Data Requirements and Modelling

Appendix E

Contents

1 INTRODUCTION

1.1 Background

The modelling that will be undertaken as part of the development of the NB DSS will be of two general types: 1) Feature oriented modelling undertaken in WP1 intended to demonstrate model capability; and 2) Study oriented modelling undertaken in WP2 intended both to exercise and test the DSS as well as to develop the base models that will form the foundation for studies to be conducted in the future by NB DSS users and stakeholders (cf. Figure 1.1). Each of these types of modelling can be further subdivided into basic water allocation modelling and specific process models and decision models. The focus of the WP1 modelling will be on building realistic representations of actual conditions in the Nile basins that demonstrate features of the system, while the focus of WP2 modelling will be on developing a complete Nile basin model and detailed process models that accurately represent the features to be studied.

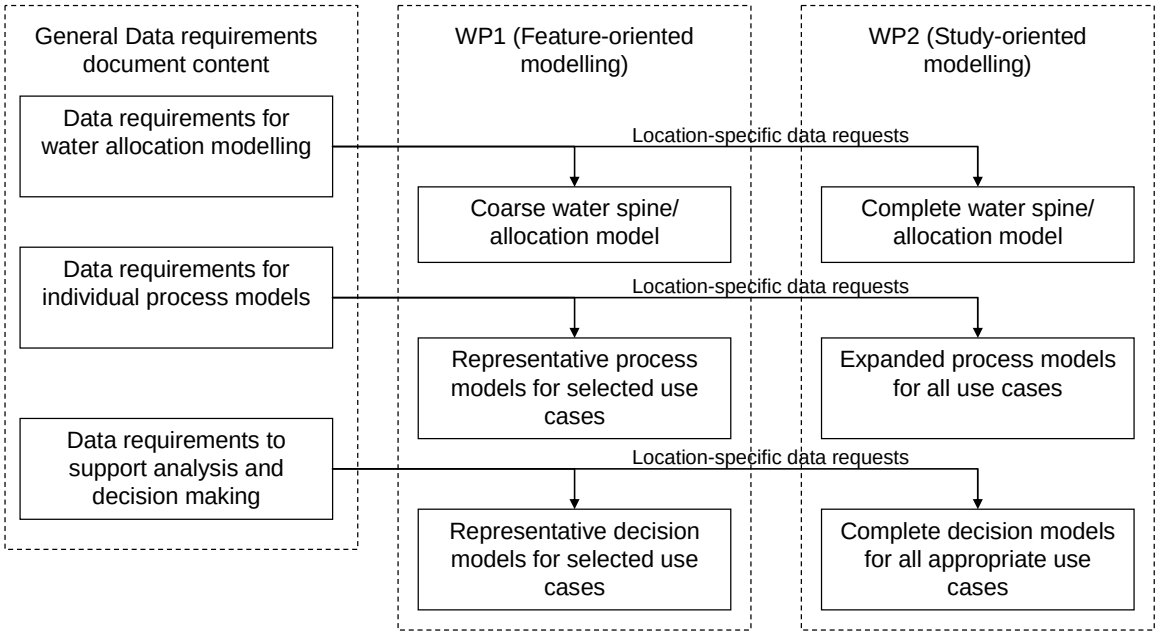

Figure 1.1 Expected application of data requirements document

1.2 Objective of this Document

The objective of this document is to list all the possible data that may be required to represent the Nile River basin and the processes and decisions associated with its development within the framework of the NB DSS. It therefore serves as a checklist of the data which may be needed.

The target groups are the NBI staff as well as national staff from the Nile Basin countries that will be directly involved in providing data for the NB DSS as well as other individuals that may be involved in the process. Furthermore, it will be useful to any other individual or organization in Nile Basin countries that in the future will be using the modelling component of the NB DSS. The immediate benefit of the document will be in relation to data collection efforts in support of WP1 and WP2 model development.

