction. If it has to cross the country, then there is a challenge. Need to take into consideration downstream impacts in case of flooding that might, for example, damage the reservoir. In terms of drought, there is a cost implication. However, there is more than just cost implications, there are also safety implications and these are also addressed in the guidelines.	Models for water resources that include climate change forecasting need to consider potential changes (evapotranspiration, infiltration) and use of historical data as well. This can give more information to be sure about the decision being made in the long term.

Step 4 *How would you ensure that the uncertainty is captured in the decision?*	Consider this in dam construction (relate to rainfall changes and temperature changes (e.g. to minimise evaporation rates).	-	Several scenarios are provided e.g. probabilistic scenario (max quantity of water for the dam and also the worst scenario (climate change will impact water availability) – looking at the worst and best scenario. You can use this information to see the best suitable conditions to meet the needs of the people.

Day 4. Water Safety Planning in the DSS and crop modelling
Thursday 11th February 2016

WSP in the DSS
Water utilities assess risks and make decisions on safety measures in order to guarantee a safe and sustainable drinking water supply. Due to the potential hazards in the raw water sources, treatment plants, their distribution systems, water supply systems and consumers are exposed to a wide range of risks. In addition, climate change, societal development and the emergence of new hazards constantly provide new risks. As a result, water utilities continuously have to assess risks and prioritise water safety measures in order to obtain a safe and sustainable supply system.

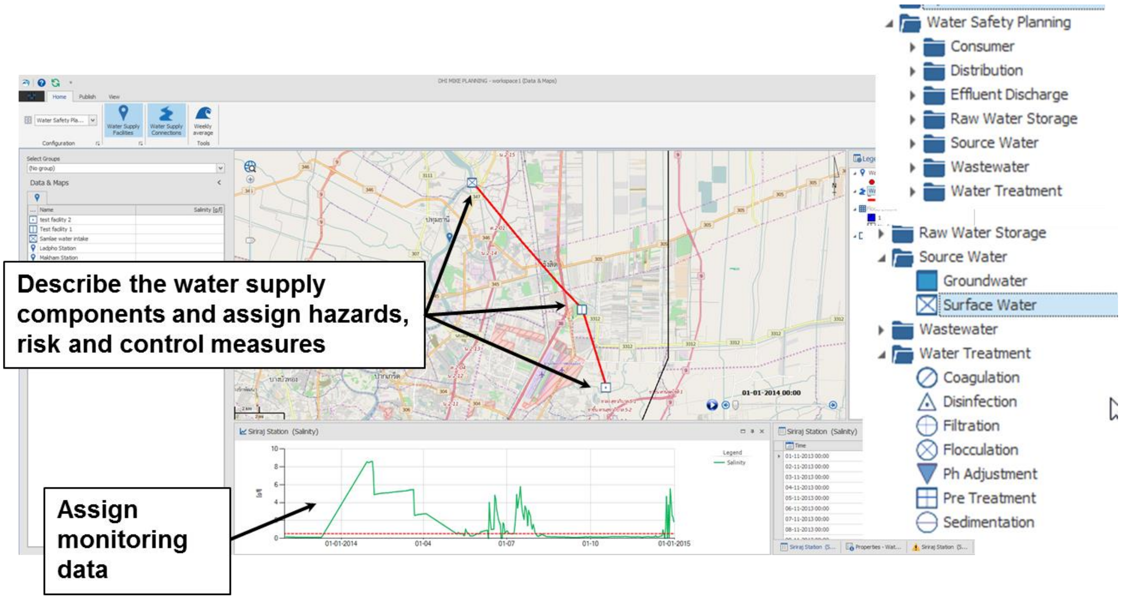
One of the most effective ways of continuously ensuring a safe supply of drinking water (safe is understood from a heath perspective; you can drink the water and not have any negative impact on your health) is through a comprehensive and continuous risk assessment and risk management approach that involves all steps in supplying water; from catchment to consumer, known as Water Safety Planning (WSP). The development and implementation of the WSP follows 11 modules that broadly address the following:

- Establishing a team and decide a methodology by which a WSP will be developed
- Identifying all the hazards and hazardous events that can affect the safety of a water supply from the catchment, through treatment and distribution to the consumers' point of use
- Assessing the risk presented by each hazard and hazardous event
- Considering if controls or barriers are in place for each significant risk and if these are effective
- Validating the effectiveness of controls and barriers
- Implementing an improvement plan where necessary
- Demonstrating that the system is consistently safe

The project is developing technical tools to support some of the WSP modules, however in different capacities. The overall idea is to digitalise the WSP process for utilities as this will help when a utility needs to update its plan.

