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RIVERTWIN

A regional model for integrated water management in twinned river basins

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Deliverable D28: Adapted model for water demand and economic aspects in the Ouémé basin

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Stockholm Environment Institute (SEI)

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The deliverable consists of this report and an enclosed CD-ROM with modeling software including the Ouémé Basin Model.

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Dissemination level		
PU	Public	**X**
PP	Restricted to other programme participants (including Commission Services)	
RE	Restricted to group specified by the consortium (including Commission Services)	
CO	Confidential, only for members of the consortium (including Commission Services)	

This report briefly summarizes the content and main features of an Adapted Model for Water Demand in the Ouémé Basin that has been developed by Stockholm Environment Institute (SEI) as part of the EC-funded Specific Targeted Research Project RIVERTWIN (work package 4.3). This report as well as the model itself are public and may be distributed freely outside the project team.

Questions and comments regarding the content of this report or the water demand model itself should be directed to the SEI project address below.

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WEAP Background

As stated in Annex I to the RIVERTWIN project contract, the water demand model for the Ouémé basin has been developed using SEI's water evaluation and planning system *WEAP*. The WEAP system has been developed by SEI over the last decade and is available for download at www.weap21.org. On the enclosed CD-ROM all the necessary installation files for the water demand model for the Ouémé basin are found. Please refer to the separate installation instruction (at the end of this document) as well as the software information found on the WEAP website for more details on how to run WEAP and how to use the water demand model for the Ouémé basin.

Introduction

The development of a regional model for integrated water management in the Ouémé basin included the creation of a water demand model for the region. This model was developed using the Water Evaluation and Planning system (WEAP), used to simulate water demand and consumption on the Rivertwin Ouémé basin in Benin. WEAP provides a structure in which to consider water supply and demand in a region and allows for the generation of scenarios of future water resources management combined with climate change scenarios.

The model provides outputs of water demand (both surface and groundwater), a breakdown of water use among the various demands, as well as the unsatisfied demand, all at the sub basin level. Results from the model provide insight into the potential magnitude of unmet demand in and among the sub basins and, in particular, in the urban areas, where population is expected to increase significantly. The model results also provide a sense of the relative distribution of unmet demand, though these numbers are subject to uncertainty, as will be described in the following section. It is clear from the model results that regardless of climate or socio-economic scenario combinations, significant effort must be made toward the provision of increased supply in the basin.

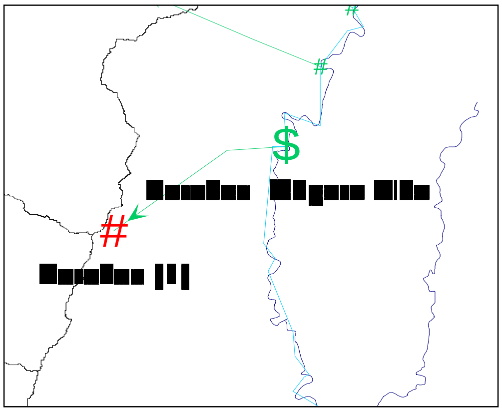
In the RIVERTWIN project context, the WEAP water demand model accepts hydrologic inputs from the HBV model as well as crop water requirement values from the EPIC/SLISYS model. Outputs from the water demand model were used as inputs to the Qual2K and MONERIS models. As in all other models, the “current accounts” or base year is set as 2003 in which existing water demand in various sectors of the basin are defined including domestic, agriculture, livestock, and industry uses.

The following synopsis presents the structure of the model, the scenarios implemented, the results obtained, and also provides a number of recommendations with regard to water management in the near future for the Ouémé basin, as well as recommendations for areas of further study and data requirements for improved management in the region.

Model Structure

Water demand in the WEAP model is disaggregated using the 13 sub-basins of the Ouémé as well as the three major cities in the basin; Djougou, Parakou and Savalou. The major cities are differentiated from the sub-basin demand, as they are served by surface water from three respective reservoirs (Figure 1), while the remaining population of the basin (in rural areas) is served by a combination of surface and groundwater.

