Grant agreement no. 243964

QWeCI

Quantifying Weather and Climate Impacts on Health in Developing Countries

M5.1.a: First versions of all SDSS, IS, and MT based on the knowledge attainment regarding the requirements of stakeholders and decision makers

Start date of project: 1st February 2010

Duration: 42 months

Lead contractor: UoC
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Evolution of milestone

Due date :	M30
Date of first draft :	M30
Start of review :	20 July 2012
Milestone accepted :	27 July 2012

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)	
Dissemination Level	
PU Public	PU
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

Introduction

Work Package (WP) 5.1 of the QWeCI project aims to develop integrated information and decision support systems based on the scientific output of various other WPs. The main challenge is to transfer complex scientific climate-disease results to the stakeholders in the target countries. In order to put science into action the QWeCI project develops a multi agency system. This system will consist of decision support tools such as *Information Systems* (ISs), *Monitoring Tools* (MTs), or *Spatial Decision Support Systems* (SDSSs). These systems are developed following a stakeholder dialogue, which is undertaken by the project partners of the pilot countries. The stakeholder dialogue identified amongst others the requirements and skills of the end-users. This will ensure a user-friendly development of the various systems.

Due to the delay of the stakeholder dialogue (D5.1.a) the development of the first systems versions was also delayed. So far, the UoC set up a web-based Java framework in which various systems will be implemented. In a first step, a pilot system of the multi agency system was developed by the UoC, which supported the stakeholder dialogue since this system can be considered as a prototype system. The African partners furthermore identified the required information and data that shall be included into the systems. UNIMA already successfully constructed the MT of near-real time disease incidence in health clinics of Malawi. This system is a stand-alone system and needs not to be included into the web-based Java framework of the UoC. IPD designed a SDSS in terms of a statistical Rift Valley fever model, which relates meteorological variables to the density of Aedes mosquitoes in different environments.

The web-based Java framework

For the development of the multi agency system a web-based Java framework was set up by the UoC and a pilot system was constructed. The web-based Java framework includes:

- A virtual Linux machine (qweci.uni-koeln.de).
- The usage of Apache Tomcat (version 6.0.26), which is an open source servlet container providing a 'pure Java' web server for Java code to run.
- The application of Java, which is an open source, class-based and object-oriented programming language.
- The utilisation of the *Google Web Toolkit* (GWT, version 2.4.0). GWT is open source and represents a development toolkit for building and optimizing complex browser-based applications. The GWT *Software Development Kit* (SDK) provides a set of core Java *Application Programming Interfaces* (APIs) and widgets, which will be used for the set up of various systems of the multi agency system of WP5.1.

In addition to the set up of the framework, the UoC trained staff in terms of the application of Java. Dr. Volker Ermert as well as Roderick van der Linden attended a Java programming course of the Institute of Informatics of the UoC.

Web- portal as based on the Java framework of the UoC regarding QWeCI available at http://qweci.uni-koeln.de.

The version 1.0 of the web-based Liverpool Malaria Model (the pilot system)

Start page of the pilot system including the configuration of the following LMM simulation.

In order to represent parts of the application spectrum of the web-based Java framework a pilot system is developed. At present the version 1.0 of the pilot system was constructed.

