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A regional model for integrated water management in twinned river basins

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the Oueme basin

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List of abbreviations

CAGIA-Benin: Coopérative d'Approvisionnement et de Gestion des Intrants Agricoles du Bénin

CAPE: Cellule d'Analyse de la Politique Economique

CeRPA: Centre Régional de Promotion Agricole

CRA-A: Centre des Recherches Agricoles d'Agonkanmey

DE: Direction de l'Elevage

FAO: Food and Agricultural Organization of the United Nations

GNP: Gross National Product

IGN: Institut Geographique National

IITA: International Institute of Tropical Agriculture

INRAB: Institut National des Recherches Agricoles du Bénin

INSAE: Institut National de la Statistique et de l'Economie Appliquée

MAEP: Ministère de l'Agriculture, de l'Elevage et de la Pêche

ONASA: Office National pour la Sécurité Alimentaire

ORB: Oueme River Basin

PADSA: Projet d'Appui au Developpement du Secteur Agricole

RIVERTWIN: A regional model for integrated water management in twinned river basins

SONEB: Société Nationale des Eaux du Bénin

SOW-VU: The Centre for World Food Studies of the Vrije Universiteit

WEAP: Water Evaluation and Planning System

WHO: World Health Organization

WP: Work Package

1. Introduction

The project “RIVERTWIN” aims in developing, adjusting, testing and implementing an integrated regional model for the strategic planning of water resources management in twinned river basins under contrasting ecological, social and economic conditions. The regional model will take into account the impacts of demographic trends, economic and technological development, the effects of global climate and land use changes on the availability and quality of water bodies in humid temperate, sub-humid tropical as well as semiarid regions. Study area of RIVERTWIN covers three basins under these contrast climates: the Neckar basin in Germany (Europe), the Oueme basin in Benin (Africa) and Chirchik basin in Usbekistan (Asia).

Among these basins, Oueme is characterized by lower data availability. Data collection is then one of the main objectives of the RIVERTWIN workpackage (WP) 4 that is related to the Oueme river basin. Agro-economic data collection is included in this workpackage 4.5. This report (deliverable D17) summarizes agro-economic data that are collected for applying the model of agro-economic valuation of water resources in the Oueme basin.

In spite of low data availability at the beginning of the project, this report presents the agro-economic database composed not only with secondary data but also with primary (survey) data. Data are provided for various levels: household, village, commune, department and national. The agro-economic database contains also data on water availability, economy and management in the Oueme basin.

The report structure is composed with 6 sections. Section 2 presents the objective while section 3 briefly describes the study area. Data collection tools and methods are outlined in section 4. The fifth section presents the results and the section 6 gives the conclusion.

2. Objectives

The main objective of the WP 4.5 is to develop an agro-economic valuation model for water resources and to estimate an economic water supply model. To achieve this objective, data collection is required. The objective of this activity is to collect agro-economic and water economic data that are used for building a database on agro-economic conditions in relation to water availability in the Oueme river basin (Deliverable D17).

3. Study area (Oueme River Basin)

The Oueme basin area is not only in the Benin borders but also in Nigeria area (Figure 1). The Oueme basin area is around 48.000 km² while Beninese part is estimated to 44.197 km² for both upper and middle parts of the basin. This zone covers the north part of the continental terminal area and part of Precambrian crystalline rocks in Benin. Its geographic borders are:

- 6°35' north latitude in the south;
- 10°12' north latitude in the north;
- border of Togo in the West; and
- border of Nigeria in the east.

In Benin, RIVERTWIN study area covers entirely or partially 22 communes in 6 departments (Table 1).

Table 1. Number of communes per department in the RIVERTWIN study area in Oueme basin.

Departments	Number of communes
Borgou	5
Donga	3
Collines	6
Plateau	3
Zou	3
Oueme	2
Total	22