1.3 Purpose and Contents of this Document

Chapter 2 of this document provides a detailed list of data which serves three important purposes:

1. Being a checklist for data collection
2. Being a common reference for WP1 and WP2
3. Being a dynamic document which will evolve with time.

Each of these three bullets are described in details below. How to proceed and use this document is dealt with in section 1.4

Serving as a checklist: As this document aims to list all the possible data which may be required to set up various components of the NB DSS, its main role is to guide data collection, to inform about the type and format of data which is required, and thereby to serve as a checklist. For each individual application a specific list of data will then have to be developed for that particular application.

A common reference for WP1 and WP2: While the data requirements for the testing in WP1 will be limited compared to the comprehensive amount of data (both in time and space) that will be required in WP2, it is the same type of data that will be needed. Thus, this document will serve as a common checklist for both WP1 and WP2 although the level of details and comprehensiveness of data will vary between the two applications. Figure 1.1 illustrates the expected use of this document in support of the modelling in both WP1 and WP2.

Being a dynamic document: The document is a dynamic document, which will be enriched the three NB DSS release cycles. The document will be updated with the incrementally evolving data requirements related to each release of the NB DSS. Initial versions of this document will emphasize data required for water allocation modelling and draw upon past experience using MIKE BASIN at individual country levels as well as on large river basins such as the Niger River Basin. As the DSS development and modelling progress toward detailed process modelling and scenario analysis, additional data requirements will be elaborated based on the associated processes and experience with other modelling tools, such as Mike 11 and Mike SHE. Templates will also be developed where relevant to ensure uniform and target-oriented preparation of data input.

1.4 How to use this Document

Being a checklist this document will work as a "master document" for the format specifications. For each individual application, e.g. each individual test case, a specific list of data to be collected will be worked out based on this checklist. The data requirement will depend on the type, extent and details of the planned model of the NB DSS, its target group, the type of output required, etc.

For each of the test cases in WP1 the NBI will investigate the availability of data within the different test case areas as well as outside these areas if necessary to see what is available and together with the consultant to make a mutual decision on where to test the different functionalities and agree on a list of data to be collected. Being a dynamic document the consultant will then work out a detailed format specification of the data to be collected, which shall contain information on:

- File type
- Column names and content
- Units of each column and other specifications as appropriate.

For WP2 the data type required are the same (or at least very similar). However, the extent in the amount of data to be collected – both in time and space – is of course much more comprehensive. As the modelling tests in WP1 has be carried out and passed the tests before the individual release versions can be used by WP2, the type of data and their formats required for use in WP2 is expected to be in place in the document before required by WP2.

Although this list eventually will aim to cover the possible data which may be required for most model setups, there may be special cases where types of data which are not mentioned here may be needed. If data listed in this document are not available, the document will also try to provide advice on alternative secondary data which may be used to make estimations and approximations.

1.5 The Type of Data

A detailed list of the possible required data will be given in the following chapters as the document develops. Presently, data required for water allocation modelling are provided in Chapter 2.

The type of required data can roughly be categorized into the following type of data:

1. Time series data
2. Spatial / GIS data
3. Various other types of data

However, before going into the details, a more overall description is given below of the type of data needed, the requirements for timely and spatial coverage, timely and spatial resolution as well as the required data format.

1.5.1 Time series data

- **Type of data:**
  The key time series are hydrometric data as well as hydro-meteorological (rainfall and evaporation) data. However, data related to water demands in the basins / catchments are also crucial for the water budget and allocation modelling. Generally, it should be aimed at getting the figures for the different demands on a catchment / sub-catchment scale. Therefore, it is important at an early stage of the data collection to make a final decision on how to divide a study area into catchments / sub-catchments, i.e. to decide the level of details to work at.

- **Timely coverage:**
  This will depend on the purpose of the study. For testing in WP1 the period for which testing does take place is not that important, and the period to use will often depend on the availability of data. For water resources management and planning purposes, the selection of period is much more crucial. Often the following will apply, to the extent it is possible:

  i. Data should cover a period of 20 years or more if possible.

  ii. Data should cover a period which – to the extent possible – is representative for the climatic conditions in the region, in terms of mean value as well as the standard deviation.