Figure 1. Demand in Ouémé Cities



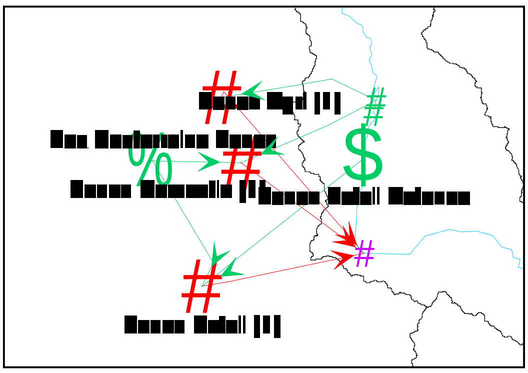
In each sub-basin water demand was disaggregated by agricultural, livestock, and domestic uses (Figure 2). Domestic uses were disaggregated further into rural and urban demand, with different water daily water consumption defined for each use. In those basins where industrial water use was identified, industrial use was also added to the model.

Only surface water is currently used for existing agricultural practices (there is very little existing irrigation in the basin, as will be addressed in the discussion of scenario development). The livestock and domestic demands are supplied from a combination of surface and groundwater. In the case of the livestock demand, a total capacity was determined for each sub-basin (using the capacities of all small livestock reservoirs in each sub-basin). It was assumed that livestock demand was satisfied through a combination of these small reservoirs as well as some groundwater sources.

Input data characteristics

Limited data is available for water demand and supply in the Ouémé basin, therefore the following modeling exercise depended on data collected from different sources as well as a number of assumptions based upon existing data and on consultations with the project team members. Important information was identified and extracted from a number of sources, as outlined in the following sections, organized by water demand.

Figure 2. Water Demand Structure in Ouémé Subbasins



Domestic Demand

Domestic demand was disaggregated into rural and urban demand. Urban population varies from sub-basin to sub-basin and in future scenarios, the percentage of urban population is projected to change. Little data exists on the water demand

(and supply) from SONEB (the public company suppliying water to urban residents) and DGE (Direction General des Eaux), the two groups responsible for the provision of water in urban and rural regions, respectively. It is important to note here, that more detailed and spatially disaggregated data is required in further studying the water supply and demand relationship in the region.

As a result of the lack of data on water supply in the region, the model assumes a water demand as a function of consumption (25 L/capita/day in urban areas and 15 L/capita/day in rural areas). In the rural areas, it was assumed that domestic demand is satisfied by both groundwater and surface water (to varying degrees in the dry months versus the wet months). For the three cities of Parakou, Djougou, and Savalou, served solely by surface water, three surface water reservoirs were added to the model to supply those regions.

Industrial Demand

Information about industrial water use in the basin is limited to the research conducted by the Rivertwin partner FSA (Faculté des Sciences Agronomiques) at several existing plants. Several of the plants in the basin had information on daily water use and all of the plants with sufficient data were included in the model at the sub basin level.

Agricultural Demand

For the purposes of the water supply and demand model, only irrigated agriculture was considered. Currently in the Ouémé basin, and in Benin as a whole, there is very little irrigated agriculture, although plans for future agriculture are beginning to project more irrigations schemes. In the Ouémé basin there are two significant areas of irrigation; one sugar cane area in Save and one area of Rice production in Zangnando.

Livestock Demand

Water demand for livestock was disaggregated by type of livestock into bovines and small ruminant animals (45 L/day and 4 L/day, respectively). It was assumed that during the dry months of January-March, 75% of livestock demand is satisfied by groundwater sources (25% by small pastoral reservoirs). During the more humid months of April-December, livestock demand is satisfied solely by surface water reservoirs.

Future Scenarios

The adjustment of the model to allow for scenario runs in the Ouémé basin was performed in close cooperation with the Rivertwin Ouémé scenario group. The two national scenarios of Alafia and Wahala were generated in the WEAP model in order to assess the potential changes in water demand and availability in the basin between 2005 and 2030.

Modeling the two national scenarios of Alafia and Wahala included several changes in the the water demand parameters. In particular, the Alafia scenario included the following changes related to water demand;

- Increased irrigated agricultural area for sugar cane and the incorporation of large-scale mango irrigation
- Two new irrigation reservoirs created at Asante (2020) and Beterou (2010)
- The use of bas-fonds ameliorés for agricultural purposes throughout the sub-basins
- Change in the distribution of population in general and shifts in urban population
- Increased per capita water use (domestic)
- Increased population of livestock

The Wahala Scenario, the more pessimistic view, included;

- Lower population growth (both domestic and in livestock)

- The status quo for per capita water use remains
- No irrigated agriculture increases
- No construction of new dams