The planning DSS will fit into the WSP framework and assist water utilities in the different stages of WSP implementation. It will not create additional work and should not replace the existing WSP manual.

The WSP supporting tools are divided into:
1. Schematic description of the water supply system.
2. Assigning potential hazards, risks, control measures and monitoring mechanisms to each of the water supply components (e.g. abstraction points, pumping stations, pipes, etc.).



The exercise allowed participants to add shape files in order to have layers to zoom to and to define observation stations and associate time series to the stations. They were then able define new components of the water supply system and to assign hazards, control measures and monitoring options to these components. When defining control measures, utilities define measures within their boundaries (from the point of abstraction to meter). Beyond their boundaries, there is limited control which makes it hard to put in place preventative measures. There is a need for an effective way to communicate beyond for the utility, for example if water is contaminated by an incident upstream. The planning DSS can help in relaying information at the different scales.

Within the groups, participants were asked to define potential hazards for the water intake from a river. For each hazard they were asked to assess the likelihood (almost certain, likely, moderately likely, unlikely), the consequence (catastrophic, major, moderate, minor) and the risk profile taking in consideration the likelihood and consequence (high risk, medium risk, low risk).

	Hazard	**Likelihood**	**Consequence**	**Risk profile**
Group B	Climate variability – not enough rainfall, limited rainfall	Moderate	Moderate	Medium
	Agriculture – farming and livestock (pesticides (agro chemicals) and ecoli in the water bodies)	Almost certain	Catastrophic	High risk
	Siltation	Unlikely	Minor	Low risk
	Mining activities (pollutants)	Moderately likely	Major	Medium risk
	The risk profiles are quite subjective; participants had differences in opinions around this. It shows the importance around assembling a WSP team as they will go through this process for the entire system			
Group C	Effluent from Industry	Likely	Major	Medium risk
Group A	Water quality - point and non-point contamination	Almost certain	Major	High risk
	Low river flow	Likely	Minor	Low risk

Picking the hazards with a high risk, the groups were asked to identify control measures and to re-assess the risk (post risk) based on the effectiveness of the control measure and what parameters could be sued to monitor the effectiveness of the control measure.

	Hazard	**Control measure**	**Effectiveness**	**Post risk**	**Parameter (monitoring measures)**
Group B	Pesticides	Education and regulation (enforcement rules)	75-80%	Low risk	Presence of algae in water
Group C	Effluent form Industry	Regulation, Treatment, Enforcement, Availability of labs	80%	Low risk	Heavy metal, P and PH COD and BOD Availability of labs
Group A	Water quality (point and non-point contamination)	Control points upstream – water monitoring upstream	80%	Low risk	PH level and turbidity – also level of chlorination (residual chlorination)

The process the groups went through gave an example of what the planning DSS will support in the WSP implementation.

More work will be done on linking WSP to flood and drought information and improvements are expected on the reporting capability for the WSP. Continuous consultation with utilities is needed to ensure that the right information and functionality is available to utilities and adds value to their efforts in ensuring a safe supply of water.

3.3 Next steps (Q2, Q3 and Q4 2016)

As the project continues, there will be more developments, especially to the DSS platform. Some of the activities planned for the first and second quarter of 2016 are:

- Finalise WSP support (easy overview and analysis of components with high risk, improve the hazard, control measure and monitoring flow, improve the reporting and dissemination functionality, and incorporating flood and drought elements)
- Finalise drought early warning and dissemination
- Development and validation of climate processing functionality
- Implementation of planning methods
- Support for Transboundary Diagnostic Analysis (TDA)
- Concept for climate change and flood management