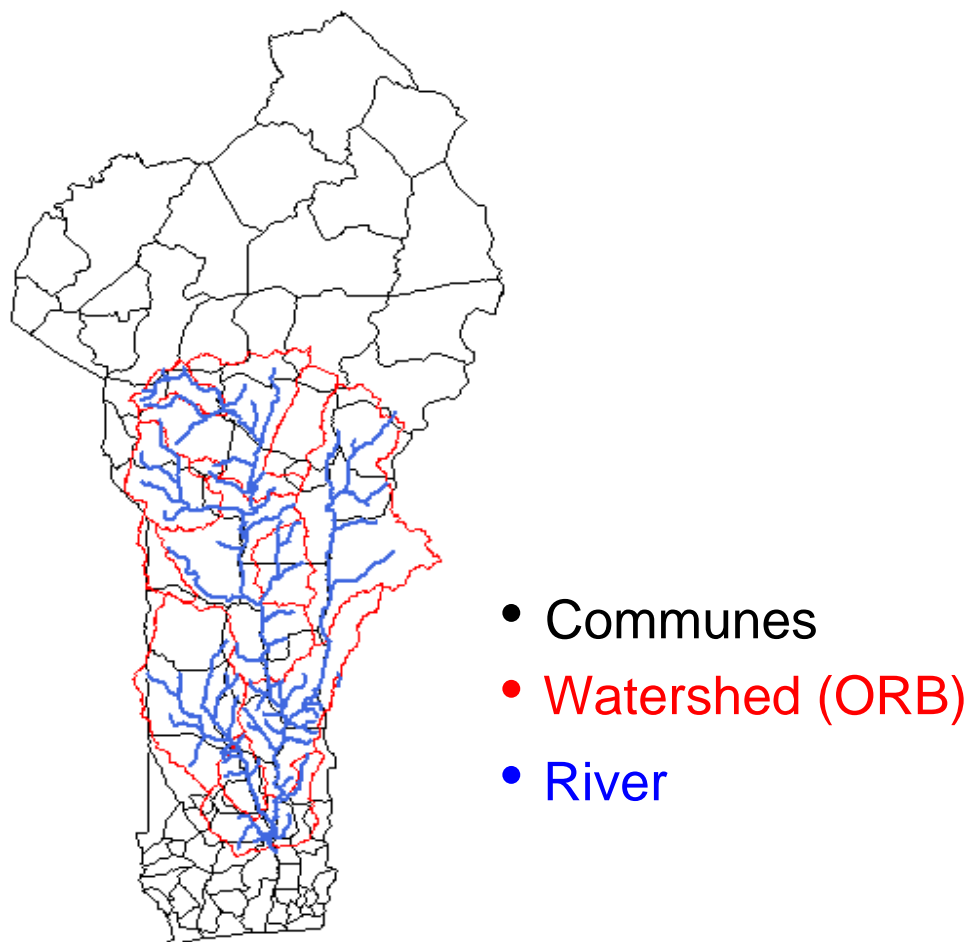
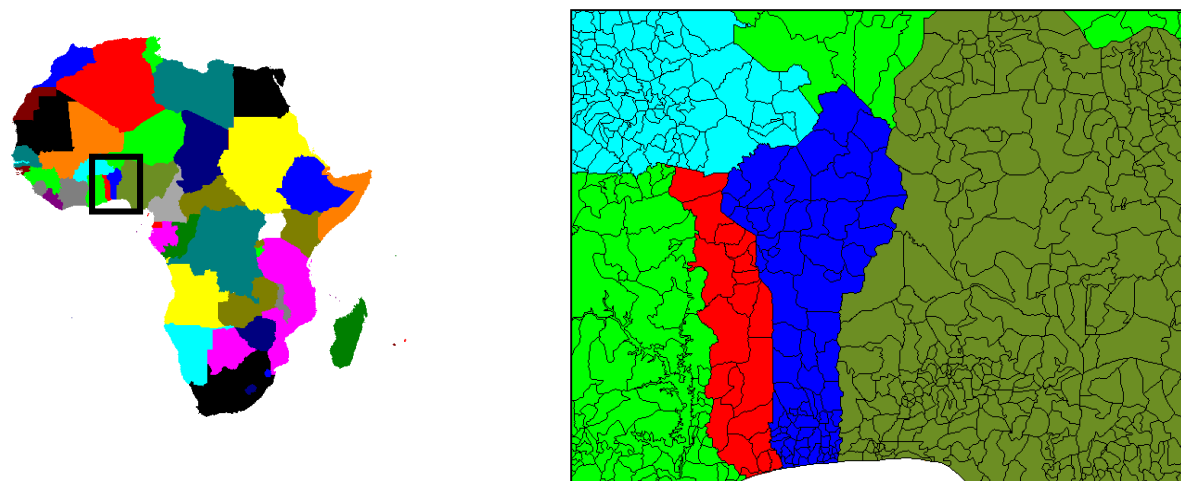


Figure 1: Borders of Oueme River Basin (high and middle parts).

4. Data collection methods and sources

4.1. Data types

Following data requirements for the RIVERTWIN integrated model in the Oueme basin, partners 3 (Centre des Recherches Agricoles d'Agonkanmey: CRAA/INRAB) and 6 (The Centre for World Food Studies: SOW-VU) made a meeting in Amsterdam (The Netherlands) in July 2004 in order to define agroeconomic data (Deliverable D17) that are necessary for the agroeconomic valuation model for water resources in the Oueme Basin.

