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Scoping Document
LVB-WIS Design and Specifications

Lake Victoria Basin Integrated Water Resources Management Programme (LVB IWRMP)

IWRM Programme Consultant (IPC)
Consultancy Lot 1: Programme Management, IWRM Data Management and Modelling, Strategic Project Pipeline Development

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Acronyms

BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
BOD	Biochemical Oxygen Demand
DBMS	Database Management System
DHI	Danish Hydraulic Institute
EAC	East African Community
EU	European Union
GIS	Geographical Information System
HPI	High Priority Investments
IPC	IWRM Programme Consultant
IWRM	Integrated Water Resources Management
JV	Joint Venture
KfW	Kreditanstalt für Wiederaufbau
KPI	Key Performance Indicators
LVB	Lake Victoria Basin
LVB IWRMP	Lake Victoria Basin Integrated Water Resources Management Programme
LVB WIS	Lake Victoria Basin Water Information System (Database and Model)
LVBC	Lake Victoria Basin Commission
LVEMP	Lake Victoria Environmental Management Programme
MoU	Memorandum of Undertaking
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
Nile DSS	Nile Decision Support System
Nile-SEC	Nile Basin Initiative Secretariat in Entebbe, Uganda
O&M	Operation and Maintenance
PCU	Programme Coordination Unit, Programme Coordination Unit
QA/QC	Quality Assurance / Quality Control
RDBMS	Relational Database management System
SWAT	Soil Water Assessment Tool
ToR	Terms of Reference
WFD	Water Framework Directive
WIM	Water Intervention Module
WIS	Water Information System
WRM	Water Resources Management
WUM	Water Utilization Module

1 Introduction

This Scoping Document has been prepared to provide information on the IWRM Database and Model (LVB Water Information System, or LVB-WIS), to be realised under the first phase of the Lake Victoria Basin Integrated Water Resources Management Programme. Because face-to-face meetings in the LVB are not possible and travel to the LVB countries not permitted or practical until further notice, work is being carried out using online communication means and according to an adjusted planning[1].

1.1 Stakeholder involvement

For the configuration and implementation of the LVB-WIS the plan is to involve the technical experts at the Regional IWRM Institutions, and if possible, also use regional model experts. In this way, the regional expertise is built, the LVB WIS is 'their' creation, and training and testing will become a part of the capacity building exercise[2].

In the original plan a series of consultation meetings was foreseen at the start of the Programme, scheduled for May 2020. But due to the current situation these cannot be realised as planned. To avoid undue delays the project IWRM team, consisting of the IWRM Programme Consultant (IPC) and the Programme Coordination Unit (PCU), have decided to gather the necessary information using a brief questionnaire in combination with online meetings when and where possible, for now. This Scoping Document will provide necessary information and background to the meeting participants; the questionnaire is included in the form of questions at the end of each of the chapters. At this moment (early June 2020) the Formal Working Framework for the Programme is being established, including the establishment of NPTTs, National Project Technical Teams[3]. These NPTTs are the direct counterparts for the IPC consultants, and will participate in the consultation meetings.

Follow up physical meetings are foreseen as soon as the situation allows, though it now seems likely that this will not be soon. Meanwhile full and thorough consultations and involvement of the stakeholders by all available other means will be pursued by the IPC IWRM/LVB-WIS team to ensure broad support and thus sustainability.

1.2 General Project Information

The Lake Victoria Basin Integrated Water Resources Management Programme (LVB IWRMP) is funded through two grants, one by the European Union (EU) and another by the Government of the Federal Republic of Germany. Both grants are channelled through KfW. The grants were provided to the East African Community (EAC), the recipient of the Programme. The EAC has appointed the Lake Victoria Basin Commission as the Project Executing Agency (PEA).

The total budget for the current phase of the project is € 31,9 million: € 20 million from Germany, € 8,9 million from the EU and € 3 million as local contribution from the partner states related to the High Priority Investments (HPIs).

The preparation phase of the program was carried out from January to December 2016. The current phase of the programme started in December 2019 and will end in February 2023.

The LVB IWRMP has two modules:

- Module 1 is for the strengthening of the long-term strategic, regional water resources management function of the LVBC Secretariat;

[1] This document also summarises the work carried out during the first 6-week adjusted work programme (wk 18-23).
[2] The establishment of the Nile Basin DSS followed a similar approach.
[3] The respective PSs will liaise with the Programme focal ministries in each country, which will subsequently constitute the National Project Technical Teams (NPTT). The NPTTs will be the main contacts for IPC and IWRM DB and modelling work.

- Module 2 is to reduce effluents into Lake Victoria through the implementation of HPIs

For both modules, LVBC has signed into consultancy contracts for both modules; this Scoping Document concerns Module 1. JV Sweco GmbH is the consultant for Module 1: the IWRM Programme Consultant (IPC).

LVBC has established the LVB IWRM Programme Coordination Unit (PCU), responsible for the implementation of the LVB IWRMP. The PCU has two fulltime staff: the IWRM Programme Coordinator and the IWRM modeller. Both positions are funded through the LVB IWRMP budget for a period of three years. The IPC also works with other professional and support staff of the LVBC Secretariat and liaises with other ongoing programmes which are carried out by LVBC. The IPC works directly with and within the LVBC Secretariat, mainly through the PCU.

Programme Objectives
The overall objective of the LVB IWRMP is:
Regional economic integration is enhanced and a contribution to preservation of biodiversity and to conflict prevention is provided through established regional water resource management at the Lake Victoria Basin. (ToR 1.2 (5))

The specific programme objective of the LVB IWRMP is:
Water quality and availability is improved through strategic and sustainable management of the Lake Victoria Basin. (TOR 1.2 (6))

The perspective is to support regional integration through the implementation of Integrated Water Resources Management (IWRM). This calls for an innovative approach, and the Programme must advocate the advantages of regional cooperation. The boundaries of water resources in the Lake Victoria Basin reach far beyond the neighbouring region, and likewise, the threats of pollution know no boundaries: what happens in one state of the Lake Victoria Basin has a direct impact on all the other states. For the implementation of a regional, transboundary IWRM programme LVBC is the most suitable institution.
The importance of LVBCs position as regional IWRM implementing agency was underlined in February 2020 by the Sectoral Council of Ministers for Environmental affairs of the EAC where it was decided to develop a water strategy for the EAC on the basis of a Water Framework and it directed LVBC to liaise closely with the EAC for achieving this long term goal.

IPC Scope of Work
To achieve the Programme objectives, 55 tasks with underlying activities were defined in the ToR for the IPC. These tasks and activities were combined in four components as summarized below.

1. Supporting the IWRM programme management: Capacity development and general support to the PCU; tasks along the typical stages of the project management cycle, including the development of an Investment Plan and a Project Pipeline; development and implementation of a project communication and visibility strategy; management of the disposition fund and establishing the Monitoring, Evaluation and Reporting system.
2. Developing a strategy to strengthen LVBC as a regional institution for IWRM: Familiarising with existing IWRM strategic documents in the LVB; assessing existing IWRM documents; drafting the regional IWRM strategy in conformity with national and other related regional and international strategies; supporting LVBC in obtaining approval of the regional IWRM strategy.

The above has been expanded with the task of supporting the EAC in the development of a water strategy and the elaboration of a Water Framework Directive.

3. Implementation of an IWRM data base and IWRM model focused at: Preparatory work (analysis); IWRM database development; IWRM model development.
4. Other support services: Among others; the organisation of exchange visits with transboundary water basin management organisations in Africa and/or in Europe.

1.3 LVB IWRM Database and Model

The general purpose of an integrated water quantity and quality model is to support policy measures and local investment decisions for the long-term sustainable development of the LVB. The model and database will result in increased awareness, better informed problem analysis and increased support for investment decisions.

A major challenge will be to obtain quality datasets. This was also identified as a major challenge in previous documents such as the technical Specification Report from 2016 (JV SWECO-Alterra-Ecorys, 2016a, 2016b). The first major effort of the PCU and IWRM Expert will be to establish links with the relevant Regional IWRM Institutions, through a series of consultation visits[4]. The objective is to gradually establish[5] a regional network of IWRM experts, that work together and know each other. Where accurate or reliable data are not available, fall-back options will be used, and support for data acquisition, validation, verification and analysis will be made available when and where necessary. While the ToR and Methodology mention that the model phase may not be possible unless required datasets of sufficient quality are made available at LVBC, the IPC assessment is that this outcome is not expected – however, the accuracy and completeness of the initial data sets may be less, to be improved when better data become available.

The ToR makes a strict distinction between the Database and Model and recognizes many interim steps. However, when designing the database structure and deciding the functionality, the eventual linking of models will have to be considered already. In addition, there are systems available that are flexible Database Management Systems (DBMSs) that are already designed to link up with and supply global (weather) data and that have pre-installed (web-)presentation and reporting functionalities. Special care will be given to including existing Regional models into the system.

A phased approach is proposed, where only the most important models as well as 'no regret' models are linked first, with further models linked when the required datasets and the human and budget resources are available. The LVB WIS will be made available to the Partner States from the start[6] during the building phase, as part of the involvement of the Partner State experts and institutions in the development, but also to ensure that it can be used where and when it is needed.

1.4 Use and Structure of the Scoping Document

In this Scoping Document the IPC summarizes and elaborates on the design and specifications for the LVB-WIS as described in the ToR, the Technical Proposal, the Design and Specification Documents of the Preparation Phase, the Inception Report as well as additional relevant information that was obtained after the inception period.

A step by step approach is outlined for the actual implementation of the LVB-WIS, with 1-4 pages of information, followed by several questions. The questions are formulated as basis for the discussion in the consultation meetings with the NPTTs. This will allow the IPC to assess and include the requirements and wishes of the LVB stakeholders with regard to the LVB WIS.

- Chapter 1 introduces the LVB-IWRM programme, and the overall approach and objective for the LVB WIS.
- Chapter 2 elaborates on the approach, comparing different ways to establish the LVB WIS database.

[4] These visits were planned for May 2020; due to travel and work restrictions caused by the COVID19 situation it has not been possible to organize and hold these visits. Instead online meetings and demonstrations have been planned.

[5] Or revive/engage: check if networks established for LVB-WRIS and even Nile Basin DSS are still active, and how these can be included.

[6] User access to data that may have restricted access has to be guaranteed; the programme aims to make the datasets as openly available as possible and practical. Data are only valuable when they are being used.

- Chapter 3 presents the technical specifications and requirements of the LVB WIS database
- Chapter 4 discusses the very important issue of data itself: data availability, collection, quality.
- Chapter 5 presents ideas on operation and maintenance of the LVB WIS.

The Annexures to this report provide relevant background information and give more detail to support the discussion in the main text:

Annex 1. Inception Report Chapter 9: Development of the LVB IWRM Database and Model
Annex 2. Terms of Reference: Development of the LVB IWRM Database and Model
Annex 3. Open source datasets
Annex 4. Technical Specifications Preparation phase
Annex 5. Data Requirements Preparation Phase

Download links to background documents are listed with the respective documents in Chapter 6, References.

2 Approach

The general approach in developing the LVB-WIS is outlined in detail in the Terms of Reference (LVBC Secretariat, 2018, Chapter 2.3, p17-21, Tasks 37-54). This ToR refers to 2 background documents developed during the Preparation Phase of the LVB-IWRMP (JV SWECO-Alterra-Ecorys, 2016a, 2016b) that detail the specifications. In addition, the Nile Basin DSS functionalities and requirements following the needs assessment as described in (hydrophil 2008) may be used as guidance, though functionalities described there are rather general. However, the consultation and needs assessment process was extensive.

During the Inception Phase (January-March 2020), the approach/methodology proposed by the IPC was reviewed and adjusted to reflect changes in the situation and adjustments on several details in, for instance:

- The proposed implementation approach: the IPC suggests explicitly to involve regional experts in building / configuring the LVB-WIS); this has been done in the establishment of the Nile Basin DSS and recommended in (JV SWECO-Alterra-Ecorys, 2016b).
- Planning: While the ToR and the Background Documents suggest that first the database is developed together with the necessary data collection and organisation of regular data transfers, it is recommended to make an inventory of essential, available and requested models at an early stage. This will ensure that the database will be suitable for the necessary models.
- Phased implementation: To show results of LVB WIS at an early stage, the quick implementation of some models / tools is recommended. A core set of most important models/tools as well as 'no regret' models are to be implemented centrally, over time, and made available to the LVB Partner States, while they are free to add further models and functionality. Further models can then be linked when the required datasets and the human and budget resources are available.
- Database as basis for models (LVB-WIS): developing the (GIS) database including all required functionality is a major effort, that is not to be underestimated. Following the recommendations of both ToR and (JV SWECO-Alterra-Ecorys, 2016a, 2016b) off the shelf / existing software is strongly preferred.
- It is mentioned several times in the supporting documents that the LVB WIS should be 'simple', it should 'not be complex'. This raises the question what exactly is meant. Simple or complex are relative and depend on the expertise and experience of the operator. It is proposed to clearly describe and agree on specific roles of the various users of the LVB WIS, and then offer these user groups different 'windows' on the LVB WIS, depending on their needs and requirements. This topic is discussed in more detail in Chapter 3, Technical Specifications / Requirements, and in Chapter 5, Operation and Maintenance.

Overall, three approaches can be recognised:

1. Use of the Nile Basin DSS database as part of cooperation with NBI.
2. Setting up a separate, existing IWRM database platform
3. Creating a new database

2.1 Nile Basin DSS

In (JV SWECO-Alterra-Ecorys, 2016a, 2016b) it was recommended to use the Nile Basin DSS software as basis for the IWRM Model.

In the ToR (LVBC Secretariat, 2018) it is stated:

"the IPC shall visit NILESEC in Entebbe, Uganda jointly with LVBC in order to investigate options to use available resources, databases and models at NILESEC for the use of LVB-IWRMP. When meaningful, the resources of LVB-IWRMP may be used for the improvements of available products or useful add-ons with the intention to make any improvement also available to NILESEC. In such case the IPC shall prepare a special report outlining a modified approach to the implementation of an IWRM database and IWRM model to be agreed upon between LVBC and KfW".

This indicates that the IPC is to assess the feasibility of using the Nile Basin DSS first, before taking a decision. While a visit to NileSEC is currently not possible, the next best thing is to have online meetings. The first online meeting took place on Monday 25 May 2020, involving the Nile Basin DSS expert team[7], the LVB-PCU experts[8] and IPC experts[9]. A second more technical meeting took place on Wednesday 30 June 2020[10].

For the discussion below the term 'Nile Basin DSS' is considered to mean both the models and the supporting database, while the focus at this stage is at the database part.

The first impression is that the Nile Basin DSS is well placed as a rather well-developed basis for the LVB-WIS:

- Much of the required functionality for both the database as well as the model part of the LVB-WIS is already developed, tested, and being used as part of the Nile Basin DSS, and some is currently under development[11]. The exact level of match and gaps needs to be determined, with focus on the database part first. This can be done after the conclusion of the consultation meetings.
- The LVB is, of course, part of the Nile Basin, and as such part of the database, datasets, GIS maps and models of the Nile Basin DSS. However, the objective of the NB DSS nor the NBI is not to create a central IWRM dataset, and no such dataset is currently available[12]. Establishing a central IWRM dataset and making the data available to Partner State institutions is an important part of the mandate of the LVBC and a core objective of the LVB IWRM Programme.
- NileSEC already has data transfer protocols in place. This is an issue that is not to be underestimated, as data availability and the arrangement to obtain such datasets is identified as the main challenge for the LVB-WIS in just about all background documents.
- NBI and LVBC have a Memorandum of Understanding in place that promotes cooperation and information sharing; this is the current basis for the discussions and it may be sufficient for further joint development of an LVB-WIS; if not, it can and should be amended accordingly.
- The Nile Basin DSS has a support organisation (online Helpdesk and User Community Portal, training materials), all NBI Member States including the LVB Partner States have 14 hardware licenses each, and many so-called 'floating' licenses are available. Feature requests can be made[13], the support website is well-developed (http://nbdss.nilebasin.org/support/home; http://nbdss.nilebasin.org/support/solutions); and a user forum is available[14]. It seems that the user base needs to be further activated to use all the tools that are at their disposal.

[7] Dr. Abdulkarim H Seid (Deputy ED / Head of Basin Wide Program); Dr. Yohannes D. Gebretsadik (Regional Water Resources Analyst); Dr. Modathir Zaroug (Regional Water Resources Modeler); Sowed Wamala (Information Systems Specialist).
[8] Arsène Mukubwa (Program Coordinator LVB - IWRM); Benjamin Ssekamuli (IWRM Modeller).
[9] Bob Pengel (IWRM Advisor); Marcus Niecke (International Junior Expert).
[10] Dr. Yohannes D. Gebretsadik (Regional Water Resources Analyst); Dr. Modathir Zaroug (Regional Water Resources Modeler); Sowed Wamala (Information Systems Specialist).
[11] River Flow Forecasting, but especially online access.
[12] Discussed during the second online meeting with technical team NB DSS on 30 June 2020. See (NBI, 2011) for details; NBI brokers in data, but does not maintain its own database.
[13] Perhaps not very active – last one dates from 3 years ago.
[14] http://nbdss.nilebasin.org/support/discussions - here also the last postings were 4 years old, by the system information expert, with one answer only.