The system makes use of the so-called *Liverpool Malaria Model* (LMM), which is a weather-driven malaria model that is driven by daily temperature and rainfall data (see Hoshen and Morse 2004). The system is primarily intended for the construction of specific sets of parameter settings for the QWeCI pilot regions (e.g. for rural and urban areas of Kumasi). Users can, for example, use this system to hindcast malaria epidemics for specific locations or they could try to forecast malaria outbreaks via the seamless weather forecasts/projections of the QWeCI project. Due to the lack of calculating capacity of the QWeCI server, the model runs will be performed only for specific locations.
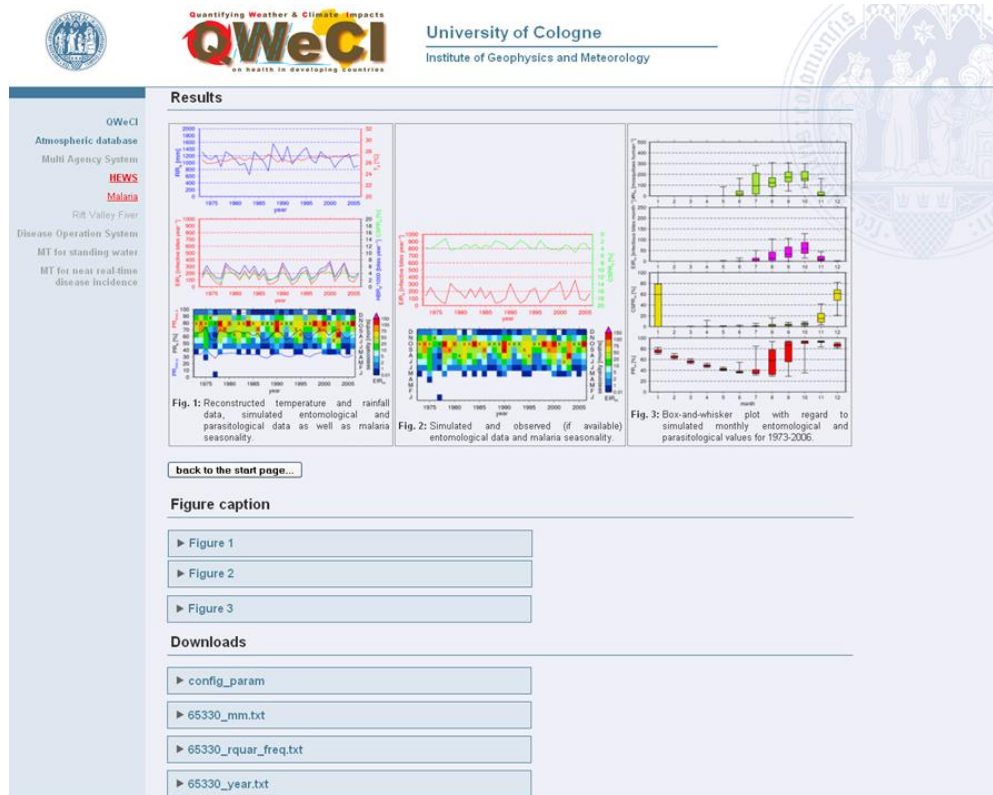
Final page of the web-version of the LMM that includes the output data as well as pre-defined figures of the LMM simulation.

In the version 1.0 of the pilot system, the user is able to run the *LMM version of 2004* (LMM_{2004}; Hoshen and Morse 2004), *that of 2010* (LMM_{2010}; Ermert et al. 2011a,b), as well as by a self-defined set of parameter setting. Model runs can be performed for 34 synoptic weather stations in West Africa (including three stations in Cameroon) covering the period 1973 to 2006. The model output can be analyzed by means of three pre-defined figures, which are visualizing eleven entomological and parasitological malaria variables. Furthermore, the user is able to download the output files of the LMM including the monthly and yearly output as well as quartile statistics in terms of the simulated and observed (if available) annual values between 1973 and 2006.

The user can also use his own temperature and rainfall time series for running the LMM. It allows scientists and stakeholders to see if the LMM is able to represent the malaria situation in their area. However, the users need to provide daily temperature and rainfall time series to the LMM. This tool provides more information to scientists and stakeholders in terms of the application spectrum of the web-based Java framework of the multi agency system.

Before the user can start an LMM simulation with his own temperature and precipitation

time series, the user must upload the input data in a specific format. The user needs to construct one single data file, which should be named by the used station (e.g. Accra.txt). This text file in ASCII (American Standard Code for Information Interchange) needs to include time series of daily mean temperatures and daily precipitation amounts. The daily mean temperatures must be provided in °C (degrees Celsius) and the daily precipitation amounts need to be given in mm (millimetres). The temperatures must be higher than - 60°C and the precipitation amounts are not allowed to be negative. Note that only up to 50 years of data can be simulated by the LMM.

No data gaps are permitted for the temperature and precipitation time series and the time series must start at 1st January and end at the 31st December. Only full years are allowed including the data for 365 and 366 days, respectively. Therefore files with incomplete time series and years are rejected.

Available is also a short upload manual for the web version of the LMM. In the near future, the provision of weekly data output is foreseen for the next iteration of the LMM web pilot system.