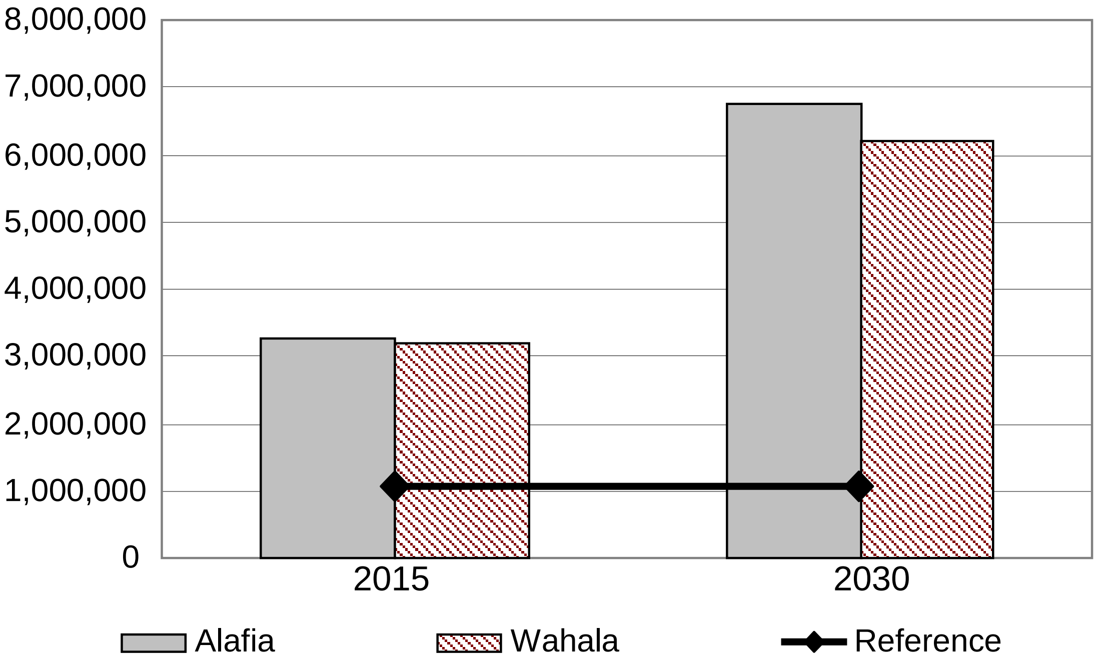
These two scenarios were analyzed with 14 climate-land use scenarios, resulting in 28 water demand calculations, as carried out in each of the Ouémé RIVERTWIN models. Hence, for each socio-economic scenario the ensemble of 14 different water demand calculations provides a spectrum of possible demand situations, reflecting climate conditions strecthing from very dry to very wet during a particular year.

Results

While the water demand model result are subject to uncertainty as a result of the assumptions made (as described above) and several limitations that will be addressed later in this section, overall, there is a significant increase in water demand projected for both the Alafia and Wahala scenarios under all of the climate regimes. In all scenarios the year 2003 is used as reference.

