Inception report for Regional Agricultural Trade and Productivity Project (RATP), Nile Equatorial Lakes Subsidiary Action Program (NELSAP)

Assessment of Agricultural Models and Data Sets for Nile Basin DSS Extension

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1. Introduction

RAPT is seeking to enhance the Nile Basin Initiative DSS (NBI-DSS) in term of the prediction of food production, demand and trade in the Nile Basin (NB) region. The successfulness of the effort will depend on effective agricultural production, demand and trade models and reliable data sets. To support the NBI-DSS extension, this consultancy work will conduct the following tasks for NELSAP/ RATP:

- *Describe the existing regional agricultural models: how they are structured (major modules), what questions they address and how detailed they are.*
- *Assess the readiness of the data base for each selected model to be applied in the Nile Basin countries.*
- *For each selected model, prepare the major adjustments to be made in (i) methodology; (ii) modeling blocks; and (iii) data base for nine Nile Basin countries.*
- *Describe the current agricultural module in the Nile Basin DSS.*
- *Evaluate the readiness for connecting each model with the current agricultural module under the Nile Basin DSS (for this, the travel to DSS office in Addis Ababa will be needed).*
- *Prepare (i) TOR and (ii) Roadmap to carry out activities for strengthening the DSS agricultural module by RATP during the implementation phase (November 2009 – June 2012).*

These tasks will basically follow up the outcomes of the RAPT-DSS Workshop in Addis Ababa, 2009 and they will also refer to the Nile Basin DSS documentation and other relevant project outcomes. This inception report presents initial assessment of the models and data sets and outlines a work plan for the rest of the consultancy period.

2. Initial Assessment of Models and Data Sets

The RATP-DSS Workshop has identified the following objectives for the NBI-DSS extension:

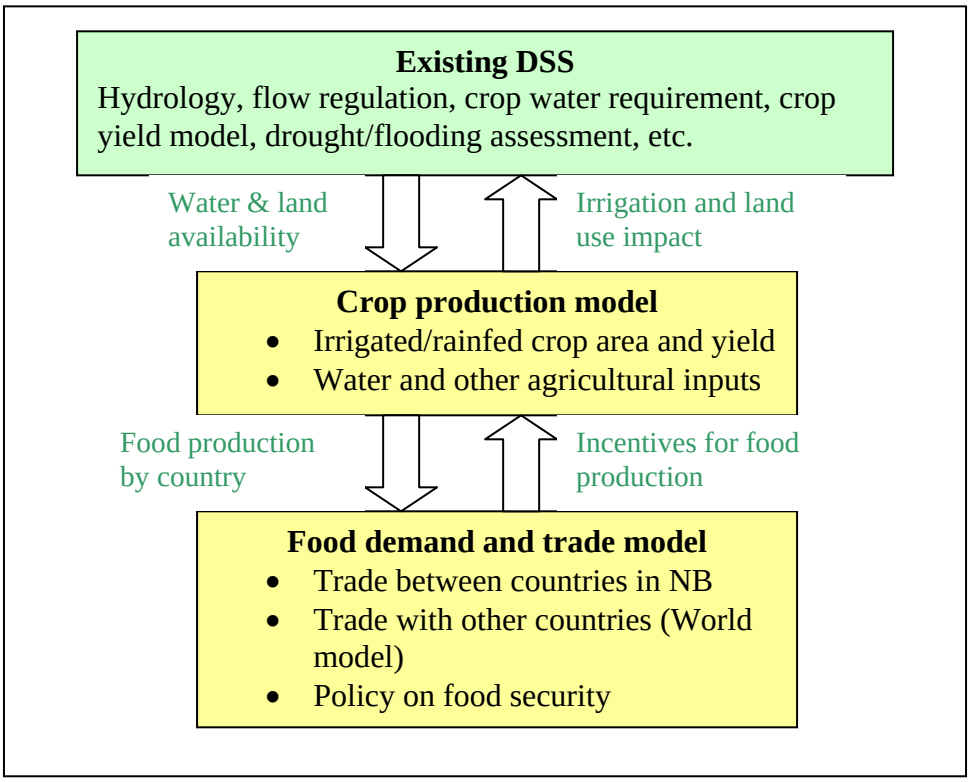
- *Present and Future food demand & supply and their effect on the changes in land and water use*
- *Irrigated and rain-fed agricultural expansion and intensification potential and its impact on the basin water balance*
- *Options to improve productivity levels under irrigated and rain-fed systems*
- *Droughts and floods impact on food production*
- *Impact of other development sectors (urban, industrial, etc.) on agricultural sector*
- *Opportunities and challenges for agriculture products markets*

To address these objectives, model extension and new data support will be necessary, which is described as below.