The web-based VECTRI

At the EGU General Assembly 2012, ICTP and UoC discussed the inclusion of the *VECToR-borne disease model of the International centre for theoretical physics* (VECTRI) into the UoC web-based Java framework. Comparable to the LMM pilot system, also VECTRI shall be made accessible via the web. The users shall be able to produce their own VECTRI malaria runs based on station data. Later it might also be possible to produce gridded malaria runs. However, this will depend on the availability of computer power of the QWeCI server, which is currently strongly limited. In a first step, the VECTRI model was successfully compiled at UoC. A new project was already initiated within Java framework. The next steps will include the set up of VECTRI onto the web-based Java framework. This will be accomplished analogous to the production of the LMM pilot system of the multi agency system.

The Health Early Warning System

The formation of the *Health Early Warning System* (HEWS) strongly depends on the performance of seasonal health forecasting (WP 4.1). This system will be developed for the stakeholders in the target countries. Operational disease forecasts will only be set in place, when both the seamless seasonal atmospheric forecasts and the disease modeling provide skillful results. Note that at present the disease modeling lacks detailed validation data such as long and quality-controlled time series of malaria cases. In case that a robust validation of the disease models is not possible, the disease forecasts will only be provided to the stakeholders and will not be published. These prototype forecasts might be able to raise the awareness of the stakeholders in terms of the provision of validation data and the set up of an adequate monitoring system. Only the involvement of the stakeholders in the target countries as well as an intense interaction between the stakeholders and modelers will enable skillful disease forecasts.

One component of the HEWS will be an IS in which KNUST and IPD describe mechanisms for early planning of vector control programs in Ghana and Malawi, respectively.

The set up of the QWeCI *Health Early Warning System* (HEWS) was discussed during the

European Geosciences Union (EGU) General Assembly 2012. A special meeting was held on 25 April 2012 between the QWeCI partners at ECMWF, ICTP, UNILIV, and UoC.

It was decided to construct a prototype malaria prediction system at the ECMWF for the three QWeCI pilot regions Senegal, Ghana, and Malawi. Used will be the ECMWF *Integrated Forecasting System* (IFS) to provide temperature and precipitation data to the malaria models. If possible, the output of the malaria prediction system will be visualized and presented at the ECMWF. If not, the forecasts will be downloaded from UoC and put onto the UoC web-based Java framework.

The ECMWF forecasts will only be used for the monthly to seasonal lead time scales. This includes two operational components of the ECMWF forecast system: (i) the 32 day *Variational Ensemble Prediction System* (VarEPS) forecast twice each week (the so-called VarEPS-monthly forecast system) and (ii) the ensemble seasonal forecast system (System 4) issued once a month with a lead time of 7 month, which is extended to 13 months four times a year. From this data a seamless forecasting system has been developed at ECMWF for the QWeCI project. The seamless forecast appends the first 25 days from the VarEPS-monthly forecast system with months 2-4 of the ensemble seasonal forecast system.

The seamless forecast is bias-corrected by the ECMWF (see D3.1.e). In terms of precipitation amounts an *Empirical Orthogonal Function* (EOF) based calibration technique is used to correct the precipitation of the VarEPS-monthly forecast system. Regarding the seasonal forecast a simple point-wise correction is applied. With regard to the 2 m temperature data a point-wise bias correction using *ECMWF Re-Analysis* (ERA)-Interim is executed. The output, the atmospheric variables, is finally taken onto a *file transfer protocol* (ftp) repository of the ECMWF, where the data is made available to the malaria models. ECMWF further set up a web site to visualise the output of the prototype malaria prediction system (see
http://nwmstest.ecmwf.int/products/forecasts/d/inspect/catalog/research/qweci/).