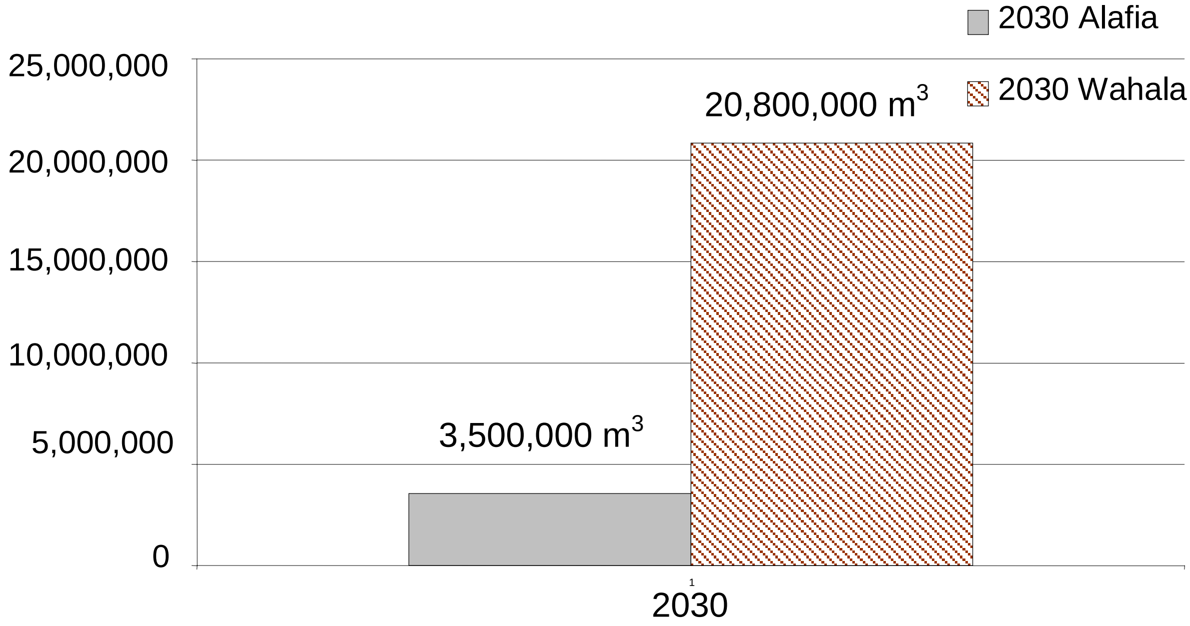
Water demand in the urban regions and particularly in the city of Parakou, was projected to rise by approximately 200% from the reference water demand in the same region in the case of the 2015 land use scenario and by approximately 500% in the 2030 land use scenario. These results suggest that something must be done to augment supply and/or reduce losses in the supply system under climate change and future population growth. The results are illustrated in Figure 3. below.

Figure 3. Water Demand in Parakou (m3)



In addition to the effects of increased urbanization, unmet water demand is expected to increase throughout the basin, in both scenarios, as a result of the projected changes in water consumption and population (of both people and livestock). In the case of the 2030 land use scenario (considering an average over the median climate years of 2026-2030), the unmet water demand throughout the basin is projected to increase significantly. The projected increase to 3.5 million m^3 and 20.8 million m^3 in the Alafia and Wahala scenarios are equivalent to the development and, in turn, water demand of approximately 3 and 19 times the current city (and water demand) of the largest city in the basin, Parakou.

Figure 4. Unmet water demand in the Ouémé Basin under Land Use Scenario 2030



These findings, as well as all others resulting from the water demand model suggest a dire need for proactive water resources management at both the basin and commune scales toward increased supply.

Interventions

After running the two national scenarios, two packages of hydrologic and agricultural interventions respectively were proposed by the partners. Only the hydrological intervention package was assumed to have a direct affect on the water demand model. These interventions were introduced and the model results were re-calculated. The hydrological interventions, included in other project models, are outlined in Table 2.

Table 2. Hydrological Interventions

Hydrological Interventions Package
Increased storage capacity of the Asante and Beterou Irrigation Dams (2 x 23 Million m^3 increased to 2 x 500 Million m^3)
Introduction of a large Hydroelectric Dam at Ketou (2 Billion m^3)
Increased capacity of the small reservoirs serving livestock 60% increase 2003- 2015 and 80% increase 2015-2030

The hydrologic interventions chosen in the course of the modeling exercise <u>did not significantly affect the unmet demand in the Alafia scenario</u>, as they were focused primarily on increasing water storage in reservoirs and initiating hydropower production. In addition, the groundwater was considered readily available for use in the basin, therefore in the absence of surface water, the model assumed that demand would be supplied by ground water sources in each sub-basin. This is a result of the uncertainty in aquifer conditions, as well as the level of disaggregation of groundwater availability (at the sub basin level). The interventions were not introduced into the Wahala scenario.

Recommendations

The results of the water demand modeling exercise provide insight into the state of water demand and the difficulties encountered in representing it in the model. The significant increase in water demand in the urban areas; Djougou, Savalou, and, in particular, Parakou, suggests the need for hydrological measures specifically designed to augment the supply in those regions. Reservoirs or any other form of increasing supply (such as decreasing losses in the supply system) should be a focus of future work in the region in order to avoid increased unmet demand.

In the rural areas, it is more difficult to provide recommendations for augmented water supply, as a result of the sub-basin scale of the model. It is clear, however, because these areas already suffer from a lack of potable water, that measures in the rural areas are also needed to augment supply in the face of combined population growth and the potential for climate change to decrease the available surface water runoff.