Annex 1 – Agenda

Monday the 8th of February 2016 *Planning and QGIS basic*		
Time	**Title**	**Responsible**
09.00 – 09.30	Welcome by VBA	VBA
09.30 – 10.00	Training objective and agenda Stakeholder interaction and roles	DHI IWA
10.00 – 13.00	**Planning** • Presentation on decision methods • Group work	 DHI DHI/IWA
13.00 – 14.00	Lunch	
14.00 – 15.00	Examples of planning applications in the DSS • Water resource assessment in Burkina • Scenario evaluation based on a case in Volta	DHI
15.00 – 16.45	**QGIS basic exercise**	DHI
16.45 – 17.00	Feedback (groups) and wrap up	

Tuesday the 9th of February 2016 *Drought*		
Time	**Title**	**Responsible**
09.00 – 09.30	Questions based on experience from day 1	
09:30 – 13.00	**Drought** • Drought presentation • Presentation of the drought portal • Group work	DHI
13.00 – 14.00	Lunch	
14.00 – 16.30	**QGIS climate and drought functionality**	DHI
16.30 – 17.00	Feedback (groups) and wrap up	

Wednesday the 10th of February 2016 *Climate in the DSS*		
Time	**Title**	**Responsible**
09.00 – 09.30	Questions based on experience from day 2	
09.30 – 13.00	**Climate in the DSS** • Presentation: objective of climate data in the DSS Seasonal forecast • Background presentation and exercise Climate change • Background presentation and exercise	DHI
13.00 – 14.00	Lunch	
14.00 – 16.00	**Group work on climate in the DSS**	
16.00 – 17.00	Feedback (groups) and wrap up	

Thursday the 11th of February 2016 *WSP in the DSS*		
Time	**Title**	**Responsible**
09.00 – 09.30	Questions based on experience from day 3	
09.30 – 13.00	**WSP** • Presentation and exercise	DHI/IWA
13.00 – 14.00	Lunch	
14.00 – 16.00	Feedback (groups) and wrap up	

**note: not all items on the agenda were addressed to ensure engagement levels remained high.*

Annex 2 – Participants

Name	Organisation	Country	Email
Participants			
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Annex 3 – Evaluation form

Evaluation of Flood and Drought Management Tools Technical Training

Name: **Organisation:**

What was your overall impression of the training?

Excellent	Good	Acceptable	Below expectations
☐	☐	☐	☐
Comments:			

General	Too high		Acceptable		Too low
How did you find the technical content of the course?	1	2	3	4	5
	Agree				Disagree
There was sufficient hands-on support during the training	1	2	3	4	5
Comments (specifically on the technical level of the training):					
	Too long				Too Short
The duration of the training was…	1	2	3	4	5
The time for discussions and group work was…	1	2	3	4	5
The time for individual hands-on exercises was…	1	2	3	4	5
Comments (specifically on length of the training and time provided to do each exercise):					

Presentations and demonstration of Flood and drought management tools	Agree				Disagree
I have a good overall understanding of the Flood and Drought Management Tools project and what it is trying to achieve	1	2	3	4	5
The demonstration of the Flood and Drought Data Portal was clear	1	2	3	4	5
The presentation and demonstration of QGIS was clear and understandable	1	2	3	4	5
The presentation and demonstrations of the Planning DSS (climate, forecasting, water safety planning, Aquacrop) was clear and understandable	1	2	3	4	5
What could be improved and made clearer when presenting and demonstrating the tools? **Are the tools provided too technical?** **Which tool are you likely to use and how?**					

Presentations and demonstration of Flood and drought management tools	Agree				Disagree

Individual exercises and group work	Agree				Disagree
The individual exercises for each of the tools was easy to follow	1	2	3	4	5
The group work on the tools was useful	1	2	3	4	5
The individual exercises and group work helped increased my understanding of the flood and drought management tools	1	2	3	4	5
Which did you prefer – group work or individual exercises (or a combination)? Why?					
What could be improved and made clearer?					