Applied will be two weather-driven malaria models: (i) the dynamical mathematical-biological Liverpool Malaria Model (LMM) and (ii) the dynamical *VECToR-borne disease model of the International centre for theoretical physics* (VECTRI). At the end of May 2012, ICTP and ECMWF set up the seamless VECTRI malaria prediction system, which is running under the *Supervisor Monitor Scheduler* (SMS; see
http://www.ecmwf.int/products/data/software/sms.html) at ECMWF. The application of the LMM is postponed since the model code was transferred to the so-called *LMM Library* (LMMLib), which still requires investigations for model bugs. Note that the LMMLib is a library of C functions designed to enable model users to run the LMM. The LMMLib can be called from a C or FORTRAN program, compiled as a shared object library for use by scripts written in the *National Center for Atmospheric Research* (NCAR) *Command Language* (NCL) or used as a plug-in to the *Disease Model Cradle* (DMC) *Graphical User Interface* (GUI).

The Monitoring Tool for Standing Water

This formation of the MT for standing water in Senegal in the Barkedji area is led by CSE and the UoC intends to support the inclusion of the MT into the web-based Java framework. CSE applies remotely sensed water bodies from Senegal that serve as mosquitoes breeding sites.

The construction of the Monitoring Tool (MT) of standing water in the Barkedji area was

discussed with CSE. CSE intended to develop a platform in Java that fits into the web-based Java framework of the UoC. However, there was no need to include the system into the dynamical core of the Java framework (see below).

At the end of May 2012, CSE has defined the outline of the MT:

1) *Input data*

The input data of the MT will include SPOT 5 (SPOT: *"Système Pour l'Observation de la Terre";* 10 m resolution) and SPOT 5 VEGETATION 2 satellite images from 2010. Regarding SPOT 5 images altogether data for five dates is available (06 July; 27 August; 28 September, 03 October, 08 November). In terms of SPOT 5 VEGETATION 2 data can be provided from the first decade in June 2010 to the last decade in October 2010. Note that there is one image available per decade. The images and processed data will be provided in the JPEG format (JPEG: *Joint Photographic Experts Group*) including figures with histograms.

2) *Processing of the images*

Already processed satellite images regarding different dates in 2010 will be uploaded to the QWeCI server. Therefore, there is no need for any software or algorithm to process the input data to compute the pond statistics.

3) *Description of the input and processed data*

CSE already defined the text with regard to the description of the input and processed data. The text will be updated to cover the SPOT 5 VEGETATION 2 image.

4) *Choices for the users*

The user will have two choices: The user can either choose the cartography of water bodies from SPOT 5 or from SPOT 5 VEGETATION 2. The user will be able to monitor water surfaces for a window by 15 km x 15 km centred over the Barkedji region. Moreover, the user can monitor the sentinel pont, which was monitored in the framework of the QWeCI project.

UoC concludes that the MT would become an Information System (IS) since only historical data from 2010 will be presented. There is no new updated data that can be processed by a MT. From the technical point of view, it will be easy to produce this information system. There is no need for the usage of the dynamical core of UoC web-based Java framework. No Java is required for these static web pages. It is therefore easy for UoC to produce the system. Provided need the text passages, the JPEG-images, and the outlay of the web pages that CSE likes to present to the users.

CSE submitted deliverable D5.2.d without the production of a monitoring tool or another system such as an information system. Therefore, the core of the deliverable is missing since no tool was provided to the end users like stakeholders. This issue remained unsolved until M30.


The Disease Operation System

The construction of the Disease Operation System is led by IPD and the UoC will support the inclusion of this system into the web-based Java framework. IPD reviewed the strategies developed for malaria and *Rift Valley Fever* (RVF) and current methods of control developed in Senegal. The large distribution of *Insecticide Treated Nets* (ITNs), the introduction of *Rapid Diagnostic Test* (RDT), the treatment using *Artemisinin-based*

Combination Therapies (ACTs), and *Indoor Residual Spraying* (IRS) have generated a considerable decrease of malaria cases. It was found that in the context of an increased epidemic risk of malaria a functional system of monitoring, early detection and response of malaria cases is required. This information can be part of an information system, which could form one part of the Disease Operation System in Senegal.

Concerning the RVF disease, statistical models tracking the relationship between environmental variables and the proportion of mosquito vectors were developed. The validation process of the different models is underway. This leads like the web-version of the LMM to the production of a SDSS.