Pooling resources with NBI / NileSEC has clear advantages to both parties:

- Adding active users by adding specific functionalities
- Sharing the overhead of providing support to the users
- Sharing costs (the license agreement with DHI is active for another 3 years out of the original 10 years; any renewal could be funded based on a cost sharing arrangement)
- Avoiding duplication of efforts
- Fostering cooperation between two major International Basin Organisations which both encompass the LVB, including the technical staff/experts of these organisations
- Strengthening the data collection and transfer by joining forces
- Strengthening data validation and verification, QA/QC of data collection efforts
- Making use of a locally built and maintained system which is actively applied in the region and LVBC Partner States

Possible disadvantages can also be identified:

- Danger of more convoluted and bureaucratic decision making
- Responsibilities must be made clear or confusion may ensue
- Perceived lack of control by one of the parties in the cooperation
- Diverging needs and requirements at some time in the future
- Other options may result in a qualitatively better LVB-WIS (database)
- At present it is not possible to have ‘customized displays’ that show the information a specific user group needs with the NB DSS (see Table 3 and Table 4). The current user interface is aimed at trained experts. A web services-based user interface is being created aimed more at providing information to decision makers; this is expected to be available by the start of the 4th quarter of 2020.
- It is stated in (JV SWECO-Alterra-Ecorys, 2016a, 2016b) that the resolution and level of detail of the modelling in the LVB part of the Nile Basin DSS may not be sufficient for the LVB-WIS. This must be checked against the requirements, though this will become relevant only when details for the modelling will be decided[15]; at that stage this can possibly be addressed by improving the schematics.
- In discussions it was mentioned that the Nile Basin DSS is not strong on water quality modelling, while this is a core functionality of the LVB-WIS. The latest available information indicates that work on water quality modelling is planned or that such functionality could be added for the LVB-WIS.
- The NB DSS does not have a central database with IWRM data; rather, the required datasets are requested from the national data providers by NBI through the national focal points.

Two further options are listed below.

[15] As per the Inception Report planning this is to start by mid-2021

2.2 Available IWRM database platform

Apart from the option to use the NBI DSS database other options exist. To set up an IWRM database platform the most practical approach is to identify platforms that are already available, operational and are being used. Referring to section 2.1, where relevant aspects of the Nile Basin DSS are discussed, any alternative has to provide a similar or better suite of functionalities and support.

One such platform is Delft-FEWS[16], which is promoted as a platform for real time forecasting and water resources management. This open-source platform was developed for real time data collection, processing and (automatic) model runs to support time critical flood forecasting. Several water management organisations have subsequently used the platform as a dedicated water resources management platform.

Delft-FEWS has a robust data model, which can operate with various different DBMSs; much of the required functionality for the LVB WIS database is built-in; import of many data formats is supported including automated import from online sources; Delft-FEWS also supports the linking of a large number of models, through the use of specialized adapters[17] and web services to work with the LVB WIS / models. Displays are configurable to suit different users with different technical skills and information requirements. The software is freely available (under a user license) and supported by Deltares (Delft Hydraulics, the Netherlands) as well as a large and active international user group.

While the requirements for the LVB-WIS do not include real-time data collection and model runs, the functionality of automatic and regular data ingestion and protocols for data quality assurance are very useful in maintaining an up to date LVB-WIS database.

Other options may be available too – and the specifications as set out in the tender may be better met by another solution. The description above is given to show that it is possible to create a state of the art LVB-WIS database within the boundary conditions of the required specifications and the recommendation to work with off-the-shelf software.

2.3 New database platform

If a database platform is to be set up, two options are available: Use an existing platform (see section 2.1 and 2.2), or build a custom platform. The idea to establish a separate database platform appears to be based on the perception that the Nile Basin DSS tools are suitable for use in the LVB, but that the database or the use of the tools in combination with the database is too complex.

It is recommended that the issue of complexity is assessed against a clear decision on how the LVB WIS will be used, which user groups with which levels of expertise will use which functionality. See also Chapter 5, Table 3 and Table 4.

The recommendation of the IPC is to present different user groups with different 'views' on the database, displays that are attuned to their specific needs. This will ensure that each user group will be working with the appropriate level of complexity.

Setting up a completely new database platform has clear disadvantages, mostly to do with the required time, costs, and the uncertainty that is always part of significant IT development projects. This option is not recommended.

[16] See website: https://www.deltares.nl/en/software/flood-forecasting-system-delft-fews-2/; for the brochure file:///C:/Users/bobpe/Downloads/Delft-FEWS_brochure.pdf; for international projects https://v-web002.deltares.nl/fewsprojectviewer/projectviewer/; for the user community website https://oss.deltares.nl/web/delft-fews/.

[17] This includes the Mike suit of models

2.4 Use of Nile Basin DSS tools

If it is decided to implement a new database platform as described in 2.2, such a platform could also be combined with the Nile Basin DSS tools – this should be a condition in the tender documents. The advantage is that joint (further) development of these tools is possible. A clear condition would be that the sharing of data between the two database platforms would be easy. The use of the same DBMS (PostGreSQL / PostGIS[18]) would be helpful to avoid data conversion.

2.5 Questions on Approach

Q2-01	Would you recommend a joint approach with Nile Basin DSS or would you prefer the development of a separate database platform? And why?
Q2-02	The needs assessment for the Preparation Phase of the LVB-IWRM Programme was done in 2016. Would you agree that the requirements for IWRM, especially when considering the information needs of the LVBC, have not changed much in the meantime?
Q2-03	It is proposed to mobilize specialists to establish the database platform, especially the technical aspects. However, during the configuration, which is a large part of the actual implementation, experts from the LVB Partner State institutions are invited to join in. This will provide a practical familiarization / on the job training and the close involvement of these regional experts will ensure that the system is suitable for all Partner States. Testing and delivery/acceptance will also be easier. The same approach was followed with the Nile Basin DSS. Will this approach work in the LVB, and if not, why not?
Q2-04	Which IWRM related databases (and DBMSs) for hydromet and water quality are currently used at institutions in the Partner States?
Q2-05	Which IWRM related models are currently used at institutions in the Partner States? In the proposed phased approach, no-regret and the most important models will be linked and operationalized first. Which models should in your opinion be included in the core model set of the LVB WIS with the highest priority?

[18] PostGreSQL (also known as postgres) and PostGIS are open source and are widely accepted and applied, even by large corporations and government institutions in mission-critical applications.

3 Technical Specifications / Requirements

For technical specifications the main source is (JV SWECO-Alterra-Ecorys, 2016a): Design and specification of an IWRM Model with a sound GIS database to support future investment decisions – Specification Document, dated November 2016. A review by the IPC shows that the specifications are still valid; the main recommendation is to allow for justified deviation in the tender documents, as the specifications are quite detailed.

Annex 4 (Technical Specifications Preparation Phase) lists the functional requirements for the database including the GIS component.

At this stage it is recommended to use these specifications as they were produced following an extensive user consultation. A detailed line by line joint review is not recommended. Specific comments and suggestions from the NPTTs are welcomed and will be discussed.

3.1 Questions on Technical Specifications / Requirements

Q3-01	There are two approaches for the development of databases for IWRM systems: prepare the design in minute detail and let the contractor implement this exactly; or specify the system based on required functionalities, and ask the contractor to propose a solution. The IPC recommends the second approach, as it provides more flexibility and allows for solutions that were not recognized in the tender preparation. It also mostly avoids discussions about the exact scope of work if there is a difference of interpretation: the system should do what is described. Would you agree?
Q3-02	Annex 4 (Technical Specifications Preparation Phase) lists the functional requirements for the database including the GIS component. Do you have any specific comments or suggestions regarding the list of functional requirements?
Q3-03	Annex 4 indicates that input data for models will be produced by the LVB WIS; model runs will produce results. The IPC recommends that model results will also be included in the LVB WIS database for retrieval and reporting. Do you agree?

4 Data Requirements

At this stage and because of the current COVID19 situation the effort on data availability, data collection, management and transfer, and the establishment of data transfer and data use protocols is delayed. These subjects will be taken up as part of the planned (online) consultation meetings to be held in June and July 2020. Data availability, consistency and quality is rightly identified as one of the major challenges in the establishment of a successful and sustainable LVB-WIS. Basic data requirements for the LVB-WIS can be derived from (JV SWECO-Alterra-Ecorys, 2016a). In Table 1 an overview of such basic data is given.

Of the data listed in Table 1 several datasets are available in the public domain online; some are managed and owned by institutions in the Partner States, some may be procured from third parties. For some of the datasets the frequency for new information (meteorological datasets) can be as high as daily or even hourly; for some (discharge, water levels) a reasonable series covering the main seasons will be sufficient for calibration of models. Land use, topography, river and waterbody GIS maps can be refreshed every year or so.

The most crucial is data on water quality. Up to now the available data is unanimously declared as insufficient, and in need of quality improvement. Initial investigations conducted by IPC confirms this problem, both for direct water quality as well as data on parameters which may be affecting water quality (e.g. fertiliser use and resulting run off). In the upcoming consultation meetings, the topic of water quality data will have to feature prominently. Not only is it necessary to collect as much available historical data as possible, but the current situation regarding hydrological data collection and management, for water quality but also discharge, has to be assessed. Based on this a needs assessment can be compiled, which will be the basis for possible support by the IWRM programme of LVBC.

Dataset category	Datasets	Source		Required for			Ideal resolution / frequency[19]
		Online	PCs	DB[20]	HM	WQ	
Hydro-meteorological	Precipitation, temperature, wind, radiation, humidity	✓	✓	(✓[21])	✓[22]	✓	± 100m, daily
	Historical climate	✓	✓	✓			one time
	Climate change	✓	✓	✓	✓		one time
Socio-economic	Population	✓	✓	✓	✓	✓	yearly
	Agricultural use, crops grown, yield, prices	✓	✓	✓		✓	20 ha, monthly
Wet infrastructure	Wetlands, swamps, biotopes	✓	✓	✓	✓		20 ha, one time
	Water offtakes		✓	✓			± 100m, yearly
	Effluent discharge		✓	✓		✓	± 100m, yearly
Lake, reservoir related data	Lakes: volume and water level	✓	✓	✓	✓		± 0.01 m, monthly
	Rivers: flow and water level		✓	✓	✓		± 0.01 m, monthly
	satellite observed water quality parameters	✓		✓		✓	10 ha, monthly

[19] This describes an ideal data situation and will be subject to change, depending on what resolution data can be obtained.
[20] To prepare data overviews and reports for management of the LVB.
[21] Possibly the institutions and individuals in the Partner Countries would use other sources for this type of information.
[22] Hydrological modelling is usually required as basis for water quality modelling.

Dataset category	Datasets	Source		Required for			Ideal resolution / frequency[19]
		Online	PCs	DB[20]	HM	WQ	
	Location and extent		✓	✓			± 100m, one time
Topography, Soil, land use/land cover data	Elevation	✓	✓	✓	✓	✓	± 10m; one time
	Land use	✓	✓	✓	✓	✓	20 ha, monthly
	Geology	✓	✓	✓	✓	✓	20 ha, one time
	Soil	✓	✓	✓	✓	✓	20 ha, yearly
Development and policies plans	National development plans		✓	✓		✓	Yearly
	Province/district/country development plans		✓	✓			Yearly
	Socio-economic sector growth estimations	✓	✓	✓		✓	Monthly
Water quality and pollution source data	Water quality parameters		✓	✓	✓		± 100m, monthly
	Water use permits		✓	✓			± 100m, yearly
	Effluent discharge		✓	✓		✓	± 100m, monthly

Table 1: Data requirement LVB-WIS

To ensure that data availability and the efforts and time required to improve does not delay the establishment of a useful and successful LVB WIS database it was considered to focus on essential datasets first, and to extend the scope as data of sufficient quality become available. This could mean a limitation in the functionality of the LVB WIS. However, as long as core functions are available this would be an acceptable trade-off. The table A2-1 in (JV SWECO-Alterra-Ecorys, 2016a, p43-44, Appendix 2) shows a list of IWRM tasks, without indicating if these are all immediately relevant to LVBC; the tasks can be classed as ‘need to have’; ‘good to have’ and ‘nice to have’. A preliminary classification for the first phase of the LVB WIS is given in Table 2 based on the assumption that the primary objective is improvement of water quality; this classification will be discussed during the consultation meetings and can be amended.

Based on the preliminary classification it appears that almost all datasets indicated in Table A2-1 are needed even for the ‘must have’ IWRM tasks. It appears that the ‘core’ dataset is already relatively extensive and that most of the listed IWRM tasks could be undertaken using this core dataset.

Table 2 also shows that there is almost full overlap with the functionalities of the Nile Basin DSS. This leads to the assumption that the core datasets (of adequate quality) for the LVB are already available at the NBI.

For more details on the data requirements as determined in the Preparation Phase see Annex 5.

	IWRM Task	LVB-IWRM Preparation	NB DSS	LVB-WIS importance
1	Flood Management	√	√	Good to have[23]
2	Rainfed Agriculture	√	√	Good to have
3	Irrigated Agriculture	√	√	Good to have
4	Drought Management	√	√	Nice to have
5	Soil Erosion / Sediment Transport	√	√	**Must have**
6	Surface Water Quality	√	√	**Must have**
7	Groundwater Management	√	[24]	Nice to have
8	Hydropower	√	√	Nice to have
9	Navigation (LV only)	√	√	Good to have
10	Fisheries	√	√	**Must have**
11	Watershed Management	√	√	Good to have
12	Wetland Management	√	[24]	Good to have
13	Climate Change	√	√	**Must have**
14	Water Resources Development		√	Good to have
15	Optimal Water Resources Utilization		√	Good to have

Table 2: Importance of IWRM tasks for LVB WIS

4.1 Online open source data

As part of the establishment of the database and basis for the IWRM model an inventory of online open source data has been made. This is in partial fulfilment of Task T42.3 *"Evaluate the use of (freely available) global datasets including GIS and RS".*

The inventory represents the current status of research and is by no means exhaustive. It is anticipated that as the programme continues, additional data sources will be identified as well as be made available[25]. Increased stakeholder involvement in the future is also anticipated to generate new data sources. This task is therefore considered to be an on-going activity, however characterised by decreasing intensity as optimal data sources are being identified and IWRM data gaps are being filled, as the IWRM DB and model works progresses.

Data groups have been defined based on the classification of table A2-2 in (JV SWECO-Alterra-Ecorys, 2016a, p43, Appendix 2); the associated progress on data collection as well as their suitability have been briefly described. For more information, reference is made to Annex 3, where a complete list of the currently identified datasets is added to this document.

The following categories are recognized:

1. Hydro-meteorological datasets
2. Socio-economic datasets

[23] Referring to recent flooding in the LVB, despite a focus up to now on water quality, flooding is 'good to have' and maybe should be elevated to 'need to have'.

[24] Possibly part of Water Resources Development and Optimal Water Resources Utilization.

[25] Available open source data is constantly evolving. Presently restricted datasets may become publicly available within the programme timeframe. Many entities are constantly conducting data collection and data improvement activities, which possibly leads to new information relevant to LVB.

3. Wet infrastructure datasets
4. Lake, reservoir related datasets
5. Topography, Soil land use/land cover datasets
6. Development and policies plan datasets
7. Water quality and pollution source datasets

4.2 LVB WRIS

In (JV SWECO-Alterra-Ecorys, 2016b, Appendix 3, p42) a note on WRIS is presented. The WRIS database is the currently operational data source that is to be used by LVBC for IWRM in the LVB. It is online accessible through http://lvbc.wris.info/. However, while an extensive list of stations is shown it appears that very few datapoints are actually accessible.

In the note a dataset is described; and in 2016 an effort to clean up the dataset was undertaken. The description of this effort illustrates the type of errors encountered and gives suggestions on how to improve the data. As the analysis was done on the input data as received from the LVB Partner States, this shows that data quality was a serious challenge at the time.

At this moment (June 2020) the improved WRIS dataset is not available. Efforts are undertaken to locate this improved dataset.

4.3 LVEMP

The Lake Victoria Environmental Monitoring Project has also been involved in the collection of water quality data in and around Lake Victoria. While it was mentioned that large gaps exist in the data series it appears that this may be one of the more comprehensive water quality datasets collected in the LVB.

4.4 Other datasets

Other IWRM datasets are available at the institutions and Ministries in the Partner States. An inventory and discussion on quality, data collection and data transfer protocols and mechanisms need to be made.