2.1. Model extension

The extended DSS needs to simulate irrigated and rainfed crops using reliable data sets, including climatic and hydrologic simulations from the existing DSS modules. The DSS may also need to incorporate both water and other agricultural inputs in the crop production simulation. Food demand and trade will be estimated by an economic module to be coupled with the DSS. Finally the extended DSS will be used to test the various options of increasing agricultural productivity and food security in the NB region.

The NBI-DSS extension may be described by the following diagram showing the connection between NBI-DSS and a crop production model and a food demand and trade model. Some existing components in NBI-DSS are directly related to food production such as crop water requirement and crop yield simulation. There are two considerations regarding crop production, one is on more detailed hydrologic-agronomic modeling and the other is on the impact of economic factors on crop area and yield. From a water perspective, crop yield depends on the actual crop evapotranspiration (ET) relative to the potential ET. Simulation of crop ET should involve soil moisture and climatic (such as temperature and wind speed, etc.) However the final crop yield depends on other inputs such as labor, fertilizer and pesticide, besides water; crop area is also a function of economic variables such as food prices and policy variables such as subsidies. Thus exact food production should jointly consider hydrologic, agronomic and economic factors.



The following options might be considered for the crop production simulation, which are listed from easy to difficult solutions regarding model implementation difficulty and data requirements:

- Option 1: Use a baseline of crop area and yield and focus on water impact only; use the estimate of potential and actual crop ET from other programs such EWUAP; estimate crop yield using a similar method as AquaCrop, CropWat and ClimWat
- Option 2: Option 1 but using a more detailed hydrologic-agronomic model (e.g., The Soil Water Atmosphere Plant – SWAP, Van Dam et al., 1997)
- Option 3: Option 2 plus an economic model to determine crop yield and area based on both water and non-water inputs.

Option 1 is basically the current crop module in NBI-DSS with data (crop ET) support from other programs. Option 2 can couple the existing DSS component (as shown in Figure 1) with an existing hydrologic-agronomic model, or develop such a model within the NBI-DSS. Option 3 will need to couple the DSS with an agricultural production model, which may not exist for the Nile Basin but developing such a model is feasible.

A key issue for the crop production modeling is to simulate irrigated and rainfed crops separately. This is necessary because of the request of RAPT to assess the potential of rainfed agriculture, as well as the irrigated agriculture, and the complementary and tradeoff relations between the two. It is also necessary to have more reasonable gross crop production simulation since the inputs, both water and non-water inputs, and land availability are usually different for irrigated and rainfed crops. The existing irrigated and rainfed crop area and yield in different countries or regions within the NB is the required data set. Also the projections of such split items will be important to assess the role of rainfed and irrigated agriculture in future of the Nile Basin. Cai et al. (2007) published a method for splitting the irrigated and rainfed area and yield from gross area and yield using hydrologic-agronomic inputs, which could be a reference for the future work.

For the food demand and trade model, there are a number of world models including partial equilibrium models and economic-wide models. Many partial models have a detailed agricultural component, to name a few, IMPACT (IFPRI), AGLINK (OECD), ESIM (USDA, Stanford Univ.), World Food Model (WFM, FAO), and FAPRI (Iowa State University). Although these are the world models, some of them have a region or country focus, for example, AGLINK has a focus on OECD countries; FAPRI has a focus on the U.S.; ESIM contains 13 countries/regions including EU countries and U.S., adding the rest of the world. Unfortunately it seems that no such a food trade model has a focus on the NB region. Thus no model might be directly used for the NBI-DSS extension. Direct use of a world model such as IMPACT and WFM may not be the best because the simulation of the study region is not detailed enough. For example, the world models do not simulate the country-to-country trade path and then they cannot be used to simulate the trade between the countries within the Nile Basin. Thus the development of a partial model with a focus on the Nile Basin region may be needed.