The draft of a first system version of the RVF model was undertaken by IPD in November 2011 (M22). The proposed design includes an analysis of the data flow as well as a design of the Disease Operation System (see below).
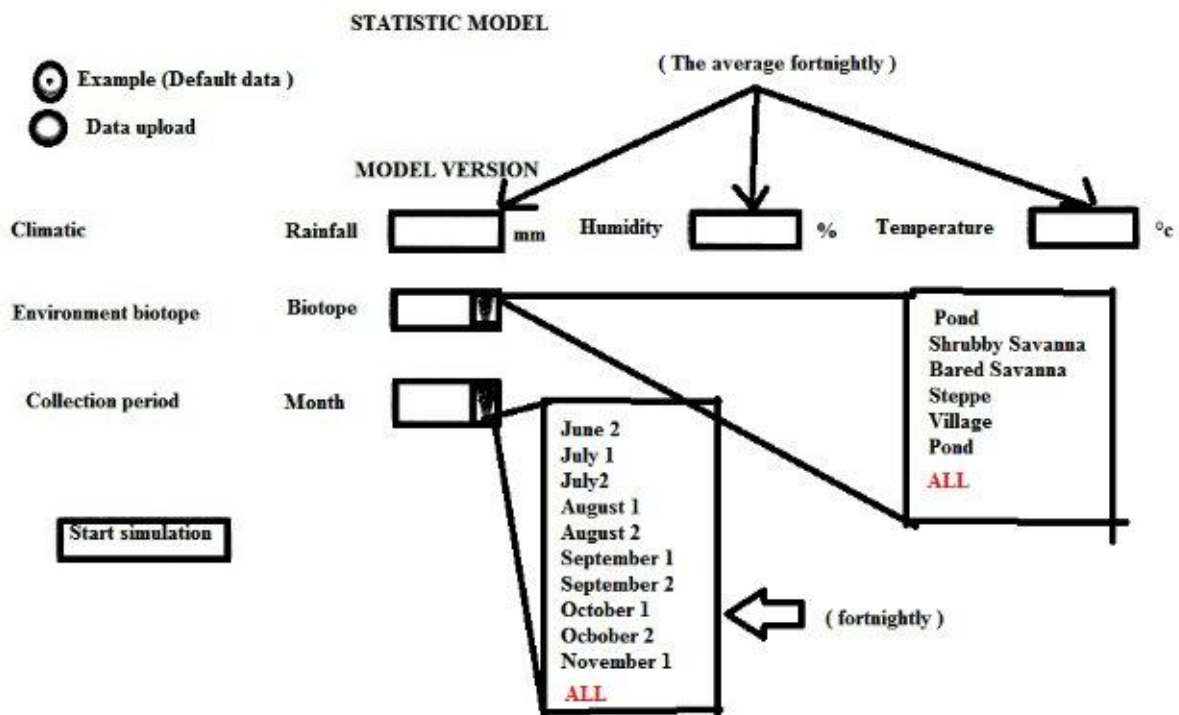
Draft regarding the start page of the RVF model including the configuration of the following RVF model simulation.

The input data of the RVF model are either time series or single values. For time series, the user shall be able to upload his own data via the "Data upload" button. In this case, only the drop down menus "Environment biotope" and "Collection period" will be active. In terms of single values, the user can enter a specific value for the temperature, humidity, and precipitation, which shall represent average fortnightly atmospheric conditions.

If the "example (Default data)" button is activated by the user, then no time series can be uploaded and no single values are enabled to be specified. In this case only the "Environment biotope" and "Collection period" drop down menus are activated.

In the following, the RVF model (programmed in the R software) is executed on the QWeCI Linux server and the model results in terms of different time periods and environments are displayed on the screen. Selected could be, for example, fortnightly time series of the density of Aedes within the bared Savanna biotope.