4.5 Questions on Data

Q4-01	A clear advantage of building on the Nile Basin DSS is the fact that a database of IWRM data is already established, and data transfer protocols keep that database up to date. Is this correct to assume, or is the database of the Nile Basin DSS not suitable for the LVB-WIS?
Q4-02	What are the experiences with data transfer to LVBC or with data transfers to regional organisations in general?
Q4-03	Is there scope for a centralized data store / IWRM database at LVBC, e.g. will this be used by institutions of the Partner States? If you have doubts, please elaborate, if possible, also mentioning how to resolve the issue.
Q4-04	Would the central database of the LVB-WIS have a role in QA/QC of IWRM data, meaning that a centralized QA/QC may be helpful in improving the IWRM data for the Partner States?
Q4-05	What are the main challenges in collecting water level, discharge and water quality data?
Q4-06	Do you see a (big) role for online open source datasets for the LVB-WIS? And could you recommend useful online data sources?
Q4-07	Do you see a (big) role for LVBC in improving the data collection and management at institutions in the Partner States? Think of activities like (limited) investments, training, and perhaps other things as well. If yes, can you elaborate?

Q4-08	Based on Table 2, would you have suggestions to change the classification (need to have, good to have and nice to have) given here? Can you clarify?
Q4-09	What type of IWRM data does your institution have available?

5 Operation and Maintenance

5.1 Operation of LVB WIS

The main theme in the background documents is that the system / operation should be 'simple' and 'not complex'. When addressing this requirement, the immediate question is: can we do complex scenario calculations using a 'simple' system? The solution is to build the LVB WIS with the necessary complexity behind the scenes, while allowing users of different levels of expertise and with different needs and requirements access to the system through dedicated 'windows' that cater to these needs and requirements.

For the database part of the LVB WIS this appears easier than for the model part. With the list of specifications, a list of user functionality can be prepared. A list of prospective LVB-WIS database user groups can be made, and these groups can be matched with the user functionalities they can access (Table 4). A matrix showing this linkage is presented in Table 4.

	IWRM role	LVBC / Regional	Description
1	System management	LVBC	Technical DBMS expert who also ensures the proper operation of the required computer hard- and software, operating system, internet links, technical issues related to (automatic) data entry, backups, security, user management.
2	IWRM management	LVBC Regional	Regional and national water managers, responsible for water management within the LVB, who need information to decide on measures, management of reservoirs / abstractions/discharge-effluent and the related permits; regional and municipal decision makers who need to know the impact and possibilities of a planned WATSAN or large water abstraction (irrigation, industrial, urban water supply). Also interest in monitoring of water (quality and quantity) situation, reports. Access to information should be straightforward and user friendly.
3	IWRM expert	LVBC Regional	Expert working at IWRM institution or company, who is tasked with carrying out the studies for the IWRM management listed under (2). Also responsible for data acquisition and management, QA/QC and data sharing/entry.
4	Policy level	Regional	Water managers at Ministry / policy and strategy level. Use the LVB-WIS to assess the effect of (changes in) policy. Will request modelling to be done by IWRM experts and receive results. Also interest in monitoring of water (quality and quantity) situation, reports. Access to information should be straightforward and user friendly.
5	Research	LVBC Regional	Full range of access to data manipulation tools (subject to user rights); able to configure modelling. Research results to be made accessible through the LVB WIS!

Table 3: LVB WIS database user profile

	IWRM Task IWRM role	LVBC (L) or Regional (R)	Manage DBMS configuration	User Management	Data definition	Data entry	Data quality checking	Data retrieval, query	Present data: tables, graphs, maps	Present statistics: tables, graphs, maps	Map queries	Report generation	IWRM Dashboard	Model management	Model results
1	System management	L	√√	√√	√√	√√								√	
2	IWRM management	L R		√				√	√	√	√	√√	√√		√√
3	IWRM expert	L R	√		√	(√)	√√	√	√	√	√	√	√	√√	
4	Policy level	R						√	√	√	√	√√	√√		√√
5	Research	L R					√	√	√	√	√	√		√√	√√

Table 4: Matrix of LVB WIS functionality and User Groups

5.2 Maintenance of LVB WIS

Maintenance of the LVB WIS database can be divided into two specific tasks: Maintenance of the datasets, and maintenance of the database configuration and DBMS. Both tasks are crucial and will require considerable resources.

Maintenance of datasets

As user and custodian of the LVB WIS database the LVBC needs to safeguard that the data are accurate. However, the LVBC does not collect its own data, but relies on institutions in Partner States and on global data sources. For global data sources the accuracy and reliability need to be assessed, with special attention to the data made available for East Africa. For all other data the primary responsibility for QA/QC is with the institution that collects and manages the data. However, by making the data available through the LVB WIS the LVBC also assumes responsibility for it and has a duty to ensure that the datasets are sound. Any suggested improvements to the original dataset can be send by LVBC as feedback to the 'owner', thus improving data quality for IWRM data used in the LVB in general.

The option to join forces with NBI / Nile Basin DSS is also being considered; one aspect of the cooperation could be joint data acquisition and management. This option will be seriously considered. Some further thoughts about the role of LVBC in data collection and management in the Lake Victoria Basin can be found in Chapter 4, Data Requirements.

Technical maintenance: DBMS updates and operation and database configuration.

The proposed approach for building the LVB WIS is to contract the services of specialists to carry out the (technical) installation of the DBMS and the basic configuration. The detailed configuration, the preparation of the datasets and the configuration of the output means (displays, reports, website access) will be realised by regional experts working with and guided by the DBMS experts. Training sessions will be followed by building / configuration, after which a QA/QC and troubleshooting / testing session completes the cycle which then begins with a new training session. In this way the specialists will be engaged in an efficient manner while regional expertise is built, and training, testing and initial approval of the system is done within the same cycle. By having the regional experts carry out relevant studies with the LVB WIS, active use of the system is promoted, and acceptance and trust generated.

From the above approach it follows that a maintenance contract with the DBMS vendor/consultant for updates and technical support is required, while changes and updates in the configuration can (also) be carried out by regional experts. For sustainable use of the system, effective user support needs to be established; this might be arranged by establishing an LVB WIS User Group and providing online support (information, training, change requests, user forum, user support by an expert/experts).

Again, the option to join forces with NBI / Nile Basin DSS is relevant here. In case a joint development of (a part of) the LVB WIS is decided, joint arrangements for technical maintenance would be practical. The established technical and user support at Nile Basin DSS is in fact a major reason to consider joining of forces in the LVB WIS development.

5.3 Questions on Operation and Maintenance

Q5-01	The IPC recommends having different displays and functionalities available for users with different information requirements and different technical skills and experience. Would you agree?
Q5-02	Do you think that users who access/use the LVB WIS should be able to model their own policy or scenario question and run it, or should a standardized set of scenarios be prepared, with special requests being handled by the LVBC experts?
Q5-03	The LVB WIS is to be established to support better informed decisions regarding policy development and investments that improve water quality and availability. Do you see other uses for the LVB WIS? Proposed are: a repository for project information such as documents and (non-IWRM) datasets; a library on IWRM related documents; and in a wider context even expert support for IWRM and especially water quality challenges that LVBC Partner States are grappling with; other?
Q5-04	Table 3 presents a list of LVB WIS database user profiles. Do you have suggestions regarding this list?
Q5-05	Table 4 presents a matrix of LVB WIS functionality and User Groups that would require access to such functionality. Do you have suggestions regarding this matrix?
Q5-06	Maintenance of the LVB WIS database can be divided into two specific tasks: Maintenance of the datasets, and maintenance of the database configuration and DBMS. Both tasks are crucial and will require considerable resources. Can you share your ideas on the following:

- Datasets should be maintained by the ‘owner’ and the responsibility of QA/QC is with the owner
- LVBC should assist by supporting with and performing QA/QC on datasets as service to the Partner State Institutions (this will have impact and depend on (human) resources available at LVBC)
- LVBC should rely on services of the NBI (NB DSS expertise) for data
- Technical maintenance can be done by LVBC in close cooperation with experts from the Partner State institutions
- Technical maintenance should be carried out under a service contract with the DBMS provider
- Technical maintenance can be a mix of the two options above

Q5-07	An automated exchange or synchronisation of (selected) data between the LVB WIS and the national datasets may be considered. This will greatly enhance data exchange and improve data quality checking. What is your opinion on this?
Q5-08	While user management will be implemented and user rights will be assigned, it is proposed to make as much information and even (selected) data series online available, possibly only after creating a user profile and indicating the objective for using the data (to enable logging of actual use of the information/data). What would be your opinion on this proposal?

Q5-09	The LVBC has the mission to be the “IWRM Centre of Excellence” for the LVB. What do you expect from the LVBC, what type of support?

6 References

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Annex 1. Inception Report Chapter 9: Development of the LVB IWRM Database and Model

The general purpose of an integrated water quantity and quality model is to support policy measures and local investment decisions for the long-term sustainable development of the LVB. Furthermore, it serves the purpose of easily tracking and disseminating information on the development of the regional priority investment plans.
The model and database will result in increased awareness, better informed problem analysis and increased support for investment decisions.
The modelling goals of the IWRM model and database can be defined as follows:

a. Tool for prioritisation of investments and other measures: The primary modelling goal of the IWRM model is to support investment decisions for water quality improvement in the Lake and tributary rivers.
b. Tool for policy development: Simulating the effects of policy measures and interventions in relation/comparison to the future autonomous development of the water quantity and quality.

To facilitate discussion the “LVB IWRM Database and Model” will be referred to as the “Lake Victoria Basin Water Information System” or “LVB WIS” in this Inception Report pending a final decision on the name.
While the LVB WIS will eventually support prioritization of investments, the LVB IWRM programme will support the PCU in setting up a pipeline of investments, an activity that will start within the first six months after the Inception phase. The LVB WIS will not yet be ready to assist in the prioritization process; until it is operational other means of prioritizing the pipeline of investments need to be used.

9.1 Capacity Building

Capacity building will be an integral part of the LVB IWRM programme. During the implementation of the LVB WIS, capacity building will be realised in three ways:

1. Experience exchange visit

An exchange visit is proposed to support the development of a Water Framework for EAC; it is proposed to use the experience of the WFD as it was adopted in 2000 and subsequently implemented in the EU member states. A visit is tentatively planned sometime in the second half of 2020[26]. In addition, a study tour can also be very useful in showing how setting up flexible Database Management Systems (DBMS) and models can help in IWRM, and to allow IWRM officers of the LVB Partner States to exchange experiences on how to implement such systems. To this aim, targeted visits are proposed for technical staff / IWRM officers to implementations of DBMSs and linked models that have comparable functionality to the one envisaged for LVBC. Suggestions are:

a. Nile Basin Secretariat (Nile-SEC), for Nile DSS (this is mentioned in the ToR and methodology);
b. Deltares, for DelftFews; DHI, for MikeBasin;
c. Implementation(s) of DBMS systems for data management,
d. Implementation(s) of DBMS/modelling systems for modelling

The group of decision makers could possibly also join in one or two of the technical visits, though this might create logistical challenges.

2. On-the-Job-Training

The consultants plan to involve staff members from designated Water Resource Management Authorities in the Partner States. in the setting up of the IWRM DBMS and models, see also the description at Task 45 and Task 51. In this way optimal use can be made of their knowledge of the area, datasets and models

[26] At the programme launch (February 14, 2020 in Kisumu, Kenya) KfW indicated that they are in favour of targeted exchange visits

that are already in use, while at the same time preparing them for using the system once it is completed. In this way local capacity is developed as well, while minimizing the input of the specialized experts, instead using them not only for building the system but also for training (and training of trainers). In this vision the testing phase will also be done together with the staff members from designated Water Resource Management Authorities in the Partner States, ensuring that the LVB WIS is known, understood, supported and accepted by all stakeholders.
A principle of the LVB IWRM programme is that all activities of the consultants are carried out jointly with the LVBC counterparts and where applicable with officers of the respective institutions in the Partner States. Such 'job-embedded support' will ensure that any results are fully supported by all and that knowledge transfer takes place in an efficient and sustainable manner.

3. Training Courses

Specific courses may be required on topics such as Data Collection, Validation and Verification, and in general on data management for IWRM, but also on. Other technical topics may further include the use of satellite data and Geographical Information System (GIS), and the use of global (open) data sources as input for modelling.
Based on the results of the round of consultation meetings which will include a skill/ / knowledge gap / needs assessment, such courses may be planned and organised, either at location in the respective Partner Countries or at a central location, depending on the requirements and number of trainees. For the training courses specialized trainers can be involved, or (part of) the training sessions can be given by the LVB IWRM (Key) experts.

9.2 Observations made during the Inception Phase

While the objective is to build one tool, the LVB WIS, this tool will consist of one or more databases, which are used by one or more models; the results of the models may also feed back into the database(s).

The LVB WIS will be established at the LVBC in Kisumu, while a local version can be developed at a selected institution in each of the Partner States. All instances of the LVB WIS should have the same overall database structure and the same linkages to model(s); however, not all datasets nor all models need to be implemented in the Partner States.

The objective is that eventually all Partner States have their own LVB WIS that can support national policy and strategy decisions[27] (see Figure 1), whereas at the LVBC all datasets and models are implemented; LVBC will thus become the regional IWRM Centre of Excellence[28] where both national and regional requests for modelling or data management support can be fulfilled.

This is in accordance to the 2nd Ordinary RPSC Meeting for the LVB IWRM Programme (Kisumu, 10-13 Feb. 2020), which:

x)	Directed LVBC Secretariat to ensure that the IWRM-Programme Consultant (IPC) factors the commitment to support the construction of the Centre of Excellence as one of the key LVB-IWR programme deliverable and report to the next RPSC *(LVBC/RPSC 2/LVB IWRM/Directive 10);*

[27] Results should be shared with the LVBC as LVB Knowledge Centre / Centre of Excellence
[28] Report from the 2nd Ordinary RPSC Meeting for the LVB-IWRM Programme, Kisumu, 10-13 Feb. 2020

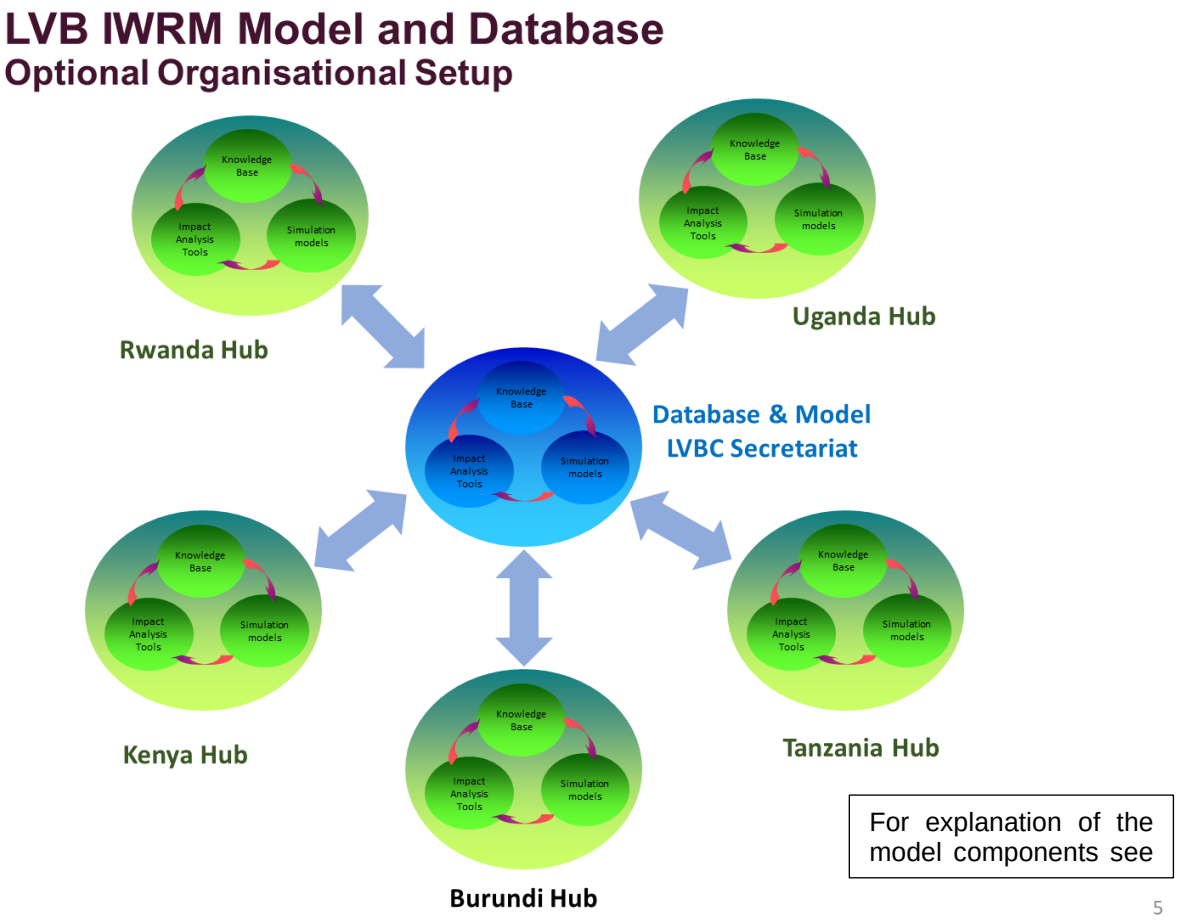


Figure 1: LVB IWRM WIS at LVBC and Partner State Institutions

9.3 Preparatory Activities

Study design and specification of IWRM model and GIS database (T37)	As the involved staff at LVBC are new to the organisation, they should thoroughly familiarize themselves with the results of the preparation phase, for the LVB WIS especially with the proposed design and specification of the IWRM model and GIS database as agreed upon during the preparation phase of this Programme in 2016. In addition, several other sources of information will be studied. This should be completed before any visits to Nile-SEC and institutions in Partner States can take place; these visits are tentatively planned for May 2020 (see T38).