- **Timely resolution:**
  This will also vary according to the application. However, in most cases it is recommended to use – if possible:

  i. The time series should be collected as daily values for rainfall and flow data – to the extent possible.

  ii. For evaporation and water use data, monthly values can be used

For applications such as soil erosion assessment, rainfall intensities are often required.

- **Data format:**
  i. The data should be in a time-series format, that means one column with date / time and one column with value, e.g.

Date	Discharge (m3/s)
01/01/1975 9:00:00	12.6
02/01/1975 9:00:00	12.8
…and so on	

1.5.2 Spatial / GIS data

Generally the GIS should be prepared as ArcGIS shape-files. However, some of the data will be as ArcGIS grid-files – including the DEM

When assessing the possible impact of climate change this is often done by calculating "Delta-change" factors based on outputs from GCM or RCM results, which describes the expected change in e.g. rainfall or temperature. These delta change factors can then

be used to modify historical time-series to represent the expected future climate change. It is worth mentioning that the Ministry of Water Resources and Irrigation (MWRI) in Egypt, with support from DHI and UK Met Office, are carrying out a climate change study, which are generating delta-change factors for the whole Nile Basin. During the Inception workshop Dr. Mamdouh from MWRI offered to make these data available to the NBI DSS once they are ready. It is proposed that the NBI staff follow up with Dr. Mamdouh / MWRI on this issue.

The system will also allow some hydro-meteorological parameters to be provided as raster data. This will make it possible to deal with zonal statistics operation of the GIS component of the DSS to generate time series mapped to HRU from staggered rasters or sets of rasters.

1.5.3 Various type of other data

- Topographic maps of the basin (very good 1:50.000 maps are available for many of the countries for detailed information).
- This may include Word or text files containing various types of descriptive information.
- A good map (in paper) for the study area
- System data such as reservoir characteristics and water abstraction rules, cf. section 2.3

2 DETAILED LIST OF REQUIRED DATA FOR WATER ALLOCATION MODELLING

This chapter contains a detailed list of the expected required data to setup the water allocation modelling part of the NB DSS.

2.1 Time-series Data

This section mainly deals with hydrometric and hydro-meteorological data. These are point source data, which e.g. represent the climate for that location or the water generated from the catchment area upstream of the station. However, it also includes other types of time series, such as water demand / water use, which also has a spatial dimension as it may represent estimated water demand within a given catchment of administrative boundary such as a district. Thus, such data will have to be supported by spatial information about the size and extent of these catchments, administrative boundaries, etc.

Table 2.1 List of required time series (TS) data needed for setting-up and calibration of the water allocation model

Priority	Type of Data[1]	Data details / notes	Data type / format	Source[2]	Indication of Availability[3]
1	**Discharge** data	This should include all: • River gauging stations that been considered important / useful • Inflow to and outflow from reservoirs • Daily values if possible – otherwise monthly values	Time series format, Excel files (external data)		
(1)	**Water level** data	Water level may be required for reservoirs and for river gages where discharge data are not available. However, in order to convert the water level data to useful discharge data it is necessary to have valid rating curves for the period of concerns.	Time series format, Excel files (external data)		

[1] If nothing else is indicated "basin" refers to the Nile Basin

[2] Please indicate from which institution / organisation the data will be available / should be collected.

[3] Please indicate the availability of data, for which period, the time resolution, to which extent the time series will be complete.