Another concern is the coupling of the food trade model and a detailed food production model. The unique requirement for the NBI-DSS extension is to connect the existing hydrologic and agricultural components within the DSS to food trade analysis so that the virtual water trade going with food trade between the Nile Basin countries, together with agricultural technology development strategies, can be explored to analyze food security in the region. In this regard, IMPACT (IFPRI) is distinguished from other partial models because it is combined with WATER, a water simulation model (Cai and Rosegrant, 2002). IMPACT-WATER simulates split irrigated crops and rainfed crops. Irrigated crops depend on effective rainfall and irrigation water, and rainfed crops depend on effective rainfall only. However, the spatial resolution and the data set (irrigated and rainfed area and yield) with IMPACT is a concern, when it is applied to a focus region. Also as mentioned above, IMPACT does not simulate food trade paths.

How to link the existing DSS modules to the crop production model and food demand and trade model will be critical for the successfulness of the DSS improvement. As stated above, the crop production model can be embedded within the DSS through a tight link; while the food demand and trade model is more likely to be connected with the DSS by a soft linkage through data exchange, particularly if the selected model is operated by another institute.

2.1. Data support

Several ongoing and recently finished projects focus on data for agriculture development, including EWUAP, ENDIS and FAO Nile. **EWUAP** uses remote sensing and field survey data to assess land use /land cover, water consumption, soil and land suitability, and agricultural production (area and yield). It also assesses the socio-economic factors and projects the impact of climate change on agriculture in the NB region.

ENIDS focuses on the productivity assessment of irrigated agriculture, including water use efficiency, irrigation design and planning and irrigation management in the eastern Nile Basin region.

FAO Nile develops the baseline and projections of water use and productivity in the Nile Basin region and explores basin wide agricultural development options by 2030. The outputs of the project include geo-referenced (GIS) information products integrating physical and socio-economic data for water resources management in the Basin. The products include agricultural water productivity case studies, basin wide survey of agricultural water use, scenarios of demand for agricultural production and transboundary hydro-meteorological monitoring network. FAO Water Report 31, *Demand for products of irrigated agriculture in sub-Saharan Africa,* is a publication related to FAO Nile. It provides irrigated agriculture baseline and 2030 projection in *sub-Saharan Africa*, which includes some Nile Basin countries.

Although it is hard to claim that these projects will provide ready-to-use data for the agricultural extension of NBI-DSS, one should feel confident that these projects will

provide solid data support for the agricultural module to be developed with the DSS. Data processing under proper coordination among the projects may still take a big effort, which however should be much easier than collecting the primary data items if without those data development projects.

It should be noted that many relevant data items are available from international database available to the public. For example, there are at least four datasets for land use and land cover with resolution of 30 arc-seconds, which are derived from remote sensing products IGBP, MODIS, GLC, and UMD, respectively. With the support from U.S. NASA, institutes including the University of Washington and the University of Montana have been developing real-time ET using MODIS and the results should be available to the public soon.

3. Work Plan and Deliverables

The rest of this consultancy project will be completed by conducting the following tasks.

Task 1: Evaluate the existing agriculture module of the NBI-DSS. I plan to visit the RATP Project management unit and DSS office to learn more about the DSS functions. Questions for the DSS may include:

- What is the fundamental unit for hydrologic modeling?
- Does the hydrologic model consider the impact of irrigation?
- What is the resolution of the current crop land coverage?
- What method is used for the crop yield model?
- Does the DSS have a soil moisture simulation module? If yes, what is the temporal and spatial resolution?
- Does the current DSS use drought and flooding forecast and provide real-time information on mitigating the extreme events?
- Are irrigated and rainfed crop yield simulated separately?
- At present, to what extend does the DSS use the data from EWUAP, ENIDS and FAO-NBI? Particularly, for the "required information" listed in the DSS presentation (Addis Ababa Workshop), which items are available from the existing projects and which will need original work?
- Without much model structural extension, what additional data will enhance the existing agricultural module?

Task 2: Continue reviewing the choices of crop production crops and food demand and trade models and provide updated options, with an assessment of the challenges and merits of the various options.

Task 3: Continue reviewing data sources for the model extension and identify the data availability and limitation with the various model choices.

Task 4: Complete the draft report by July 15, 2009, as indicated in the TOR. The report will include the evaluation of the model connection and the roadmap to carry out activities for strengthening the DSS agricultural module. Following the draft report, the final report will be completed by July 30, which will address the comments and suggestions from RAPT and the World Bank on the draft report. To conduct this task, I

will visit the hosts of selected agricultural models and data sets such as IFPRI in Washington, D.C. and FAO in Rome if necessary.

References:

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