To guide adjustment of the proposed approach the findings of the 2nd Ordinary RPSC Meeting for the LVB-IWRM Programme (Kisumu, 10-13 Feb. 2020) and the IWRM kick-off meeting (Kisumu, 15 Feb. 2020) will be take into consideration.

The 2nd Ordinary RPSC Meeting for the LVB IWRM Programme:

ix)	Directed LVBC Secretariat to guide the establishment of the necessary Programme coordination structures at national levels including National Technical Committee and the National Policy Steering Committee as provided for in the Project Document and Financing Agreement *(LVBC/RPSC 2/LVB-IWRM/Directive 9)*

xi) Directed LVBC Secretariat to identify and leverage on opportunities for collaboration with other NBI initiatives under component 1 of the LVB-IWRM programme such as the hydromet project, surface water models and Nile DSS databases by utilizing the collaborative MoU between LVBC and NBI to avoid duplication *(LVBC/RPSC 2/LVB-IWRM/Directive 11)*

From the Report of the IWRM kick-off meeting, Kisumu, 15 Feb. 2020:

Observations made with respect to IWRM Database and Model Development

i) The need to map the databases and models being used in the Partner States is critical at this stage before development of new LVB-IWRM database and model;
ii) There is need to appreciate efforts from other existing/completed initiatives so as to build on the efforts already in place with regard to databases and models, e.g. LVEMP Lake Victoria Water Quality Model, Nile Basin Initiative Monitoring Network, etc.
iii) There may be need for targeted monitoring in cases where there are no monitoring stations or even in cases where it is limited;
iv) In most cases, the aspect of water quality has been omitted in water resources modelling efforts, but in this case, it should be emphasized; and
v) Relevant institutions in all Partner Stated should be involved in the development of the IWRM Strategy.

The findings above clearly guide LVBC and the IWRM IPC to carefully consider the following:

1. Ensure that the correct institutions in the LVB Partner States are involved and work together through a programme coordination structure
2. Start with a thorough inventory of all other initiatives, existing databases and IWRM models within the LVBC to build upon the efforts already in place
3. Evaluate the datasets and data collection practices, with emphasis on water quality data, and consider the options of supporting data collection in the Partner States.

Visit Nile-SEC in Entebbe. Special report with modified approach (T38)	The IPC/LVBC IWRM team plans to visit Nile-SEC in Entebbe, Uganda to investigate options to use available resources, databases and models at Nile-SEC for the use of LVB WIS. A key objective of the visit is to assess if the Nile-SEC Mike-Basin based model/database system can be used as basis to create the LVB WIS. In that case the resulting (improved) system can be used at both LVBC and Nile-SEC and the IPC will prepare a special report outlining a modified approach to the implementation of the LVB WIS to be agreed upon between LVBC and KfW.
Data exchange proposal in relation to HydroMet (T39)	During the talks with Nile-SEC the IPC/LVBC IWRM team will discuss procedures and make proposals for data exchange between the LVBC Partner Countries, Nile-SEC and LVBC. This will include the new Nile Basin Regional HydroMet system and the proposed data transmission mechanisms. Existing data transfer mechanisms should be used where possible to minimize efforts and duplication of efforts[29]. To facilitate the data exchange, the existing MoU which covers cooperation between NBI and LVBC that is currently dormant, can be revived. In addition to Nile-SEC, visits to all partner countries & relevant institutions are planned to conduct a thorough inventory on data availability and assess data quality; assess the need for assistance in improving data collection,

[29] Similar initiatives are undertaken at the Partner Countries at national level; for instance, with the Water Resources Authority (WRA) in Kenya: the WATER RESOURCES AUTHORITY STRATEGIC PLAN 2018 – 2022 (© WRA 2019) mentions as essential steps to come to enhanced water resources management the following steps: "2. Develop effective, efficient and reliable water resources information acquisition, management and sharing systems; 3. Put in a place a centralized national ground water resources data and information management including technically and commercially viable options for sustainable utilization (p28). It is expected that other Partner States have similar systems planned or operational.

verification, validation and analysis, or optionally the practical possibilities and implications of setting up new, regular and high-quality data collection. Based on the consultation meetings a gap / needs assessment will be prepared to inform on the capacity building / training needs as well as other issues that may need to be addressed to ensure successful data exchange.

9.4 IWRM Database

"The database shall include all basic data of the water system, the water quantity, water quality, meteorological data, the georeferenced physical and administrative elements of the LVB such as sub-catchments, hydraulic infrastructure, diversions and confluences, lateral catchments, and points of demand such as settlements, farms and irrigation districts, industries, or wetlands. It shall also contain all other types of information needed for the development of the IWRM model.

The database must contain data tables as well as it will contain geographical information (GIS). In addition, a literature database needs to be established. The database should be easy to use/operate and maintain – nevertheless, it should facilitate several tasks of users like data exporting, mapping and quality control or tasks that also need capacity development, and which cannot be executed at this stage." (ToR, Aug 2018)

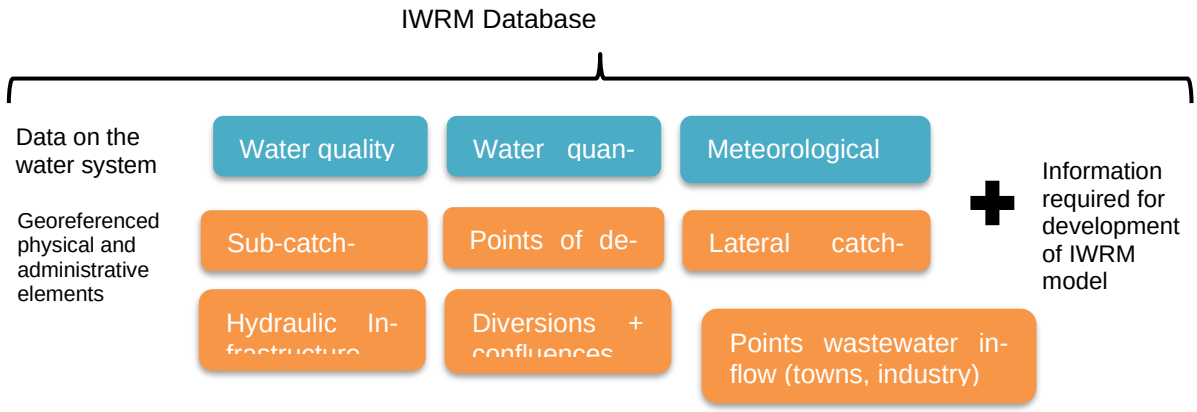


Figure 2: DBMS Approach

An idea of data stored and managed within the LVB WIS DBMS is shown in Figure 2.

It is very important to see the development of the DBMS as closely interlinked with the requirements of the model(s) that are to be implemented. While minimum requirements of data fields and GIS data to be included are listed in the ToR, the models to be used with the DBMS will determine which datasets are essential, while the other way around certain models can only be successfully implemented if the required datasets are available. A flexible implementation of the DBMS is essential in ensuring that new models can be incorporated / linked with relatively little effort.

The term "Data" includes GIS spatial data and may include Remote Sensing (raster) datasets. The cooperation of the LVB Partner States IWRM institutions in obtaining especially the IWRM related GIS data is a prerequisite and essential for the successful implementation and operation of the spatial part of the DBMS / LVB WIS.

Establish the database and enable the PCU (T40)	A major task of the IPC is to establish the database and enable the PCU to take over responsibility for data management. This is done according to the following activities/tasks:

Review database implementation approach (T41)	The consultant will review the IWRM database specification detailed in the Final Specification Report[30] and the Background Document[31], and prepare an updated version, taking into account the methodology as previously proposed and outlined, and the findings during the consultation visits with the relevant institutions at the Partner States (Task 42).
Data transfer procedures (T42)	Without (reliable and complete) datasets there is no database and there can be no models. Data collection / sharing / transfer is an essential step in the process of establishing a viable LVB WIS, and a step that will need involvement and support at all relevant institutions as well as at the Ministry level in the LVB Partner States. To ensure that the LVBC can become the regional 'Centre of Excellence" the IPC and LVBC PCU will support the LVB IWRM institutions, where this is needed, to bring the procedures for data collection, verification, validation, analysis and management up to the required standard. It is highly recommended to set the frequency of any data transfer to one month at the most, as this will enable LVBC to signal any possible issues early, and offer timely assistance where this is needed, required and possible. The consultation meetings planned at the Partner State IWRM institutions and the subsequent regional level IWRM meetings will be used to draft the specific, defined procedures and rules required for successful data exchange. Global data sources In parallel, the options to use 'global datasets', data that are freely available through the internet, should be explored. Such datasets, obtained by satellites and weather stations, are already successfully being used as input in hydrological modelling. A huge trove of satellite imagery and GIS maps are in the public domain, as well as global meteorological data. The use of satellite sensors to signal localized nutrient pollution in Lake Victoria might be feasible; a study into documented applications of satellite data for data gathering and modelling for Lake Victoria is proposed.
Database implementation Plan (T43)	Based on the findings of the consultation meetings, inventory of data and models, the IPC will develop an LVB IWRM data base implementation plan, closely linked to the requirements for the LVB WIS. The plan shall describe the required implementation steps, milestones, planning and responsibilities for implementation. The implementation plan will be included in the tender documents required for the procurement of IWRM soft- and hardware.
Procurement of IWRM soft- and hardware & tender documents (T44)	The IPC will facilitate the procurement of suitable LVB WIS soft- and hardware, including the preparation of tender documents[32]. While for practical and planning purposes the development of the DBMS and the model(s) are separated, a solution that combines not just the DBMS but also the functionality to link models to it will be included in the description of requirements[33]; the hardware specifications will take the requirements of modelling and GIS into account as far as these are already known. The actual implementation of (the) model(s) can then take place as soon as the required datasets have been entered, validated and verified (T51-53).

[30] Final Specification Report, Design and Specification of an IWRM Model with a Sound GIS Database to Support Future Investment Decisions; LVBC/JV SWECO-Alterra-Ecorys, November 30, 2016

[31] Background Document, Design and Specification of an IWRM Model with a Sound GIS Database to Support Future Investment Decisions; LVBC/JV SWECO-Alterra-Ecorys, November 30, 2016

[32] The procurement will be covered by the disposition fund. The required procurement regulations will be adhered to.

[33] Such DBMS model platforms exist; Mike Basin is one example (in use at Nile-SEC; Delft-FEWS is another. Both have pre-defined DBMS systems that can be extended to include additional datasets, have functionality to automatically obtain global data and GIS/remote sensing information, and can be linked to a series of (IWRM and other) models (for MikeBasin based on information obtained from LVBC PCU staff, for DelftFews from own experience).

Supervision of software development and implementation (T45)	Guided by the implementation plan the IPC will supervise the (technical) DBMS installation. Then, based on the results of the consultation meetings, LVB Partner States' IWRM technical staff can be involved in the configuration of the DBMS to meet the requirements of the LVB users. This can be done by conducting training sessions by the DBMS specialists, after which the LVB IWRM staff can work on the configuration, guided by the DBMS specialists. Depending on the availability of LVB IWRM technical staff, the demand for such 'job-embedded support' and possibly budget constraints, several such sessions can be carried out, step by step building the LVB WIS database. It is also possible to include joint testing, as basis for completion and handing over. The IPC will retain the overall responsibility of the DBMS installation and configuration.
Tasks and responsibilities for data management (T46)	It is essential that tasks and responsibilities for data management within PCU specifically or LVBC in general are well defined; the IPC shall support the PCU in this important task. As part of this task and of Task 39 and Task 42, a professional network of IWRM technical officers in the LVBC Partner States will be established and facilitated from the PCU / LVBC. This network will also form the LVB WIS User Group, which will support the continuity and necessary upgrading of the LVB WIS (see also Task 54a).
Capacity development, training in the use of tools, manuals (T47)	Capacity development for the PCU/LVBC team and LVB Partner States IWRM technical staff will be carried out as part of the LVB WIS DBMS configuration (see Task 45), jointly with the LVB WIS DBMS developer. As per ToR such (hands-on) training will enable the users to successfully and confidentially carry out the following tasks: a. Proper use of basic database functions (querying, mapping) b. Management of the database The IPC and LVB WIS DBMS developer will, in close cooperation with the LVBC PCU: c. Develop pre- and post-processing tools and conduct training in the use of these tools d. Define and implement IWRM reporting standards e. Support data collection and data analysis (see also Task 42) f. Define responsibilities for quality assurance / quality control and reporting of results, including protocols g. Develop user-friendly manuals and training material.

9.5 LVB IWRM Knowledge Hub

The ToR and the Final Specification Document both mention a "Literature Database". The objective is to make the collection of books, documentation, reports and (scientific) papers, articles and presentations now available at LVBC accessible and searchable. This fits squarely with the intention, voiced at the 2nd Ordinary RPSC meeting of February in Kisumu, to build the LVBC into a Centre of Excellence for IWRM.

Chapter 3 of the Final Specification Document describes the current situation, approach and requirements in detail. It also stipulates that maps and datasets should not be considered for this database. While strictly speaking (GIS) maps and (MS Excel) datasets are not literature, there are good arguments to widen the scope of the described Literature Database into an LVB IWRM Knowledge Hub, which also stores and manages products and resources of (earlier) projects and activities:

- In many cases, studies that are undertaken need data; rough datasets are improved or new datasets are acquired as part of the study but are not used to improve the original database (either by improving the original dataset or by adding the improved dataset). While this would be the preferable course of action, it is often not done[34]. For that reason, it is strongly recommended to create project data and information repositories, where all relevant digital data is stored in an accessible manner.

- Access to the non-literature information could be arranged by including clear descriptions of the (project) data in a (standardized) document that can be accessed in the "literature database" part of the Knowledge Hub. Requests for information can then be submitted through a web-portal, stating the reason / justification for the request and a means of verification of the identity of the person / organisation requesting. This access management can be set up at various levels of restriction, from pre-vetted organisations to – for some information – open access for valid purposes. The repository can be organised in a relatively simple manner (even as an agreed, predetermined file directory structure), with data delivery by sending a link to a VPN download site, for instance. In all cases the intervention of a human information manager is still required, though an automated system might be designed and implemented at a later stage.

- To ensure that project data does not become inaccessible, LVBC should consider obliging all IWRM and related projects to submit a digital copy of reports and datasets for the Lake Victoria Basin upon completion. Ideally all EAC member states could follow suit at some date in the future, creating depositories and one central access point or consolidated depository for all projects and project results carried out within the EAC Partner States.

The EAC has implemented an online Document Repository which also holds documents under the subheading of LVBC (http://repository.eac.int/handle/11671/5, 169 publications on February 26, 2020). At the moment this is more limited than the 'literature database' envisaged under the Knowledge Hub; there are more than 300 reports, books and articles collected at LVBC. As it is desirable to make use of existing systems as much as possible the first action would be to see how the EAC LVB repository can be included in the LVBC Knowledge Hub. Based on consultations, either a parallel system with the required functionality will be built at LVBC or requested functionality can be added to the EAC LVBC document repository. If parallel systems are needed, then a very active exchange of (a selection of) documents between both repositories needs to be realised, and hyperlinks at each web portal installed that point at the other portal.

The concept of a knowledge hub can easily be replicated at the relevant IWRM institutes in the Partner States. If this is implemented, a protocol for exchange of documents needs to be set up to ensure all Knowledge Hubs have all (relevant) documents available.

9.6 IWRM Model

The specification report for the IWRM model[36] proposes off the shelf tools or models to be given preference. Software development of a new model is considered inefficient. The LVB WIS should be built upon existing national and regional tools and models, for which capacity has been built at national level over the years. This means that (modules of the) Nile Basin Decision Support System (Nile DSS) or Soil Water Assessment Tool (SWAT) are possible model codes[35]. The preferred solution would have a flexible (DBMS) system that can handle the variety of tools and models presently being used within the LVB. A final decision will be prepared with care in coordination with the relevant stakeholders in the Partner States.