Priority	Type of Data[1]	Data details / notes	Data type / format	Source[2]	Indication of Availability[3]
(1)	**Rating curves**	Historical rating curves of stage versus discharge or rating equations are needed for the periods where only water level data are available at river gages.	Sequences of corresponding Q and H data + rating equations		
2	**Precipitation** data from major stations	This should include rainfall as well as snow measurements (if relevant). • Daily values if possible – otherwise monthly values • **NOTE:** We will need to estimate the rainfall falling on the reservoirs. Thus rainfall data from stations at or close to the reservoirs would therefore be particularly important to have.	Time series format, Excel files (External data)		
2	**Evaporation** from key climatic stations	• Monthly values • We will need to estimate the evaporation losses from the reservoirs. Thus evaporation data from stations at or close to the reservoirs would be important to have	Time series format, Excel files (External data)		
2	**Temperature** from key climatic stations	• Monthly values will often be OK • Mean, max. and min. values may be required • May be useful to estimate evaporation losses • Will be required if snow and snow-melting are involved • May be required for other applications			
	Groundwater levels from observation wells	**➔ Daily values – or monthly if daily data are not available** • These would be important to access the use of groundwater and recharge to the groundwater	Time series format, Excel files (External data)		
2	**Abstraction of water for major irrigation schemes**	If available these data will be extremely useful for the modelling. If not available we will need to rely on estimation of irrigation demand (see below) and assess to what extent such demands will be / have been fulfilled • Data will be required on 7 days, 10 days or monthly basis depending on the situation and what is availableNOTE: For modelling purposes it will be crucial to know to what extent surface and groundwater are being used for irrigation purposes	Excel spreadsheet files		

Priority	Type of Data[1]	Data details / notes	Data type / format	Source[2]	Indication of Availability[3]
2	**Estimation of irrigation demands** for irrigated areas in the basin	This requires information on: • Irrigation demands for various types of crops in different parts of the basin (depending on the climate) • Information about the irrigated area for each type of crop in different parts of the catchment (the area could be calculated per sub-catchment) • Information about rainfall and effective rainfall in each catchment ➔ **NOTE:** Data will be required on 7 days, 10 days or monthly basis depending on the situation and what is available ➔ **NOTE:** For modelling purposes it will be crucial to know to what extent surface and groundwater are being used for irrigation purposes. ➔ **NOTE:** As modelling may cover a period of e.g. 20 years, it will be important to have information about the changes in water use during this period. Furthermore, present days and future estimates of water use for irrigation or any purpose will be crucial to have. ➔ **NOTE:** These issues to be discussed in details with NBI staff.	Excel spreadsheet files		
2	**Hydropower production**	• The best would be the actual releases (hourly values) • Otherwise the actual power production or • The planned hydropower production • See also Section 2.3 on turbine efficiency, etc.	Excel spreadsheet files		
	Number of livestock	Although probably not a major water consumer, changes in livestock figures for the different type of livestock over the period would be good to have. Again it would be best to have these catchment by catchment (although they often exist at Administrative levels) ➔ **If there exist agricultural censuses, e.g. for every five years these figures can be used and then interpolate in between.**	Excel spreadsheet files		
2	**Population**	For estimating the water demand for domestic purposes we will need to know the changes in population during the cali-	Excel spreadsheet files		

Priority	Type of Data[1]	Data details / notes	Data type / format	Source[2]	Indication of Availability[3]
		bration period, i.e. the period for which we are using runoff data. This can e.g. be done based in information in the attribute tables for the shape-files with information about cities or data that can be extracted from population censuses, and then interpolated between the censuses ➔ **NOTE:** As WP2 will be calibrating the model over a longer historic period of e.g. 20 years, it will be important to have information about the changes in water use during this period. Furthermore, present days and future estimates of water use for irrigation or any purpose will be crucial to have.			