OUTPUT WITH DEFAULT DATA
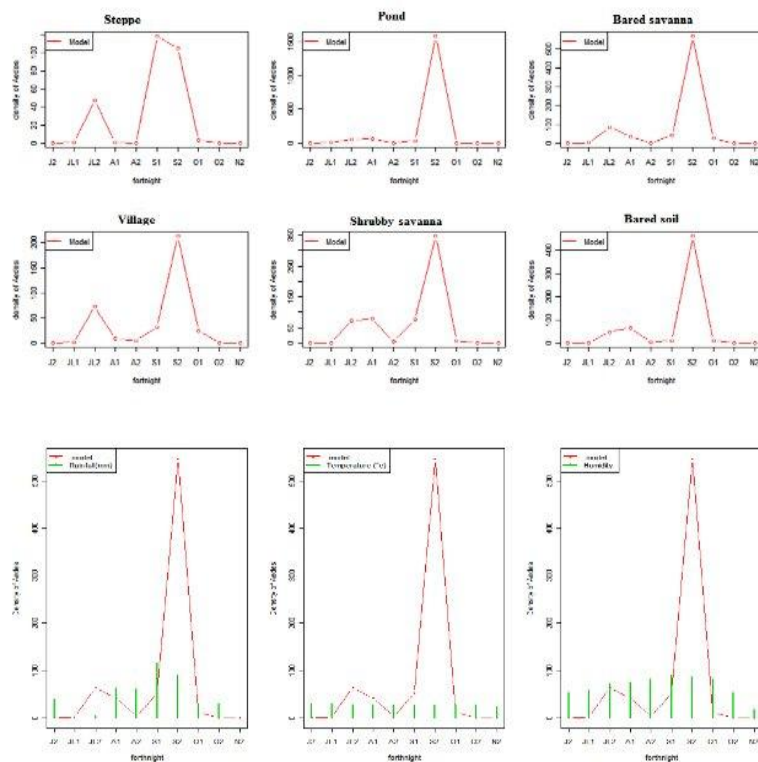
Draft of the output of RVF model simulation in terms of the use of default data and all environmental biotopes.

IPD reported to work on the user manual. The user manual shall be presented bilingually in French and English. The first draft was discussed with the UoC in terms of the feasibility of the inclusion of the system into the web-based Java framework. In the following, the alpha version of the RVF model shall be produced by the UoC and shall be presented by IPD to the end users in Senegal. At present the R software code of the RVF model was not passed by IPD to UoC. Note that UoC requires the model code for the production of the first system version.

The Monitoring Tool of near-real time disease incidence in health clinics

UNIMA successfully constructed the MT of near-real time disease incidence in health clinics of Malawi. This system is a stand-alone system and will not be included into the web-based Java framework of the UoC.

In the preparatory stages of the MT development, a preliminary study of the format, quality, and availability of the malaria incidence rate and meteorological data from individual locations was undertaken. In the following, the UNIMA was setting up the so-called *district Health Information System version 2* (dHIS2) of the University of Oslo (available from http://www.dhis2.org). The dHIS2 is a web-based IS (available under the password protected web page http://www.hispmalawi.org.mw) and was implemented at the UNIMA under the Linux Ubuntu platform. The IS is developed for the Malawi Ministry of Health and is used for the following purposes:

- Definition of data elements such as monthly malaria reports from health clinics

- Collection of disease data from health facilities in Malawi

- Serves as an data archive of disease incidence data in Malawi and provides quality checks of the data

- Visualization of time series of disease incidence data

- Computation of indicators of disease outbreaks and for the provision of early warnings

- Measures the impact of control measures/intervention

- Provides an assessment of the quality of outreach programs of the Ministry of Health (Is there a decline of, e.g. malaria cases, after the training of health facilities?)

- Construction of disease incidence reports that include predefined graphs and analyses

- Includes a Geographic Information System component, which is able to map the disease incidence data