[34] In fact, it happens all too often that any digital reports, (GIS) maps or other datasets are no longer accessible relatively soon after completion of projects and programmes – this amounts to a destruction of value and capital.

[35] An updated and more comprehensive list of models that are used within the LVB will be a result of the planned Consultation Meetings, Task 42

In 2016, SWECO[36] developed the IWRM model concept. It is the basis of the development of the LVB WIS, see 0.
While the aim is for an integrated modelling system, it is recommended that the LVB WIS to be used to make limited model runs, for instance (groups of) river basins of tributaries to Lake Victoria. In practice this depends on the influence of the lake on the river basin models; for hydrological models the lake level will be an important boundary condition.

Table 5: LVB IWRM Model Description

Functional Component	Description
Regional knowledge base	A regional knowledge base that provides a common and shared information basis for the planning and decision-making processes, locally, sub-regionally, and basin wide, directly accessible for all stakeholders in line with the Lake Victoria Basin Data and information sharing and exchange procedures;
An LVB modelling system (LVB WIS) built around 3 modules	A **Water Resources Module (WRM**) as a dynamic water budget and water quality model, building on/using the existing models. The WRM is expected to be extended to fully cover the lake system. The WRM computes water supply and demand on a daily basis and can be aggregated to monthly and annual water budgets for any node, sub-catchment, or administrative grouping. This basic core model system interacts with logical pre-processors (hydro-meteorological data management, time series analysis, rain-fall runoff model, irrigation water demand, watershed erosion) and in turn provides the inputs for a water quality model (BOD, nutrients, conservative substances, first order decay, turbidity/sediments including bank and bed erosion and transport).
	A **Water Intervention Module (WIM)** that helps to design and evaluate possible interventions, strategies and projects in response to the problems and challenges identified and prioritised in the stakeholder consultations. The WIM enables the IWRM model to be used as a decision support tool for policy makers to decide on feasible development scenarios, anticipate autonomous developments, and set priorities in investments. The WIM considers the effects and outcomes of measures and investments in the sector of water supply, treatment projects, dams, irrigation etc. as well as of policy changes like water pricing and environmental protection. Within the WIM the effects of these changes can be identified for the current situation and for the expected future development scenarios (e.g. climate change, economic growth, demographic changes, etc.).
	A **Water Utilization Module (WUM)** that helps in ranking scenarios contemplated under the WIM based on certain pre-defined criteria. Those criteria may be economic, environmental or social (to rank and select alternative solutions for win-win strategies). The WUM shows relations between water quality problems and damages on one side, and pollution sources on the other side. By mapping water users and potential sources of water quality problems, water resource managers will be able to better assess the effect of measures (which users will be affected), to gain improved understanding of potential causes for damage and to better assess research and monitoring needs.

While the objective is to build one LVB WIS, this tool will consist of one or more databases, which are used by a suite of models; the results of the models are also fed back into the database(s) if relevant (Figure 3). The LVB WIS can be seen as only the combination of DBMS and models, but in a wider definition it takes in all knowledge available at the LVBC, including expert knowledge and the information stored, managed and shared in the LVBC Knowledge Hub. This is visualized in Figure 4. To establish a sustainable and successful LVB WIS the human resources aspects need to be taken into account; retention of knowledge, proper handing over and training of new staff is currently a serious challenge and will need considerable attention by the LVBC management.

[36] Final Specification Report, Design and Specification of an IWRM Model with a Sound GIS Database to Support Future Investment Decisions; LVBC/JV SWECO-Alterra-Ecorys, November 30, 2016

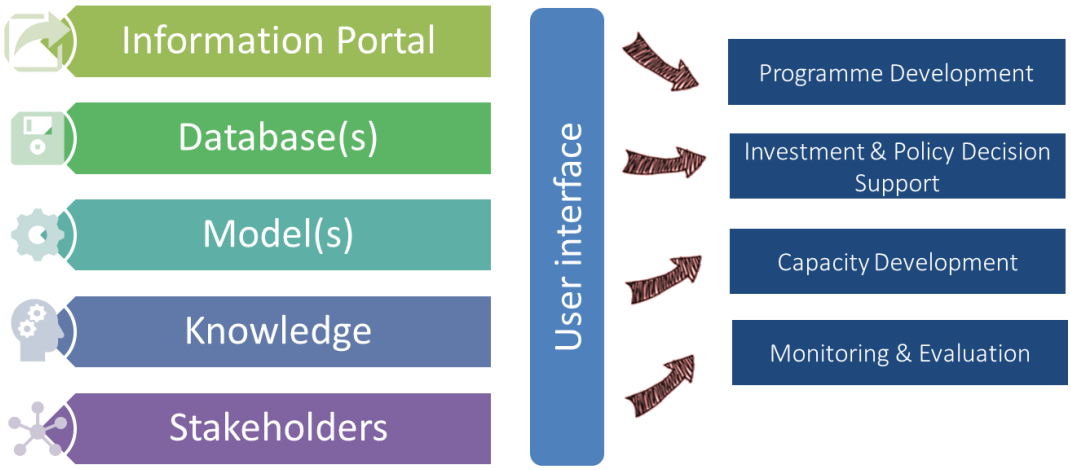


Figure 3: LVB WIS - Wider Definition of WRM Information Centre

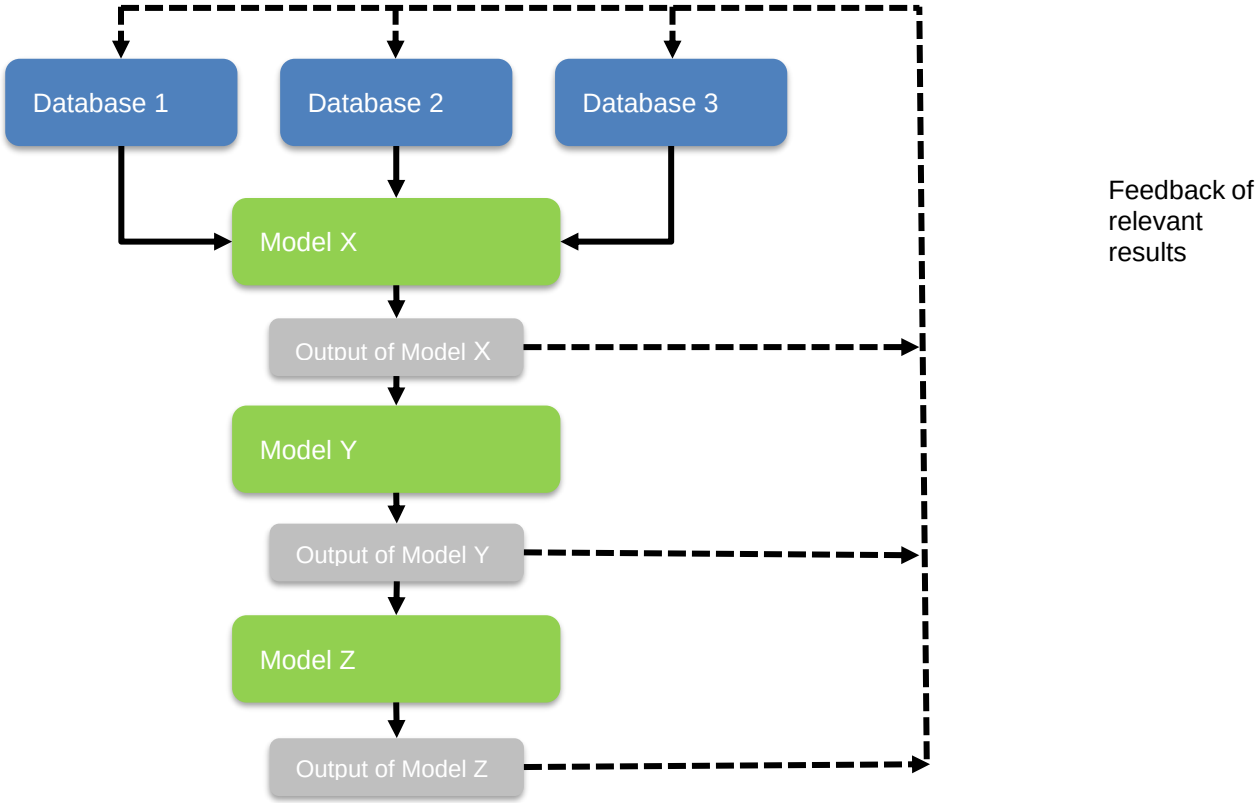


Figure 4: Concept of LVB WIS – Example of DBMS – Model Linkage and Data Flows

The LVB WIS will be established at the LVBC in Kisumu, while a local version can be developed at a selected institution in each of the Partner States. All instances of the LVB WIS should have the same overall database structure and the same linkages to model(s); however, not all datasets and not all models need to be implemented in the Partner States at this first stage of the programme.

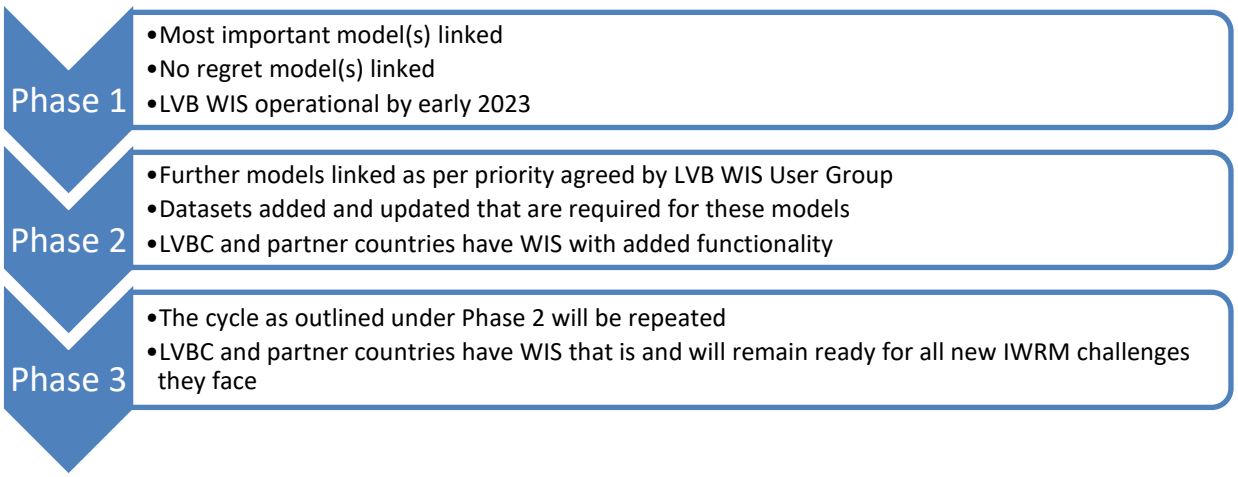


Figure 5: Phased approach implementation of WIS functionality

In general, a phased approach is recommended; the addition and/or configuration of the most important models as well as 'no regret' models (easy to link and implement) will have the highest priority; other models can then be phased in depending on need and available resources (HR and financial), see Figure 5. In this way the LVB WIS can be seen as a 'living system', where there is no hard completion state, but functionalities are added over time, ensuring that the LVB WIS will be useful relatively soon, and become more useful in time.

In the description of activities / tasks below the generic term "model(s)" or "modelling capabilities" is used. These terms include all the capabilities described in Table 5 under "Water Resources Module (WRM)", "Water Intervention Module (WIM)" and "Water Utilization Module (WUM)"; in the prioritization of model elements to implement the proper implementation sequence needs to be taken into account; without at least a set of WRM models the WIM and WUM modules cannot work.

Special report on scope and detail of the model (T48)	A final decision of the scope and resolution of the IWRM model will be taken at the latest by September 2021 (18 months after start of the LVB IWRMP). This decision will be based on extensive consultation with the relevant Partner State IWRM institutions and LVBC, and on the status of the data availability and quality by then. The rationale for the decision will be outlined in a special report ("Scope and detail of the LVB WIS modelling") to be presented to the LVBC, RPSC and KfW.
Review implementation approach (T49)	In parallel with the preparation for (T48) a review of the implementation approach as outlined in the IWRM model specification report will be carried out, also with extensive consultation with the stakeholders, and the updated approach will be presented together with the Special Report.
Updated implementation approach (T50)	The updated report will include a draft LVB WIS modelling implementation plan. The plan shall describe the required implementation steps, miles stones that need to be achieved before other steps are implemented, responsibilities for implementation, and timelines.
Model implementation Plan (T51)	Based on suggestions and comments from LVBC, RPSC and KfW an updated and final version of the "Scope and detail of the LVB WIS modelling report" and updates of the implementation approach and implementation plan will be prepared. Consultation meetings and meetings dedicated to DBMS configuration and training will be used from the very start of the LVB IWRM programme activities to discuss ideas and concepts on the required model capabilities and existing models that can and should be included. The first set of basin wide consultation meetings is scheduled for May 2020.

While the focus for the LVB IWRM programme is on water quality, the LVB WIS could be a sound basis for the installation of a Flash Flood Guidance System. While this cannot be facilitated under the current Phase 1, the potential benefits can be investigated, and if desired a pre-feasibility study could be carried out and an assessment note may be compiled.

Procurement of soft and hardware (T52)

The IPC will facilitate and support the PCU with procurement of suitable LVB WIS software required for the modelling capabilities, including the preparation of tender documents. If additional hardware is required this will be included, though it is foreseen that the hardware procured under (T44) will be dimensioned to facilitate both the DBMS as well as all modelling and GIS requirements for the LVB WIS[37]. The requirement to favour existing systems within the LVB or at least to allow the continued use within the LVB WIS will be included in the tender.

Supervise software development and implementation (T53)

Guided by the implementation plan the IPC will supervise the (technical) model system installation. Based on the results of the consultation meetings, LVB Partner States IWRM technical staff can be involved in the configuration of the models to meet the requirements of the LVB users. This can be done by conducting short training sessions by the modelling specialists, after which the LVB IWRM staff can work on the configuration guided by the modelling specialists. Depending on the availability of LVB IWRM technical staff, the demand for such 'job-embedded support' and possibly budget constraints, several such sessions can be carried out, step by step building the LVB WIS modelling capabilities. It is also foreseen to include joint testing, as basis for completion and handing over. The IPC will retain the overall responsibility of the model installation and configuration.

As it is expected that existing models will be included for which capacity exists within the LVB, the LVB model officers with this knowledge can also fulfil the role of 'model implementation specialist' and take an active role in the training and support of other LVB IWRM officers in the "on-the-job training sessions.

Capacity development (T54)

Capacity development for the PCU/LVBC team and LVB Partner States IWRM technical staff will be carried out as part of the LVB WIS DBMS configuration (see Task 45 and 54), jointly with the LVB WIS model developer. As per ToR such (hands-on) training will enable the users to successfully and confidentially carry out the following tasks:

a. Training in the proper use, management and configuration (updating) of the model(s); in the case of inclusion of (river basin or other) models that were developed by one of the LVB Partner State IWRM institutions the responsibility for management and updates of the configuration is and will remain with this institution; necessary model software updates can be (partly) financed by the LVBC[38].
b. Update and implementation of IWRM reporting standards by using modelling results.
c. Develop mechanisms to use modelling results for the development of a regional IWRM priority investment plan.