Course practicalities	Agree				Disagree
The venue was satisfactory	1	2	3	4	5
Lunch and refreshments were satisfactory	1	2	3	4	5
The training was well organised	1	2	3	4	5
I received practical information well in advance	1	2	3	4	5
Comments:					

Results of the Evaluation

n *13*

	Excellent	*Good*	*Acceptable*	*Below expectation*
What was your overall impression of the training?	2	9	2	
Comments	#2. J'ai un probleme de langue (manque de introduction durant l'utilisation du logiciel); Logiciel inacheve [Problem with the language (introduction during the use of the system is missing); Software is unfinished] #4. The tool will be good for planning #7. The portal is very useful to my organisation (Hydrological Services Department) #11. It is so difficult for me to follow and understand the goal of all sessions #12. It was good but too short			
	2	*9*	*2*	*0*

General						*n* *13*
	Response					
	Too High		*Acceptable*		*Too Low*	
	1	*2*	*3*	*4*	*5*	
How did you find the technical content of the course	3	4	3	2	1	
	Agree				*Disagree*	
	1	*2*	*3*	*4*	*5*	
There was sufficient hands-on support during the training		8	5			
Comments (specifically on the technical level of the training)	#2. Chaque module deait prendu du moins un jour / [Each module should take at least one day] #3. Since local data/historical data were not integrated the scale of applicability remains to be worked on (performed) #4. Within the time limits percentage allocation was okay. However, more time for the overall training needed #6. Beneficial technically #7. The team who conducted the training was very patient to take us through #10. The exercises are not good because our computer doesn't work with the software (French) #11. I prefer more assistance, if it is possible to interpreted in French the training #13. Technical support was good					

	Too Long				*Too Short*
	1	*2*	*3*	*4*	*5*
The duration of the training was...		1	5	5	1
The time for discussion and group work was...	1	2	6	2	2
The time for individual hands-on exercises was...		6	4	2	1
Comments (specifically on length of the training and time provided to do each exercise)	#1. Time allowed could be increased for exercises #2. Accordu plus de temps aux cas pratique individuel car dans les travaux de groupe to as l'impression d'avoir tout compris / [Provide more time on the individual exercises because in the group exercises there is the impression that all is understood] #3. At this stage of the software construction, it is okay that we couldn't do more than what we did #4. Percentage allocation of time was okay. The overall training time was inadequate #6. The duration of the training was alright exercises were adequate #7. The time provided for each exercise was appropriate #10. No time to do exercises step-by-step #11. I found the training too short with all sessions #13. Time for the training was enough and time for each exercise helped with critical thinking				
	4	*21*	*23*	*11*	*5*

Presentations and demonstrations of flood and drought management tools						*n* *13*
	Response					
	Agree 1	*2*	*3*	*4*	*Disagree* 5	
I have a good overall understanding of the Flood and Drought Management Tools project and what it is trying to achieve	4	7		2		
The demonstration of the Flood and Drought portal was clear	8	2		3		
The presentation and demonstration of QGIS was clear and understandable	6	4	1	2		
The presentation and demonstration of the Planning DSS (climate, forecasting, Water Safety Planning, AquaCrop) was clear and understandable	3	7	1	2		
What could be improved and made clearer when presenting and demonstrating tools?	#1. Being able to undo in the model; Ability to couple the model to other systems/models; Creation of dropdown menu to add water use limits #3. Data sources #4. How the tool can be linked to other models for integrated planning #10. The software is not working in French #11. Do the presentation in French #12. This part of the activity was important but it was a new tool for most of us #13. Presentation was good					
Are the tools provided too technical?	#1. No #3. No #4. Not really, can be understood #6. No, they are acceptable #7. Not really #8. No #9. Yes #10. Software doesn't work #13. No					

Which tool are you likely to use and how?	#1. DSS, QGIS, AquaCrop, Forecasting #3. All of them #4. The sensitivity of the tool #6. Flood tools #7. The portal because it gives you an idea about the conditions within a particular location #8. Data portal, QGIS #9. All of them #10. DSS introduction #11. QGIS for making charts; DSS for planning management of resources #12. MIKE planning