2.2 Spatial / GIS data

Table 2.2 List of required GIS / MAP data needed for setting-up and calibration of the water allocation model

No	Type of Data	Data details / notes	Data type / format	Source	Indication of Availability
1	**DEM** of the whole of the Nile Basin	A DEM will be one of the most important items of information for the whole study. It will among other things be used for: • Delineation of catchment boundaries • Delineation of sub-catchment boundaries • Snow modelling (if required) • Etc.	GRID-file		
	Satellite images of the Nile Basin and individual countries	These will among other things be useful to identify areas of irrigation and their extent.			
2	**Maps of the Nile Basin as well as the individual countries**	This could be a JPEG-file of the basin, which could be used as the background layer. • Useful for presentations • Gives a good overview of the basin and its properties • Useful when checking the location of rivers, towns, roads, etc. ➔ **Satellite images could also serve as good background layer**	JPEG-file or similar file format		
2	**Basin / catchment boundaries**	If one already exist that would be fine. Otherwise we will probably generate it from the DEM by an "overall" catchment delineation based on the location of the outlet of the catchment	ArcGIS shape-files		
2	**Sub-catchment boundaries**	It would be good if one already exist. Otherwise we will just generate it from the DEM NOTE: Existing basin, catchment and sub-catchment boundaries and information of the size of the catchments, are useful for checking the correctness of the catchment delineation.	ArcGIS shape-file / feature class		
1	**Location of discharge stations**	The attribute table should contain the following information: • Size of the catchment area upstream of the gauging station (this will be very useful for checking with the area generated based on the catchment delineation).	ArcGIS shape-file / feature class		

No	Type of Data	Data details / notes	Data type / format	Source	Indication of Availability
		• Name of station • Station number • Longitude • Latitude • Altitude • E.g. Year of establishment and other relevant information **Note:** These are very crucial as they determine how the catchment delineation of the catchment upstream of the station will take place.			
2	**Location of precipitation stations**	The attribute table should contain the following information: • Name of station • Station number • Longitude • Latitude • Altitude • E.g. Year of establishment and other relevant information	ArcGIS shape-file / feature class		
2	**Location of climatic stations / temperature / evaporation stations**[4]	The attribute table should contain the following information: • Name of station • Station number • Longitude • Latitude • Altitude • E.g. Year of establishment and other relevant information	ArcGIS shape-file / feature class		
1	**Location of reservoirs**	Point shape-file just showing the outlet of the reservoir	ArcGIS shape-file / feature class		
	Physical extent of the reservoirs	A polygon shape-file showing the extent of the reservoirs (when full) would be useful and a support to the HVA curves.	ArcGIS shape-file / feature class		
	River network	A shape-file with the river network digitized from topographic maps. The attribute table could include information about the different branches / tributaries, such as name of the branch/tributary, its	ArcGIS shape-file / feature class		

[4] It should be assessed whether there just should be one shape file with all the climatic stations no matter how much are measured at them. One solution could be to have all climatic station in one file and then in the attribute table have a column for each of the climatic parameters and then indicate with "Yes" or "No" whether the parameter is being measured at that station.

No	Type of Data	Data details / notes	Data type / format	Source	Indication of Availability
		length, catchment area, etc. **NOTE:** Although the model will trace the rivers, it is important to have this shape-file with existing river network to see where the river starts, and to check the correspondence. However, the experience is that the model is able to trace the river network relatively precisely from the 90 NASA DEM expect from flat areas.			
	Generated river network	From the DEM an internal model river network will be generated. A copy of this should be saved as a separate shape-file.	ArcGIS shape-file / feature class		
	Land use map(s) / extent of lakes, irrigated areas and wetlands.	A land use map will be useful for the modelling, and also useful information if estimating runoff from un-gauged catchments. As a minimum shape-files (or grid files) with the following land use categories – important for the water uses in the basin – should be available: • Lakes • Wetland areas • Irrigated area ➔ **NOTE:** The land use should be of recent date. ➔ **NOTE:** If major land use changes have taken place it would be useful to have older land use maps in order to be able to prepare time series file with e.g. the area under irrigation in the basin	ArcGIS shape-file / feature class		
2	**Large cities**	A shape-file with the large cities in the basin will be required when estimating the water use for domestic purposes. From 1950s till today there have been big changes in the population in the basin and probably not least in the cities. Thus attribute table could contain the population in the cities during different periods. This could be used to generate the time series for population in the basin.	ArcGIS shape-file / feature class		
	Other major cities / towns	As above. It could be combined with the map above and then just use different legends depending on the size of the cities.	ArcGIS shape-file / feature class		
	Large scale industries and mines	This will be useful for determination of their water use. Since we be dealing with water quality as well, such information will also be useful.	ArcGIS shape-file / feature class		
	Roads	A shape-file with the major roads in the basin would be useful, e.g. for presentation purposes.	ArcGIS shape-file / feature class		