Operation and Management (O&M) of the LVB WIS (T54a)

Once the first version of the LVB WIS is operational, it is important that a sustainable mechanism is established to support the operation and maintenance of the LVB WIS. This will include technical support with the DBMS and models, ideally set up through

[37] The procurement will be covered by the disposition fund. The required procurement regulations will be adhered to.
[38] Depending on the availability of budget

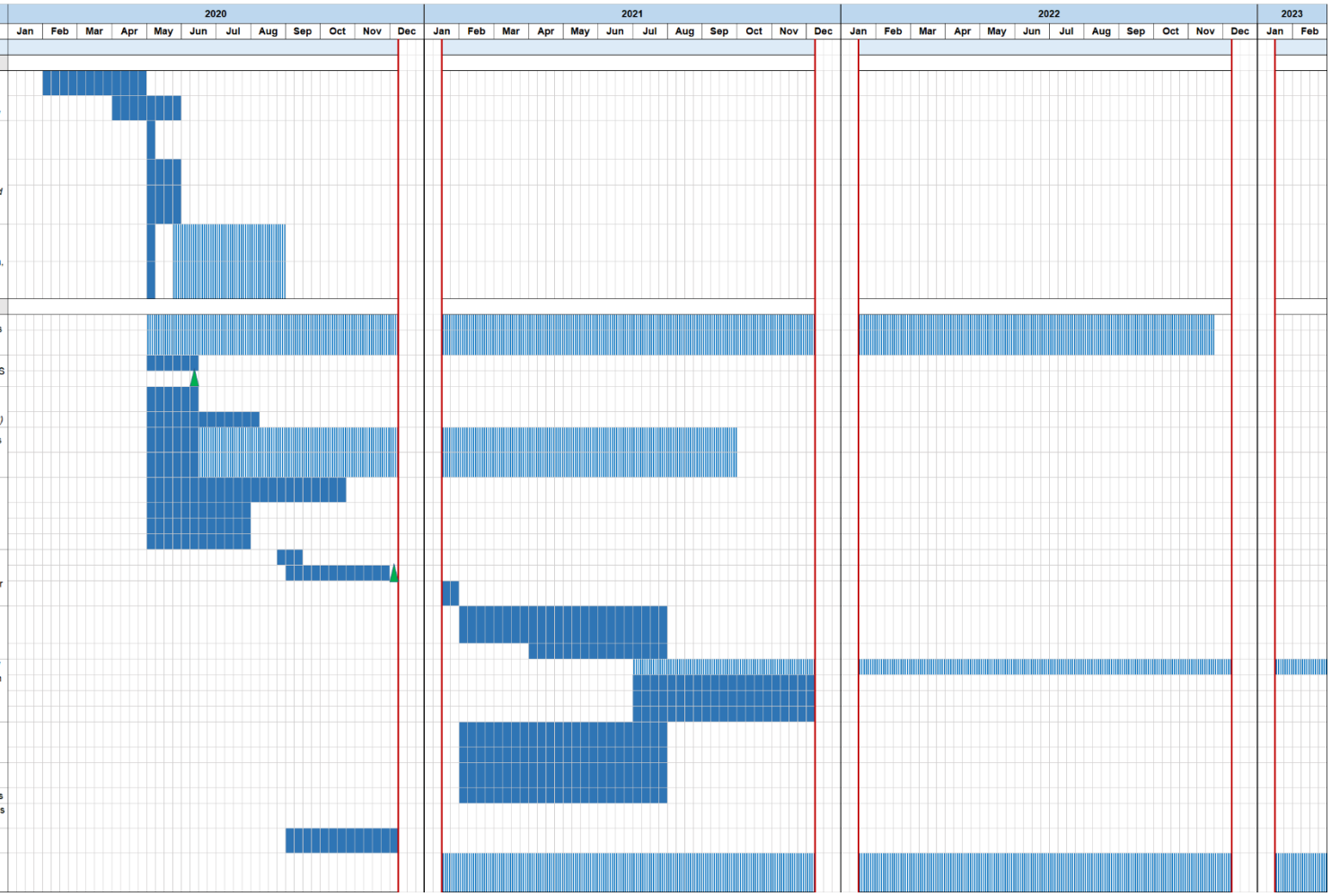
an online and easy to use web portal. A system to submit and handle change requests needs to be established at LVBC, which is when users find that in day to day use of the LVB WIS certain improvements would be helpful. Feedback on the actual use of the system is an invaluable way to improve it and to ensure that it is easy to use, and thus actually used.

Progressive or phased implementation is the preferred approach to ensure sustainability. Core and priority models are implemented first, other models / capabilities can be added at a later stage. Such additional models can of course only be implemented if the required datasets are available and of sufficient quality.

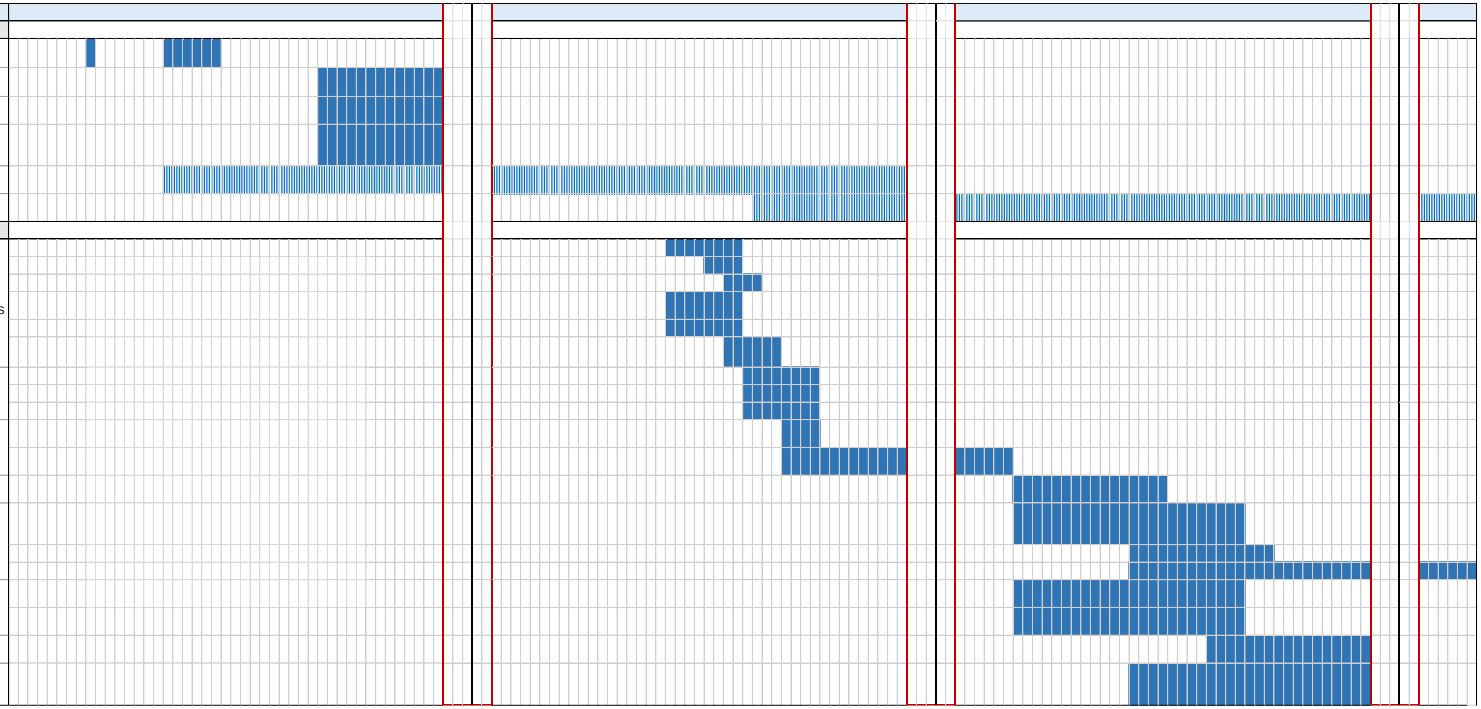
To enhance involvement of the users in decisions on further development of the LVB WIS, it is recommended to set up a LVB WIS User Group, and to organise regular (6-monthly) meetings of representatives to decide on further improvements and developments, especially taking into account the list of change requests. The User Group should recommend prioritization of these change requests and other maintenance activities based on the available (time, human and budget) resources. Any change requests not fulfilled can be carried over to the next round. Minutes of the meeting are to be shared with all members of the user group and should show clear justifications for the decisions. The recommendations are submitted to the LVBC for endorsement and financing.

IPC Activity Planning 2020 - 2023

Task		Activities	Results
3.1 Implementation of an IWRM database and IWRM model			
	Preparatory activities		
T37	Study design and specification of IWRM model and GIS database	Familiarise with "Design and Specification of an IWRM Model with a sound GIS DB"	Staff and Consultants familiar with prior documentation and well versed in requirements of
		Understand the requirements of an improved database and the implementation of an IWRM model	
T38	Visit NILESEC in Entebbe	Investigate options to use available resources, databases and models at NILESEC for the use of LVB-IWRMP. *If this appears possible,*	*If agreed : Special report outlining a modified approach to the implementation of an IWRM database and IWRM model to be agreed upon between LVBC and KfW (see also T41)*
		1 - Determine options to make improvements available to NILESEC	
		2 - Define a modified approach to the implementation of an IWRM database and IWRM model using Nile-DSS, if so decided	
T39	Data exchange proposal in relation to Hydromet	Discuss procedures and make proposals for data exchange between the Riparian Countries of the LVB, NILESEC and LVBC	Explore and make preparations for an arrangement to share data, resulting in data being shared
		Discuss in consultation with LVBC the new hydromet design system for the Nile Basin and the proposed data transmission mechanisms	
	IWRM database		
T40	Establish database, enable PCU	Establish the IWRM database	Ongoing activity - includes O&M phase!
		Enable PCU to take over responsibility for data management	
T41	Review database implementation approach	Carry out consultation visits to the LVB Partner States	Needs assessment, data availability & quality, DBMS & models in use - part of
		Organize joint consultation meeting	
		Critically review the implementation approach outlined in the IWRM database specification report	Revised database implementation approach *(depends on outcome T38)*
		Modify the proposed approach if necessary	
T42	Data transfer procedures	Define data transfer procedures from partner states to LVBC	Agreements and protocols in place; frequent data exchange established
		Facilitate data exchange agreements between the partner states	
		Evaluate the use of (freely available) global datasets including GIS and RS	Final IWRM database implementation plan
T43	Database implementation Plan	Describe the required implementation steps and milestones	
		Define responsibilities for implementation	
		Elaborate a timeline	
T44	Procurement of IWRM soft- and hardware & tender docs	Prepare the tender documents	All hard- and software is supplied and installed (including requirements for modelling)
		Assist the PCU during procurement	
		Assist the PCU with the supervision of hard- and software implementation	
T45	Supervision of software development and implementation	DBMS configuration by DBMS experts, jointly with LVB Partner State IWRM officers - implementation and on-the-job training	DBMS configured, tested and operational
		Test the developed software	
T46	Support PCU in defining tasks, responsibilities for data management	Support database operation and maintenance	A professional network of IWRM technical officers in the LVBC Partner States will be established and facilitated from the PCU /
		Within PCU specifically or LVBC in general	
		Within LVBC	
		In relation with specialized institutions	
T47	Capacity development, training	Develop pre-&post-processing tools, conduct training in the use of those	Carried out as part of the LVB WIS DBMS configuration / on-the-job training
		Define and implement IWRM reporting standards	
		Define responsibilities for quality-assurance/-controll, result reporting, incl protocols	protocols for QA/QC and reporting
		Develop user-friendly manuals and training material	manuals, training materials
		Support data collection and data analysis (see also Task 42)	data collection and analysis improved
		- conduct training	staff in Partner Countries trained
		- if required / allowed: LVBC to carry out data sampling/collection	*additional data sampling/collection implemented*



3.1 Implementation of an IWRM database and IWRM model			
	LVBC Knowledge Hub		
T47a	Establish Literature Database	Investigate feasibility of using (LVBC part of the) EAC Document Repository as Literature Database	*If feasible: agreement on joint upgrading*
		If not feasible: design literature database	*if not feasible: LVBC literature DBMS*
		Set up exchange protocols with Partner States	Exchange protocol established
T47b	Establish Project info repository	Set up Repository for non-literature project datasets and maps, incl. assignment of Information Manager at LVBC	Project Information Repository Data Manager assigned
		Lobby for LVBC obligation for projects to submit all datasets and information in a structured manner upon completion	Improved data and information availability
		Lobby for EAC obligation for projects to submit all datasets and information in a structured manner upon completion	Improved data and information availability
	IWRM model		
T48	Special report on scope and detail of the model	Determine the scope and resolution of the IWRM model	Final LVB WIS implementation plan including updated LVB WIS implementation approach
		Prepare corresponding special report	
		Present results to the LVBC, RPSC and KfW	
T49	Review implementation approach	Review the implementation approach of the IWRM model specification report.	
		Identify necessary updates to the implementation approach	
T50	Implementation approach	Update the implementation approach acccording to the project progress	
T51	Model implementation Plan	Describe the required implementation steps and milestones	Final IWRM model implementation plan
		Define responsibilities for implementation	
		Elaborate a timeline	
T52	Procurement of soft and hardware	Investigate procurement options for existing systems within LVBC	Procurement completed
		Assist PCU in all steps with the procurement of the IWRM hard- and software	
		Assist PCU in all steps with the supervision of hard- and software installation	Hard- and software supplied and installed
T53	Supervise software development & implementation	Model configuration by modelling experts, jointly with LVB Partner State IWRM officers - implementation and on-the-job training	Full LVB WIS configured, tested and operational
		Test the developed model configurations	
		Support LVB WIS model operation and maintenance	
T54	Capacity development	Training in the proper use, management and configuration (updating) of the model(s)	Carried out as part of the LVB WIS DBMS configuration / on-the-job training
		Update and implementation of IWRM reporting standards by using modelling results.	
		Develop mechanisms to use modelling results for the development of a regional IWRM priority investment plan.	Step by step procedure described and agreed
T54a	O&M LVB WIS	Establish professional network of IWRM technical officers and faciliated by PCU/LVBC. This network will also form the LVB WIS User Group. See also T46	WIS User Group established



Annex 2. Terms of Reference: Development of the LVB IWRM Database and Model

This Annex presents the part of the Terms of Reference that relates to the LVB WIS, or as it is referred to there the LVB IWRM Database and Model.

2.2 Development of a strategy to strengthen LVBC as regional institution for IWRM

(48) The management of water resources in LVB requires a common strategy of the Partner States, which oblige the states to take dedicated actions. Partner states have their own policies and strategies and also LVBC has its own strategy.

T. 33: The IPC has to familiarise with existing IWRM strategic documents in the LVB.

T. 34: The IPC shall asses existing IWRM strategic documents with respect to their implementation level. Results of the assessment shall be presented in an assessment report.

T. 35: The IPC shall draft a regional IWRM strategy in conformity with national and other related regional and international strategies. The process of updating / developing the IWRM strategy shall be coordinated with LVBC. For that purpose the rationale and purpose of the IWRM strategy shall be discussed and agreed upon with LVBC in consultation with the Partner States.

T. 36: The IPC shall support LVBC in obtaining approval of a regional IWRM strategy through LVBC Governing structures.

2.3 Implementation of an IWRM data base and IWRM model

2.3.1 Preparatory works

(49) So far LVBC maintains a regional Water Resources Information System (WRIS) but doesn't use this information to run quantity or quality models. The general purpose of building or specifying an integrated water quantity and quality model and underlying database is to support both policy measures and local investment decisions for the long term sustainable development of the LVB and to inform the development of the regional priority investment plan. The outputs of the model and database can be described as increased awareness, better informed problem analysis, better informed analysis of measures and increased support for investment decisions.

(50) The modelling goals of the IWRM model and database can be defined as follows:

a. Tool for prioritisation of investments and other measures: The primary modelling goal of the IWRM model is to support investment decisions for water quality improvement in the Lake and tributary rivers.

b. Tool for policy development: Simulating the effects of policy measures and interventions in relation to the future autonomous development of the water quantity and quality.

(51) The WRIS system is the currently operational database system at LVBC that contains the water quality data, hydromet data and maps. This regional knowledge base at the LVBC is still in its infancy. The WRIS database currently does not contain the required data for modeling, but only covers a limited amount of recent data. Furthermore, the database contains many errors. This makes the database even unusable for presenting or analysing data. Furthermore the database does not contain some of the functionalities to make it 'useable', such as exporting water quality data in a simple table: the data structure does not allow for this basic functionality.

(52) In order to develop a successful IWRM database and IWRM model, a wide range of conditions must be met as there are many fail factors that individually may lead to failure of the database or model. A study consultant therefore has prepared a specification report for the IWRM database and the IWRM model in 2016, which include, technical aspects, organisational aspects and capacity development aspects that take into account lessons learned from previous models and database efforts. The specification report is available in annex 3. Further background information for the IWRM database and IWRM model development are provided in a background report in annex 4.

T. 37: It is the task of the consultant to familiarise with the "Design and Specification of an IWRM Model with a sound GIS Database" (annexes 3 and 4), which sets out the requirements of an improved database and the implementation of an IWRM model.

(53) The "Nile Basin Initiative under the Water Resources Management Department' operates a databases with relevant water information in the LVB. It has also developed a wide NBI Decision Support System (LVB – DSS) which supports countries within the NBI to make policy and investment decisions in the Nile Basin. This system can also be customised for the LVB region as most of the data collected covers the LVB. EAC/ LVBC and NILE Basin/ NELSAP entered into a cooperation agreement in July 2006. This agreement is under review between the two Institutions to enhance cooperation.

T. 38: After familiarisation with the "Design and Specification of an IWRM Model with a sound GIS Database" Report (annexes 3 and 4) the IPC shall visit NILESEC in Entebbe, Uganda jointly with LVBC in order to investigate options to use available resources, databases and models at NILESEC for the use of LVB-IWRMP. When

meaningful, the resources of LVB-IWRMP may be used for the improvements of available products or useful add-ons with the intention to make any improvement also available to NILESEC. In such case the IPC shall prepare a special report outlining a modified approach to the implementation of an IWRM database and IWRM model to be agreed upon between LVBC and KfW.

T. 39: During the talks with NILESEC the IPC in consultations with LVBC shall also discuss procedures and make proposals for data exchange between the Riparian Countries of the LVB, NILESEC and LVBC. In addition, the IPC shall also discuss in consultation with LVBC the new hydromet design system for the Nile Basin and the proposed data transmission mechanisms. Duplication of efforts in data transfer from Riparian Countries of the LVB to central data bases shall be avoided.