21 20 2 9 0

n *11*

Individual exercises and group work					
	Response				
	Agree 1	*2*	*3*	*4*	*Disagree* 5
The individual exercises for each of the tools was easy to follow		6	4	1	
The group work on the tools was useful	2	6	1		2
The individual exercises and group work helped increase my understanding of the flood and drought management tools	2	6		3	
Which did you prefer - group work or individual exercises (or a combination)? Why?	#1. Combination - It increased my understanding from other perspectives #2. Combination - les travaux de groupe permet d'eclaire et les travaux individuel permet bien assimiler / [Combination - the group work helps to get enlightened on the topic and the group works helps you apply this in a context] #3. Both of them #6. Group work - sharing ideas #7. Group work because it helps to share ideas #8. Permit team to move faster, get other points of view for review #9. Combination - it help with individual effort and sharing ideas #10. I prefer group work, it is a moment to discuss and look carefully at the input data				

	#11. I prefer the two to get other's experience #12. Combination - it permits us to understand better, especially for groups that do not understand anything #13. Group work was much better, ability to discuss diverse views before presentation and avoiding repetition
What could be improved and made clearer?	#1. Allowing more time for both group and individual exercises #2. La planificat de usages et de l'eau et les provision saisonnier / [The planning, uses and provision of water (seasonal scale)] #7. The portal, in terms of rainfall data. I expect the resolution to be improved #8. Give explanation of basic information on use of Aquacrop as most people are not familiar with it #11. DSS planning #12. The last days and water safety planning

	4	*18*	*5*	*4*	*2*

n 13

<u>Course practicalities</u>					
	Response				
	Agree				*Disagree*
	1	*2*	*3*	*4*	*5*
The venue was satisfactory	4	6		1	2
Lunch and refreshments were satisfactory	3	7	1	1	1
The training was well organised	7	2		3	1
I received practical information well in advance	5	3	1	2	2
	19	*18*	*2*	*7*	*6*

Any other comments	#2. Consulter les participants avant de choisir les conditions d'hebergement et de restauration / [Consult with the participants before choosing the accommodation and subsistence] #4. Excellent facilitation. Facilitators were ready to assist especially in the hands-on exercises #10. For the text training, please if it is possible to get one day to take a rest to visit the host town. The per diem is very small but we are leaving our country for some days and generally we do not get a per diem from our office. The training organisers should give us a per diem of the level of the host country #11. No comment on the organisation #13. Presentation by other organisation was very good and informative

Annex 4– Daily Feedback

Day 2 - Comments

What 3 things were useful and what 3 things can be improved?

	Group 1 (B)	**Group 2 (C)**	**Group 3 (A)**
Three useful	Data portal is very good, one of the issues with Tiger net is that you need to take a huge chunk of information, so this is a good part of the portal, you go straight to the basin and take the information (improvement form tiger net)	Application this morning is user friendly	Availability of rainfall data Usage of QGIS is a good and powerful tool to manage data Portal, interesting to share data with partners
Three improvements	Link with WEAP (that is what is being used in the basin) – high priority Drought means different things for different people… need to reflect this but need to see how to take it into consideration, drought for an energy producer might not be drought for a farmer Data ensemble is good but need to see how to make good use of it (how to interpret) If we have to combine a number of factors to explain drought, we should find a way to weight them	*Application (web portal)* Application – link the DSS with other tools like WEAP and SOPEC Web application charts look very clustered… have a pan function when you zoom in SWI open all charts at the same time so that its easier to compare (multiple charts) Option to minimise (resizing) Oti basin example, since you can have different rainfall patterns it would be better if you can provide a summary for showing the different occurrences for different parts of the basin (each basin has a different climatic condition e.g. different wet and dry seasons) – climate zones (be clearly defined)	Improve the resolution of satellite data (good data) Going from rainfall, to run off (absolute values/observed values
Mapping out stations (based on coordinates) – The Hydrological Services Department (HSD) can provide that information Work towards an improved version that they can use and play around with the tool – after a year no dongle			

Day 3 - Comments

What 3 things were useful and what 3 things can be improved?

	Group 1 (B)	**Group 2 (C)**
Three improvements	*Properties window* Graphical Visibility of layers (check box to hide and show) Text style has no drop down Style type: simple and unique values changes the menu and the view of the map Visibility range, no values	Software does not work in French Version problem with WRIS and Mike Planning Difficult to download layer Problems with internet. Background map independent of internet needs -

Day 4 - Comments

WSP part was a bit slow (software problem) – this part needs to be more simple.

Running the crop water functionality went well