The Information Cycle
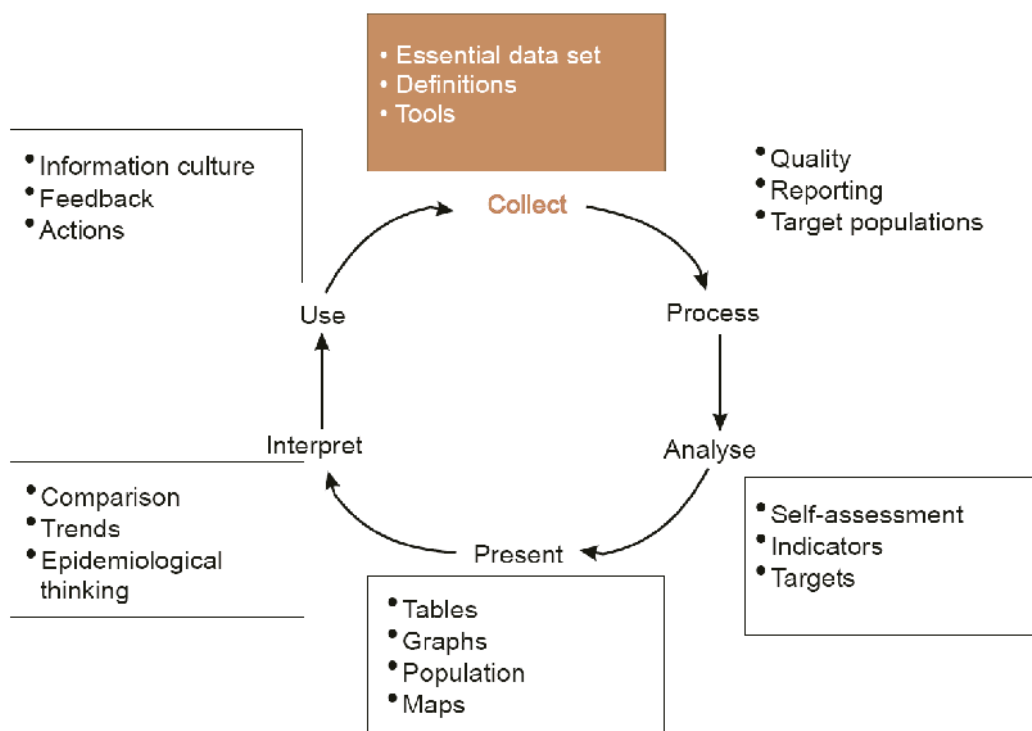
The information cycle of the dHIS2 (source: http:www.dhis2.org).
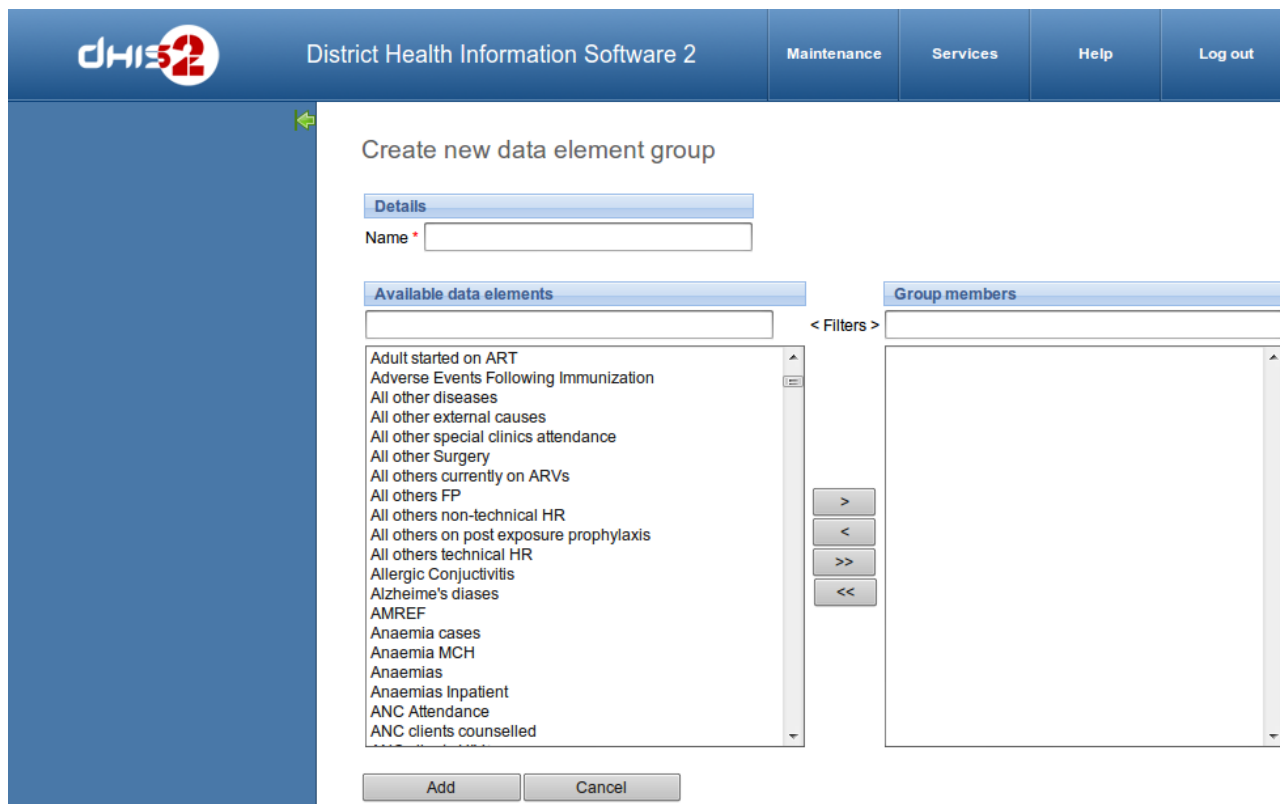
Creation of a new data element group within the dHIS2 (source: http://www.dhis2.org).
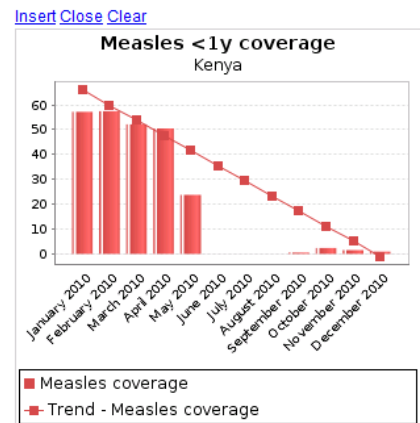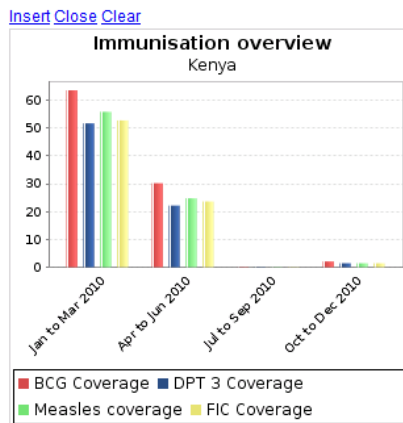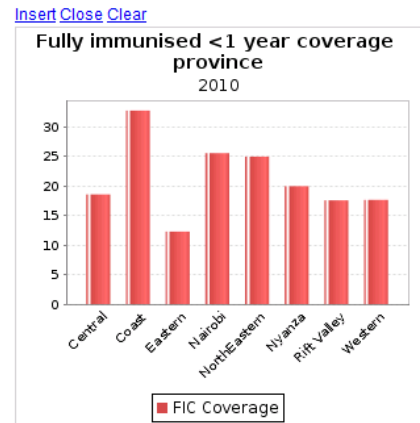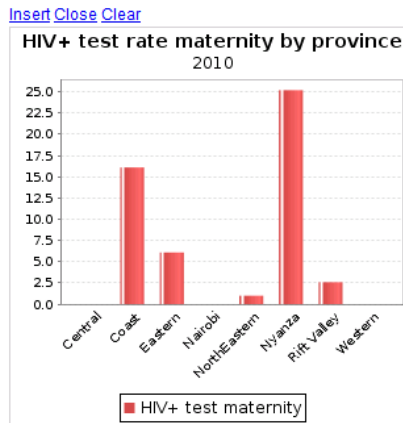
Dashboard of the dHIS2 as providing analyses and pre-defined figures (source: http://www.dhis2.org).

After the successful implementation of the system disease incidence data was digitized and inserted into the incidence database of the dHIS2. Training was provided at the facility and district level. Note, the data is usually collected and digitized at the district level. One key element in terms of the provision of the data is the WiFi link that was installed by ICTP in collaboration with UNIMA. Without the WiFi link a near-real time collection of the data would not be possible.

Various problems were faced, when the disease incidence data was collected:

- Untimely reporting
- No reporting
- Insertion of arbitrary disease values by the health facilities

For this reason, training programs were started and control audits were undertaken up to the facility level.

UNIMA intended to provide a detailed report on the formation of the MT of near-real time disease incidence at health clinics in Malawi until M21 of the project (October 2011). Note that the report was not forwarded to UoC until M30.