2.3.2 IWRM database

(54) Annexes 3 and 4 provide some background information about the database and guide the services for the implementation of the IWRM database.

(55) As mentioned above, a wide range of conditions must be met for the implementation of the database or the model as there are many fail factors that individually may lead to failure of the database or model as a whole. Initial services of the IPC therefore have a focus on the establishment of the IWRM database, since the database in turn is a precondition for the development of an appropriate IWRM model.

(56) The database shall include all basic data of the water system, the water quantity, water quality, meteorological data, the georeferenced physical and administrative elements of the LVB such as sub-catchments, hydraulic infrastructure, diversions and confluences, lateral catchments, and points of demand such as settlements, farms and irrigation districts, industries, or wetlands. It shall also contain all other types of information needed for the development of the IWRM model. The database must contain data tables as well as it will contain geographical information. In addition, a literature database is needed to be setup. The database should be easy to use/operate and maintain – nevertheless, it should facilitate several tasks of users like data exporting, mapping and quality control or tasks that also need capacity development and which cannot be executed at this stage.

(57) Information to be stored in the database include:

a. Point data on water quality and water use
   - ✓ Water quality data
   - ✓ Contamination data
   - ✓ Discharge data, water use data

b. Hydro-meteorological and discharge data
   - ✓ Time series data needed for hydrological modeling
   - ✓ Sediment loads and sediment transport

c. GIS Data (to be stored in a separate Spatial Data Infrastructure (SDI) system)
   - ✓ Model input maps
   - ✓ Scenario management maps

d. Literature database (to be stored in a separate literature database)
   - ✓ Literature is to be collected in a separate database

(58) The background report (annex 4) suggests the implementation of the IWRM database in 4 phases:

a. Phase 1: Data analysis and database development (approximately 10 months)

b. Phase 2: Further data collection, needs assessment and 1st trainings (4 months)

c. Phase 3: Final database design (approximately 4 months)

d. Phase 4: Maintenance and training phase (approximately 5 years)

(59) This timing is indicative. In order to serve as the regional knowledge hub for IWRM it is foreseen that the PCU will take over main responsibility for maintenance and the training phase.

(60) The IPC for the establishment of the IWRM database has the following tasks:

T. 40: Main task of the IPC is to establish the database and enable PCU to take over responsibility for data management.

T. 41: The IWRM database specification report outlines an implementation approach for the IWRM database. It is the task of the consultant to critically review this implementation approach and modify it if he deems necessary.

T. 42: Information flow will require specific, defined procedures and rules. It is the task of the consultant to define data transfer procedures from partner states to LVBC, so that LVBC can serve as a data hub for the LVB. The scope of data need to be agreed upon between the partner states.

T. 43: The IPC shall develop an IWRM data base implementation plan. The plan shall describe the required implementation steps, miles stones that need to be achieved before other steps are implemented, responsibilities for implementation, and time lines.

T. 44: The IPC shall facilitate the procurement of suitable IWRM soft- and hardware, including the preparation of tendering documents. Funds for the procurement of hard- and software are included in the disposition fund of € 1,000,000. This includes the IWRM database and the IWRM model. The IPC shall assist PCU in all steps with the procurement of the IWRM hard- and software including the supervision of hard- and software implementation.

T. 45: The IPC shall supervise software development and implementation according to the IWRM data base implementation plan.

T. 46: The IPC shall support the PCU in defining tasks and responsibilities for data management within PCU specifically or LVBC in general.

T. 47: The IPC shall implement suitable capacity development measures for the PCU/LVBC team jointly with the software developer according to the data base implementation plan; Such capacity development shall include

a. Training in the proper use of the database (querying, mapping)

b. Training in the management of the database

c. Development and training in the use of pre- and post-processing tools

d. Definition and implementation of IWRM reporting standards

e. Support to data collection and data analysis

f. Definition of responsibilities for quality assurance / quality control and reporting of results

g. Development of user-friendly manuals and training material.

2.3.3 IWRM model

(61) Similarly to the IWRM database, the design of the IWRM model is outlined in the specification report in annexes 3 and 4. These documents shall guide the services for the implementation of the IWRM model.

(62) For the IWRM model to operate it is important that the IWRM database is functional and meet the requirements of the IWRM model.

T. 48: A final decision of the scope and resolution of the IWRM model shall be taken approximately 18 months after start of services. It is the task of the IPC to prepare such decision through a special report to be presented to the LVBC, RPSC and KfW.

(63) The specification report for the IWRM model proposes off the shelf tools or models to be given preference. Software development of a new model is considered inefficient. The model should be building on existing national and regional tools and models, for which capacity has been built at national level over the years. This would leave either Nile Basin Decision Support System (Nile DSS) or Soil Water Assessment Tool (SWAT) as possible model codes. A final decision should be prepared with care in coordination with the relevant stakeholders in the Partner States. Further information about the selection of possible standard software is contained in annex 4.

(64) The background report (annex 4) suggests the implementation of the IWRM model in 4 phases:

a. Phase 1: Model development and model set up (approximately 7 months)
b. Phase 2: On-location training of calibration and needs assessment (approximately 4 months)
c. Phase 3: Final model delivery (approximately 8 months)
d. Phase 4: Maintenance phase (approximately 4 years)

(65) In order to serve as the regional knowledge hub for IWRM it is foreseen that the PCU will take over main responsibility for the maintenance phase. Important task of the IPC is to enable PCU to take over its obligations.

(66) The IPC has the following tasks for the establishment of the IWRM model:

T. 49: Review the implementation approach of the IWRM model specification report.

T. 50: Prepare an updated implementation approach for the IWRM model latest 18 months after start of services, considering the progress on the implementation of the IWRM database.

T. 51: Development of IWRM model implementation plan. The plan shall describe the required implementation steps, miles stones that need to be achieved before other steps are implemented, responsibilities for implementation, and time lines.

T. 52: Procurement of suitable IWRM model soft- and hardware, favouring existing systems within LVB. Preparation of tendering documents. The IPC shall assist PCU in all steps with the procurement of the IWRM hard- and software including the

supervision of hard- and software implementation. Soft- Hardware shall be procured through the disposition fund.

T. 53: The IPC shall supervise software development and implementation according to the IWRM model implementation plan.

T. 54: The IPC shall implement suitable capacity development measures for the PCU team jointly with the software developer according to the data base implementation plan; Such capacity development shall include; capacity development of PCU; definition of tasks and responsibilities within PCU.

Such capacity development shall include, but no be restricted to:

a. Training in the proper use, management and update of the model.

b. Update and implementation of IWRM reporting standards by using modelling results.

c. Develop mechanisms to use modelling results for the development of a regional IWRM priority investment plan.

Annex 3. Open source datasets

Satellite based elevation data form the foundation of the IWRM model. Having accurate and catchment wide elevation data without any gaps is the basis for any subsequent modelling task. SRTM 1 Arc-second raster data (approximately 30m raster cell size) have been obtained. This represents the highest resolution elevation data identified. Previous work received through LVBC is based on 3 Arc-second raster data (approximately 90m raster cell size) which is still deemed accurate enough, considering the catchment size of LVB. It is therefore concluded that adequate elevation data has been obtained.

Other satellite based data includes a wide range of satellite based panchromatic (as low as 15m cell resolution) and multispectral images (as low as 30m cell resolution) e.g. from the Landsat family, mainly available through the United States Geological Survey Earth Explorer tool. A wide range of sensors (e.g. AVHRR, GLCC, GLS, ASTER, MODIS, Sentinel-2) and associated spectral ranges (wavelengths recorded) provide information on moisture content, waterways, land cover (changes), vegetation and temperature. Although all data is available for the entire LVB and some data is dated, this group of data presents a credible source of information. The specific suitability of particular datasets requires a clearer definition of the model's respective scope, which will be developed jointly with the stakeholders.

Hydrological catchments and river data were identified in a 15 Arc-second resolution. Although helpful for initial investigations, the catchments are based on coarser elevation datasets then the ones described above and river locations are based on generic algorithms rather than accurate real world mapping. Therefore, it is concluded that this dataset requires updating and revision. No openly accessible gaging stations or hydrograph data has been identified so far. Satellite altimetry data are available for large waterbodies, like Lake Victoria.

A number of weather and climate (change) data sources have been identified. Data such as minimum and maximum temperature, precipitation, wind, relative humidity and solar radiation can be downloaded in bulk (e.g. from SWAT+, NOAA). Current weather data is also provided by several sources. The current challenge is seen in establishing an automated link between these sources and the model, in order to input the data-sets in the required data formats and temporal resolution (i.e. current weather). The national partners may be able to provide access to the respective national weather services for improved climate and weather data.

Soil, geological and hydrogeological data have been identified at small map scale (low resolution) only. As these types of data usually refer to the situation below the land surface, their remote collection suitability by, e.g. satellite, is lower, making them harder to come by. Nevertheless, soil and underlying geological strata impact the movement water and pollutants and are an important factor in erosion vulnerability. The extend of required datasets requires further discussions on the exact scope of the DB and model. The available global soil maps for Africa (FAO) can and are used for watershed-based investigations and modelling; for detailed studies for smaller catchments locally obtained more detailed maps may be needed.

Agricultural and crop data have been identified at small map scale, relatively low detail only. At this time their currency could not be validated. As agricultural activities/data will have a significant impact on the model, collecting more accurate data is crucial.

Environmental data sources identified so far are spotty and do not cover the entire LVB. It is hoped that consultations with the national partners can reveal further data sources.

Water Quality and pollutant data; So far no openly available sources for water quality data have been identified.

Population and socio-economic data identified are limited. Many sources only provide data on country-wide scale but not on a hydrological catchment scale needed for the LVB. It is hoped that the national partners can contribute information on administrative district level to match data closer to what is required for the LVB.

Base map data can be obtained from sources such as Google Earth, Open Street Map, Natural Earth or purchased affordably from NextGIS. These datasets may not necessarily be required for the IWRM DB and modelling itself. However, this data can facilitate visualisation as well as be used as basis for deriving other relevant data such as settlement concentrations, land cover or river locations, just to name some examples.

Data groups have been defined based on the classification of table A2-2 in (JV SWECO-Alterra-Ecorys, 2016a, p43, Appendix 2). The following categories are recognized, of which category 6 and 7 are not yet represented in the identified online data:

1. Hydro-meteorological datasets
2. Socio-economic datasets
3. Wet infrastructure datasets
4. Lake, reservoir related datasets
5. Topography, Soil land use/land cover datasets
6. Development and policies plan datasets
7. Water quality and pollution source datasets

1. Hydro-meteorological datasets

Name	Global Weather Data for SWAT
URL	https://globalweather.tamu.edu/
Data	Min – Max Temperature; Precipitation; Wind; Relative Humidity and Solar
Meta-data	from 1979 - 2014

Name	SWAT+ Global weather data
URL	https://swat.tamu.edu/media/99082/cfsr_world.zip
Data	Weather station data
Meta-data	Data from 1960 – 2006.

Name	Global Historical Climatology Network (GHCN)
URL	https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn
Data	Climate summaries from land surface stations across the world
Meta-data	Possibly limited data for LVB?

Name	Climate Data online
URL	https://www.ncdc.noaa.gov/cdo-web/
Data	Climate and weather data
Meta-data	

Name	World Climate
URL	http://www.worldclimate.com/
Data	Climate and weather data
Meta-data	

Name	Weatherspark
URL	https://weatherspark.com/
Data	Current weather data
Meta-data	

Name	Climate Change Scenarios
URL	http://gisclimatechange.ucar.edu/
Data	GIS climate change scenario data.
Meta-data	

Name	IRI/LDEO Climate Data Library
URL	http://iridl.ldeo.columbia.edu/
Data	Climate data, including agricultural data
Meta-data	

Name	Global climate monitor
URL	https://www.globalclimatemonitor.org/
Data	Global climate data such as temperature, rainfall an evapotranspiration
Meta-data	

Name	Chelsa Climate data
URL	http://chelsa-climate.org/downloads/
Data	Global climatologies at resolution for land surface temperature and precipitation
Meta-data	Geotiff, 30 arc sec (~1 km) resolution.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	AVHRR 1K Global
Meta-data	Temperature data from 1992, 1993 and 1995

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	ASTER 1T; ASTER GED 100AG; ASTER AG1KM
Meta-data	Satellite based Thermal Emission and Reflection data. E.g. land surface temperatures, snow cover, water vapour

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	MODIS…
Meta-data	Collection of land cover, land surface reflection, surface temperatures, thermal anomalies, evapotranspiration, etc. -data.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	NOAA CDR NDVI
Meta-data	NOAA Climate Data Records provide historical climate information using data from weather satellites. This dataset contains daily Normalized Difference Vegetation Index derived from surface reflectance data acquired by the Advanced Very High Resolution Radiometer (AVHRR) sensor. Data from 1981 to 2013.

2. Socio-economic datasets

Name	World Bank
URL	https://data.worldbank.org/country
Data	
Meta-data	

Name	CIA Factbook
URL	https://www.cia.gov/library/publications/resources/the-world-factbook/
Data	
Meta-data	

Name	NASA SEDAC
URL	https://sedac.ciesin.columbia.edu/data/collection/gpw-v4
Data	Raster file or world population rom 2017
Meta-data	

Name	Famine Early Warning Systems (FEWS-NET)
URL	https://fews.net/
Data	Food supply, Agriculture
Meta-data	

Name	GeoHive
URL	https://geohive.ie/catalogue.html#gallery
Data	Population and county statistics
Meta-data	Spot datasets, not covering entire LVB?

Name	FAO Agro Maps
URL	http://kids.fao.org/agromaps/
Data	Crop and land use data
Meta-data	Land use data which contains statistics on primary food crops, aggregated by sub-national administrative districts, on crop production, area harvested and crop yields. Most data records stop in 2012.

Name	Biosphere Atlas
URL	https://archive.vn/20131104102048/http://www.sage.wisc.edu/atlas/maps.php
Data	Human impact-, land use-, ecosystems and water resources data.
Meta-data	Not accessible during testing?

Name	Crop Calendar Dataset
URL	https://web.archive.org/web/20090901080647/http://www.sage.wisc.edu/download/sacks/crop_calendar.html
Data	Crop data
Meta-data	Some download links broken?

Name	Crop Explorer
URL	https://ipad.fas.usda.gov/cropexplorer/imageview.aspx?regionid=eafrica
Data	Crop data
Meta-data	

3. Wet infrastructure datasets

Name	Global 200
URL	https://www.worldwildlife.org/publications/global-200
Data	Global patterns of biodiversity to identify a set of the Earth's terrestrial, freshwater, and marine ecoregions that harbor exceptional biodiversity and are representative of its ecosystems
Meta-data	

Name	Global Lakes and Wetlands Database
URL	https://www.worldwildlife.org/pages/global-lakes-and-wetlands-data-base
Data	Global Lakes and Wetlands Database.
Meta-data	

Name	UN WCMC
URL	http://datadownload.unep-wcmc.org/datasets
Data	various environmental datasets, potentially not covering entire LVB.
Meta-data	

Name	OCC environmental data
URL	Repository for environmental public data sets of scientific interest
Data	various environmental datasets, potentially not covering entire LVB.
Meta-data	

4. Lake, reservoir related datasets

Name	Hydrosheds
URL	https://www.hydrosheds.org/
Data	Catchments and river data derived of SRTM Flow accumulation and flow direction data
Meta-data	15 Arc sec resolution

Name	Global Reservoir and Lakes Monitor (G-REALM)
URL	https://ipad.fas.usda.gov/cropexplorer/global_reservoir/ https://ipad.fas.usda.gov/cropexplorer/global_reservoir/gr_regional_chart.aspx?regionid=eafrica&reservoir_name=Victoria_1
Data	Reservoir/lake level data
Meta-data	

5. Topography, soil, land use/land cover datasets

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	SRTM 1 Arc elevation data
Meta-data	Global DEM, 1 Arc resolution, approximately 30m raster size. Data from 2000 shuttle mission.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	GMTED 2010
Meta-data	Global DEM, with 30-, 15-, and 7.5-arc-second spatial resolutions, replaces GTOPO30.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	GTOPO 30; GTOPO30 1K
Meta-data	Global DEM with a horizontal grid spacing of 30 arc seconds (approximately 1 kilometer). Outdated.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Orbview 3
Meta-data	Panchromatic images from 2007

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Declass 2 (2002)
Meta-data	KH-7 and KH-9 satellite photography, data from 1980

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Eo-1 Hyperion
Meta-data	see EO-1 ALI, Hyperion is unique spectral channels ranging from 0.357 to 2.576 micrometres

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	ISERV
Meta-data	Satellite images, covering only a small percentage of LVB, data from 2013 and 2014

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	GLCC
Meta-data	Global Land Cover Characterization (GLCC) is a series of global land cover classification datasets that are based primarily on the unsupervised classification of 1-km AVHRR (Advanced Very High Resolution Radiometer) 10-day NDVI (Normalized Difference Vegetation Index) composites