Difficulty in specifying interventions in the rural area is a consequence of the model being disaggregated to the sub-basin level and no further, due to the lack of spatial data on water demand and supply at the commune level. The inclusion of spatially disaggregated supply and demand information would allow for a more thorough understanding of unmet water demand and, hence, would provide a more detailed understanding of the potential interventions for the basin.

The level of hydrological detail (as a result of the gage data available for validation of the HBV model) also limits the level of spatial disaggregation of the model. Lower level stream networks might allow for a better understanding of the demand structure at the commune level, to be more certain of the hydrological conditions at that scale. More detailed streamflow data would be required for such a thorough understanding of the hydrology at this smaller scale and, therefore, future work might focus on efforts to expand the prevalence of stream gages and other forms of hydrologic monitoring.

All of these limitations speak to the importance of pursuing water demand models in this region at a more local (perhaps, commune) level. The commune scale would allow for the development of scenarios that are directly applicable in particular areas. It was, for instance, difficult in the course of this study to pursue scenarios with local reservoirs being built for domestic water supply, in order to assess how those might reduce unmet demand. It is important to note here that the additional hydrologic interventions including those such as rainwater harvesting, should also be considered in future discussions of water provision in the region. As the supply side of the system was not adequately modeled, the opportunities for improvement in supply (such as reduced losses) could not be studied, but should be considered in future management considerations to supply the unmet demand under future scenarios.

Data availability on water demand significantly limited the level of detail studied in the development of the Ouémé basin model. As Benin is in the course of decentralizing their water management systems and will begin to rely heavily on management at the sub-basin level, the provision of support for data collection and housing is also recommended as a focus of future work. Such support should include identification of the most relevant and useful data to be gathered and help in finding and structuring financial support for such endeavors, where necessary. At the local level, information on water use tendencies, water uses specific to the given region (such as auquaculture), costs for the provision of local infrastructure, etc., are extremely important in the development of water demand models, therefore the collection and effective sharing of such information should be promoted at the commune level.

Installation instructions

The enclosed CD-ROM holds all the necessary files for the RIVERTWIN water demand model for the Ouémé basin (as of Nov. 2006). Once installed, the model is fully functional except that the "Save Data" feature is disabled. It will allow you to explore the features of WEAP and the RIVERTWIN water demand model for the Ouémé basin. To activate the "Save Data" feature, you must obtain a license from SEI through the WEAP website: www.weap21.org.

WEAP requires a PC with Windows 95 or later and at least 32MB of RAM[1].

To install the model, simply insert the CD in a computer and then follow the instructions below. It is useful if the computer is connected to the internet, but not necessary for the installation as such.

1. Run the *setup.exe* program by double-clicking on it in the list of files on the CD.
2. When the installation software ask whether you want to register as a user or not, click “no”. In case you want to become a fully licensed user, it is possible to register and obtain a license later. It is not, however, needed for the demonstration purposes of this project deliverable.
3. Run the software by choosing “WEAP” from the program list (pressing the “start” button) or by double-clicking on the icon on the desktop. The water demand model for the Ouémé basin will automatically load.
4. Please refer to the WEAP user guide and tutorial material (available at www.weap21.org) for assistance on how to operate, modify or run the model.

5. To open the WEAP model, select the “File” menu and navigate to “Open”. Select the “OUEMEFINAL” model.

Should there be any further questions or needs for clarification, please do not hesitate to contact SEI using the contact details found above.

[1] WEAP requires a 200 MHz or faster Pentium class PC with Microsoft Windows 95 or later (a 400 MHz PC with Windows 98 or later is recommended). A minimum of 32 MB of RAM and 50 MB of free hard disk space is also required (64 MB of RAM recommended). In addition Microsoft Internet Explorer version 4.0 is required for viewing WEAP's HTML Help. If you do not have it you can download it for free from the Microsoft web site. It is OK to install Internet Explorer after installing WEAP. Your computer screen should be set to a minimum resolution of 800x600, but preferably even higher (e.g., 1024x768 or 1280x1024), to maximize the presentation of data and results. An Internet connection is not required, but is useful for tasks such as emailing data sets and receiving automatic updates to the software. WEAP can also communicate with Microsoft Excel and Microsoft Word, but they are not required. NB: WEAP is designed as a single-user system. It is not intended as a multi-user system and we do not recommend running it from a shared network drive.