No	Type of Data	Data details / notes	Data type / format	Source	Indication of Availability
	Climate change data	When assessing the possible impact of climate change this is often done by calculating “Delta-change” factors based on outputs from GCM or RCM results, which describes the expected change in e.g. rainfall or temperature. These delta change factors can then be used to modify historical time-series to represent the expected future climate. Delta-change factors will normally be available as grid-data	Grid data		

2.3 Other Types of Data

Table 2.3 List of other types of data required / useful for setting-up and calibration of the water allocation model

	Type of Data	Data details / notes	Data type / format	Source	Indication of Availability
1	Information about irrigation schemes	For modelling purposes we the following information about irrigation schemes / areas are crucial: • The percentage of water demand covered by surface and groundwater, respectively • Irrigation efficiencies at different levels • Estimates of return flow and whether return flow is through drainage canals or via the groundwater • Estimates of linear routing coefficient	Word / Excel file		
2	Assessment of the quality of the river gauging stations	This include information on: • Is there a stable control • Rating curves including information on when any shift of the rating curve has taken place.	Word file (Excel file)		
3	Information about the physical characteristics of the reservoirs	• A HVA curve (the relationship between the heights, volume and area of the reservoirs – Volume and Area as a function of the height / water level in the reservoir. • Maximum releases during flood control operations can be limited by the limited hydraulic capacity of a spillway. This limitation can be specified for reservoirs in form of an h-Q table.	Excel file		
4	Operation rules for the reservoirs	Especially if there are no discharge measurements of the outflow from the reservoirs it is crucial to know based on which criteria they have been operated. • Which users have been given priority in periods with any possible water shortage? • What have been the hydropower production targets (see also elsewhere)? • Have there been any reduction levels below which the demands have only been partly fulfilled? • Has there been any flood control level and how has that varied over the year? • Use of spillway	Word / Excel file		

5	Flood control	Information about any flood control measures apart from possible flood control levels at the reservoirs	Word / Excel file		
6	Characteristics of hydropower plants	This includes: • Installed capacity (Number and size (MW) of turbines) • Target Power • Machine efficiency (may be head dependent) • Tail water level (Constant or time series file with tail water level)	Word / Excel file		
7	LPCD values	We need to know the average water consumption per capita (LPCD = Litre per capita per day). This may vary from rural to urban areas, and within urban areas it may depend on if there is a central water distribution system or not. Also, this has probably changed over time, so we might need to generate a time series with LPCD-values for different groups of users.	Word / Excel file		
8	Livestock demands	We will need information about the daily water demand by the different type of livestock. Contrary to the water demands by capita, this has probably not changed substantially from 1970 till today. As the water demands by livestock at the same time generally is low compared to other uses, we can probably use the same daily demand over the whole period	Word / Excel file		
9	National water policies, legislation and planning	It might be useful to know about water policy and planning which may have an implication of the water use and management in the basin in the future, including: • Water policies • Water legislation (including regulation and enforcement) • Water Master Plans			
10	Regional / trans-boundary water policies, legislation and planning	It might be useful to know about regional water policies and planning which may have an implication of the water use and management in the basin in the future, including: • Trans-boundary agreements for regulating and sharing the waters of the basin • River basin plans			

3 DETAILED LIST OF REQUIRED DATA FOR PROCESS MODELLING

➔ To be established during cycle 1.

4 DETAILED LIST OF REQUIRED DATA FOR MCA / SCENARIO ANALYSIS

➔ To be established during cycle 1.