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Landsat collection 1 Level 2 (on demand, meaning has to be ordered, not readily downloadable)
Meta-data	Landsat 2 - 8. Surface Reflectance Level-2 Data Products at a 30-meter spatial resolution can be ordered for Landsat 8 OLI/TIRS Collection 1 scenes. Data from 2013-present. Surface Reflectance Higher-Level Data Products at a 30-meter spatial resolution can be ordered for Landsat 7 Enhanced Thematic Mapper Collection 1 scenes. Data from 1999 – present. Surface Reflectance Higher-Level Data Products at a 30-meter spatial resolution can be ordered for Landsat 4-5 Thematic Mapper Collection 1 scenes. Data from 1982 – 2012.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Landsat collection 1 Level 1
Meta-data	Landsat 4 - 8. Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) 15 (panchromatic) - to 30 (multispectral)- meter multispectral data from Landsat 8. Enhanced Thematic Mapper Plus (ETM+) 15- to 30-meter multispectral data from Landsat 7. Data from 1999 to present. Thematic Mapper (TM) Level-1 30-meter multispectral data from Landsats 4 and 5. Data from 1982 to 2012. Multispectral Scanner (MSS) Level-1, collected at 80-meter multispectral data from Landsats 1 - 5. Data was processed to 60-meter pixel size. Data from 1972-1992.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Global Land Survey
Meta-data	Global Land Surveys (GLS) datasets. This collection contains images acquired from 1972 to 2012. Resolution 15m from latest Landsat 7 images.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	ETM+ Pan Mosaics 1993 - 2003
Meta-data	Tri-Decadal Global Landsat orthorectified mosaic data collections are derived from a global set of relatively cloud-free orthorectified ETM+ Pan-Sharpened imagery from Landsat 7. Data from 1993 - 2003.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	TM Mosaics
Meta-data	Tri-Decadal Global Landsat Orthorectified mosaic data collections are derived from a global set of relatively cloud-free orthorectified TM imagery from Landsat 4 and 5. Data from 1984 – 1997.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	MSS 1-5
Meta-data	Tri-Decadal Global Landsat Orthorectified single scene data collection consisting of a global set of relatively cloud-free orthorectified MSS Landsat 1-5. Data from 1972 – 1987.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	SYS ETM+ L1G
Meta-data	Tri-Decadal Global Landsat orthorectified single scene data collection consisting of a global set of relatively cloud-free orthorectified Systematic Correction (Level 1G) Landsat 7. Data from 2000 – 2003.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Sir -C
Meta-data	Shuttle Imaging Radar-C (SIR-C) from 1994 mission. Several types of data. Resolution is approximately 100 meters. Not covering entire LVB.

Name	Earth Explorer
URL	https://earthexplorer.usgs.gov/
Data	Sentinel 2
Meta-data	The ESA Sentinel-2 satellite provides global 10-meter resolution, multispectral images every 10 days (2015-present).

Name	Global Map
URL	https://www.gsi.go.jp/kankyochiri/gm_global_e.html
Data	Global Map Global Version is raster data which cover the globe in a single dataset and have three layers: Elevation; Land Cover; and Vegetation
Meta-data	

Name	UNEP Data Explorer
URL	http://geodata.grid.unep.ch/
Data	Includes global forest cover, global potential evapotranspiration, global average monthly temperatures, dams, watershed boundaries, and much more. Use the advanced search to select geospatial data sets
Meta-data	

Name	Open Aerial Map
URL	https://map.openaerialmap.org/#/34.32128906249999,-0.34057416628374637,7?_k=yd2w8e
Data	Satellite images, not covering entire LVB.
Meta-data	

Name	Harmonised World Soil Database
URL	https://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-data-base/HTML/index.html?sb=1
Data	World soil data
Meta-data	Low resolution?

Name	FAO Soil Portal
URL	http://www.fao.org/soils-portal/soil-survey/soil-maps-and-data-bases/harmonized-world-soil-database-v12/en/
Data	Terrain soil and land cover data.
Meta-data	

Name	Geological data
URL	https://www.orrbodies.com/maps/
Data	Geological data at cost.
Meta-data	

Name	NextGIS
URL	https://data.nextgis.com/en/?lvl=countries
Data	GIS base layers like rivers, some land use, roads, railways, Pol
Meta-data	

Name	Open Street Maps
URL	https://www.openstreetmap.or
Data	Open street map layer data (use e.g. in QGIS with QuickmapServices)
Meta-data	

Name	Natural Earth
URL	https://www.naturalearthdata.com/downloads/
Data	Public domain map dataset available at 1:10m, 1:50m, and 1:110 million scales
Meta-data	

6. Development and policies plan datasets

To be identified.

7. Water quality and pollution source datasets

To be identified.

Annex 4. Technical Specifications Preparation Phase

The following technical specifications are listed on page 7 of (JV SWECO-Alterra-Ecorys, 2016a): Design and specification of an IWRM Model with a sound GIS database to support future investment decisions – Specification Document. 30 November 2016.

2.3 Functional Requirements

2.3.1 Key Database Management System (DBMS) Software Requirements

1) Software or web client availing the full set of functionalities in the DBMS, working with postgres. This standard functionality includes back-up, user rights management, ODBC windows implementation, mutation logging and roll back capabilities.
2) User management, that will enable user rights to be specified per country or water management authority and that may enable specific authorities to share specific data with other authorities or specific persons for a limited time (temporary accounts), as well as to work out procedures for user management (who decides who can have access to which data, can edit data, delete records, etc.).
3) Data definition and the compatibility with local databases. The data should be stored such that it can always be linked back to the data owners' own system, e.g. in order to make a comparison between these databases. Additional fields may be needed to achieve that.
4) Data definition needs adequate data coupling. For example, data from discharge permits should be linked to discharge quality monitoring data at that same location. As such links are currently not made in between the different 'databases' in the countries, these links may need to be established.
5) Data definition comprises the linkage of all data / owner and country as to enable user rights for viewing to be defined for each data type.
6) Data entry should either by done manually or by incremental addition. Data from different sources is preferably stored in one table that provides the needed information for IRWM purposes. Local database systems should take care of data irrelevant for IWRM, such as names of contact persons of pollutant sources etc.
7) Quality control should be given by the system in terms of feedback after the data is imported. Also, manual procedures for QC should be added to achieve adequate QA/QC. If found, erroneous, added invalidated data can be deleted by the user that entered the data.
8) Data retrieval (exporting of data); by querying and downloading data from the database system, both from predefined queries or from user specified queries.
9) Simple post processing or data screening methods for mapping data and making graphs of data, e.g. by plotting time series of selected data, to make scatter plots of selected data or by making maps of data queries. Frequently required simple pre- and post-processing needs should be available in an on-line environment.
10) Reporting: predefined queries should be established that enable users to easily generate reports, e.g. yearly monitoring reports on data collection and benchmarking of the performance. These queries will be developed during the training.
11) Historical data input, data collection. Due to data scarcity and lack of harmonised data, historical data, especially from LVEMP I should become available in the system.
12) Possibility to interact with currently available systems as well as with the IWRM model (Nile DSS) as far as systems are known[39].

[39] Currently both Tanzania and Uganda are preparing database systems that enable different types of data to be collected into a single database. The system should allow to exchange data from the available platforms. This also means that it should be possible to change the database design to cover future not yet known needs. By using local consultants to maintain the database it may be easier to implement such future changes.

13) Hydromet data should be stored in such a way that the format is compatible with the Nile DSS. Like the other point data, data should be selectable by owner, country, and sub basin. Currently both Tanzania and Uganda are preparing database systems that enable different types of data to be collected into a single database. The system should allow to exchange data from the available platforms. This also means that it should be possible to change the database design to cover future not yet known needs as well. By using local consultants to maintain the database it may be easier to implement such changes.

The above-mentioned functional requirements are minimum requirements. In addition to the basic post processing needs (simple online map queries, exporting data using queries that may be predefined) additional functional requirements are stated below:

1) User interface where a monitoring point type and substance can be selected, a statistic can be selected and a time frame can be selected for plotting on a map with a predefined legend; for example the average concentration of discharge waters in the previous year that is to be tested against 0.5, 1 and 2 times the effluent standard(interactive mapping).
2) Enable simple map queries, such as only present data from Kenya, only present Lake data, or to only present emissions larger than X.
3) A user interface where newly added data can be compared to existing data using time series plots and scatter plots to aid in QC.
4) The necessary post processing that will generate data that can be read into the models.
5) Interactive hydromet data representations: rainfall – water level, rainfall – discharge, precipitation-evaporation time series graphs etc.

For IWRM, LVBC will only need coordinates, abstraction rates and time information from abstraction permits. However, it is preferred that the database should also handle basic additional information such as owner, the permit itself or permit reference, permit ending date, a memo field, etc.

2.3.2 Key GIS Database (SDI) Requirements

Except for normal data the database system will also need to contain spatial data (maps) that are needed for IWRM models.

For GIS data management many systems are available which are referred to as SDI (Spatial Data Infrastructure). SDI is defined as providing a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general (The SDI Cookbook http://www.gsdi.org). A SDI brings together different types of spatial data that together are needed for IWRM.

The SDI should contain the general basic functionalities existing SDI's have, such as downloading of data and on-line mapping of data. The following requirements are given in addition:

1) Support many data formats, such as shapefiles, file geodatabases, tables/spreadsheets, CAD, and raster. A file geodatabase should be able to provide structural, performance, and data management advantages over other formats.
2) On-line capabilities for presenting data of several map layers and exporting map views with sufficient resolution for presentation in reports.
   a. Preferably: Storing, sharing, and exporting map views that consist of these layers.
   b. Preferably: Changing legend level divides and storing of map views with predefined levels.
   c. Preferably: Capability for direct connections to the database, thereby enabling to on-line map new and existing queries on the dataset.
   d. Preferably: Pop-up graphics showing charts of current data for regional stations, with options for expanding in a separate window; flexibility for multiple parame-ters, selection of time periods,

and time intervals. Ability to download the selected data (time series) from single or selected points.

3) Capable of handling meta data (normal functionality of SDI), with additional capabilities:
   a. Searchable / selectable by data type (DEM, land use, soil, other), by region, country or basin wide maps as well as by data owner. Also it should be possible to make a complete selection of the data used in the IWRM model (map sets).
   b. Version management should be available when maps are updated, in overviews it should also be possible to select the latest versions only.
   c. > 30 records / maps should be visible in one view on the web page in table format in order to better keep a clear overview of the data in the SDI. The overview should preferably not work with different pages to present the maps available in the system.
4) For some types of data on-line data exchange systems may already exist, e.g. from meteor-ological stations or from loggers in rivers. An overview of operational systems should be made that need to be integrated to enable these to work with the DBMS.
5) Capability for direct connections to prepared queries on the DBMS that is developed in this project as to map data from the database on the maps.
6) Coordinates of spatial data should be harmonized.
7) Data collected should fit the expected spatial resolution that is needed for IWRM purposes and for the IWRM model.

An optional requirement may be to have automatic synchronisation of data at the main server with local hard disk drives in order to have faster and more reliable access to data.

The detailed design of the database are additionally described in Annex 1 (of JV SWECO-Alterra-Ecorys, 2016a). This description focuses on the water quality and the emission database. For hydromet and GIS-data ‘standard’ designs are generally available.

Data requirements are presented in Annex 1 (of JV SWECO-Alterra-Ecorys, 2016a). Detailed base maps not directly used in the model should preferably be taken from servers (e.g. open street map) and do not need to be implemented in the database.

Annex 5. Data Requirements Preparation phase

The following technical specifications are listed in Appendix 2 on page 43-44 of (JV SWECO-Alterra-Ecorys, 2016a): Design and specification of an IWRM Model with a sound GIS database to support future investment decisions – Specification Document. 30 November 2016.

Table A2-1 Example of relation of data needs for IWRM to IWRM tasks

IWRM tasks / Data Needs for Water Management Issues	Flood Management	Rain Fed Agriculture	Irrigated Agriculture	Drought Management	Soil Erosion / Sediment Transport	Surface Water Quality	Groundwater Management	Hydropower	Navigation	Fisheries	Watershed Management	Wetlands Management	Climate Change
River Stage/Discharge	●		●	●	●	●	●	●	●	●	●	●	●
Lake/Reservoir Level	●		●	●		●	●	●	●	●	●	●	●
Precipitation	●	●	●	●	●	●	●	●	●		●	●	●
Temp, RH, Evap.	●	●	●	●							●	●	●
Groundwater			●	●			●					●	●
Sediment Sampling			●		●			●			●	●	
Surface Water Quality			●			●				●	●	●	
Land Use/Cover					●						●	●	●
Water use /abstraction						●							
Effluent quality						●							
Fertilizer use						●							
Satellite data	●	●	●	●	●	●	●	●	●	●	●	●	●
Lake / reservoir characteristics	●		●	●									
Soil characteristics	●	●	●	●	●	●							
Etc.													

Data Requirements for the IWRM Model

Various categories of data will be needed to have an operational IWRM model, these are, hydro-meteorological, socio-economic (including agricultural areas, crops), infrastructure (includes water abstraction facilities, types), development plans and policies, Lake related data, topography, soil and land cover/land use as well as pollution source and water quality data. Table 1 gives preliminary data but more data may be necessary based on the software (model) selected.

Table A2-2 Data required for WRM

No	Category	Data
1	Hydro-meteorological	▪ Daily gauge rainfall data (including, location) ▪ Daily observed temperature, windspeed & direction, radiation, sunshine hours, humidity data (including, location) ▪ Satellite rainfall data (daily time step)
2	Socio-economic	▪ Population data at the county/district level ▪ Agricultural statistics showing area cultivated, crops and if possible, yields ▪ Prices of agricultural produce ▪ Irrigated area and crops grown
3	Wet infrastructure	▪ Irrigation diversions and return -if applicable- (type (e.g. ▪ weir, pipe) and location) ▪ Municipal/rural water supply offtake (type (e.g. weir, pipe) and location) ▪ Effluent discharge (type (e.g. weir, pipe) and location) ▪ Wetland locations and typology ▪ (Hydropower) dam/ lake locations and typology
4	Lake, reservoir related data	▪ Lake/reservoir level, area, volume relationship table and curve ▪ Observed daily river water level and rating table or discharge ▪ Observed daily lake level ▪ Satellite observed water quality parameters ▪ Satellite observed water level data
5	Topography, soil, land use/land cover data	▪ Digital soil maps showing physical (texture, water holding capacity, soil depth) as well as chemical properties ▪ Digital land use/land cover maps ▪ Digital Elevation Model (at resolutions of 30 and 90ms)
6	development plans and policies	▪ National development plans ▪ Province/District/country development plans ▪ Socio-economic sector growth estimations
7	Water quality and pollution source data	▪ Water quality data: BOD, N, P, etc. (including associated discharge, location) ▪ Water abstraction and discharge permit data (showing permit dates, amounts and abstraction location) ▪ Water effluent data: discharge ▪ WATSAN and other point source data

Data Collection and Processing

Since for water quality measurements, preferably daily discharge data is needed for all rivers at all monitoring points. As most availably water quality data is from after the year 2000 and after this year discharge data is very incomplete, a technical solution must be found to be able to calculate river water concentrations on a daily basis. Furthermore, interpolation techniques may need to be defined in the model in order to estimate discharges at ungauged water quality monitoring stations.

It is suggested to obtain reference historic data from the COWI study (1950-2000) and from discharge data and hydraulic modelling efforts for the period 2000-2016. It is suggested Q-h relations will be stored in a database as well, and training will also deal with this aspect, by addressing it with real (historic) data. In

the future it is suggested that river water quality data should always be completed by a water level measurement, and Q-h relations of monitoring points should be present at all tributary rivers and of important waypoints in longer river systems such as Kagera river basin.

Quality Control: The consultant will need to carry out quality control of data preferably through a training workshop which will achieve both the capacity building goal and at the same time ensure a quality controlled dataset which will be made available.

Gap Filling: Gaps filling will not be required during database setup. During model setup, gap filling will be addressed if needed to get time series suitable for modelling. There is a gap filling tool in the Nile DSS using linear interpolation but this is only suitable for gaps of a few days and preferably during dry season. Rainfall-runoff models (if sufficiently calibrated and validated) can be used to fill gaps longer than a month.

Amount and Availability of Data: Data collection, quality assurance and gap filling for categories 1 to 5 is critical to a successful modelling activity. In order for a water quality model to be successful there should be enough data to set-up the model at the required spatial and temporal resolution. If data is scarce, more than 90% of a modelling effort consists of collecting data and overcoming data scarcity problems. For a water quality model, there should be enough data of the ‘target variable’ (water quality) in both space and time to both calibrate and validate the model. Currently such data is not available. It therefore is of paramount importance for the consultant to collect all historic data on both water quality and discharges, especially from the last 15 years, as otherwise it will be difficult to have meaningful calibration and validation data available.