These data concern in general the following area:

- Crop information
- Agricultural Input data
- Agricultural prices
- Animal husbandry
- Irrigation
- Water demand
- Population growth

These data may be obtained from both primary (survey) and secondary sources. Secondary sources are used for the research of historical or panel data. The focus period is from 1983 to 2003 in the Oueme river basin. The reference year is 2003 and this means that the models are built for the 2003 and also this year represents the scenario base line. The primary data concern survey data on the household or village level. These data are cross section data and related to agroeconomic condition of rural area in the Oueme basin. These primary data concern also the water availability, economy and management in the basin.

In addition to this list, other data were collected with the request of the partner 6 (SOW-VU) in charge of building and applying the model for agroeconomic valuation of water resources in the Oueme basin.

4.2. Data collection: source and methods

Data are collected in many institutions such as Ministry of Agriculture (MAEP) through its directions which are Animal Rearing Direction (DE), Programming and Prospecting Direction (DPP) and Benin National Institute of Agricultural Research (INRAB); Ministry of Health (MSP); Benin National Society of Water Resources (SONEB); National Institute of Statistic and Economic Analysis (INSAE); Benin Cooperative of Agricultural Input Provision and Management (CAGIA-Benin), World Health Organization (WHO), International Institute of Tropical Agriculture (IITA), Food and Agriculture Organization of the United Nations (FAO),

Regional Center of Agricultural Promotion (CeRPA), etc. Websites are also used for data collection.

Annual activity reports of these institutions are used for data collection. For each data, some sources are often used for data controlling. For instance, both MAEP and FAO data are collected and are compared for crop production data (area, production and yield). In addition, some data sources are required for building historical or panel data.

Concerning the primary data, two surveys are realised. The first one is a qualitative survey and aims to collect qualitative data (farmers' perceptions) on water constraints and farmers solutions in the Oueme river basin. The second survey is quantitative and aims in agro-economic data collection. Survey on water constraints and farmers strategies to reduce these constraints begins in 2004 and ends in 2005. Data are collected with a questionnaire that is used in focus-group (group discussion). This survey is realised in 28 villages within 17 communes of the RIVERTWIN area in the Oueme river basin. These villages are selected in cooperation with water and agriculture management authorities in the study area. The following criteria are used for the selection of two villages in each communes: water sources for population during dry season and rainy season, water and land constraints, geographic situation, presence of vegetable production, etc.

The second survey data begins also in 2004 and concerns the central area of Benin between 7°15' and 9°00' latitude north. In the year 2005, the survey was extended to the remainder area of the RIVERTWIN zone. This survey was realised in 55 villages within 16 communes of the Oueme river basin. Data collection method was mainly based on that used by Eco-regional Programme for the Humid and Tropics of Sub-Saharan Africa in 1999 – 2000 to characterize coastal savannah zone. For the choice of villages, maps with 1/200000 scale from National Geographic Institute (IGN) are used. In these maps, study area are divided in grid with size 20' x 20'. Village in the center (medium) or the nearest village to the medium is chosen as a survey village. Five different questionnaires are used in each village and allow socio-economic, geographic, agronomic and environmental data collection. The first questionnaire concerns geographic data and is executed with the assistance of extension or research agents who are living in the village. The remaining data are collected in group discussion in a public place of the village. The second questionnaire is executed with all members of the group that represents the village. This questionnaire allows collecting of global data about the village. These data concern food consumption practice, agricultural activities, income sources and the main kinds of expenditures. At the end of this group discussion, the group is divided into three heterogeneous sub-groups and questionnaires 3, 4 and 5 are simultaneously filled with these sub-groups. Data collected with questionnaire 3 are related to infrastructures, sources of supply water, energy sources,

rearing and processing activities, crop storage and conservation, extension service and technological innovations in the village, availability and type of labour, and so on. With the fourth questionnaire, collected data are: land tenure, types of crop production (rain-fed, irrigated), management of natural vegetation, data on plantations, etc. Finally, data on dominant crop, crops and land management (mixed patterns and sole patterns, crop succession patterns), usage of chemical input, new crop varieties availability and agronomic problems encountered in the village are the main data collected through the fifth questionnaire.

Otherwise, data are also obtained from research institutions and projects. For instance, data were obtained from Support of Agricultural Sector Development Project (PADSA) and Analysis of Economic Policy Unity (CAPE). The data obtained from CAPE were collected in 2003. These data were collected in 68 villages in Benin for 999 households.

5. Results

5.1. Time series (panel) data

Data from secondary sources collected for evaluation of agroeconomic water resources in the Oueme river basin are presented in this subsection. These data concern in general several years. Data are provided at different levels such as commune, department and national. Data characteristics (temporal resolution, spatial resolution, type of data and time period for collected data) are summarized in table 2. As it is noted in this introduction section, Oueme basin has the lowest level of data availability. Various sources are then used in order to have chronological data. However, some data do not exist or are not available according to the foreseen spatial and temporal resolutions. For instance:

- ✓ For crops, data of the period between 1980 and 1986 are only available at the national level.
- ✓ For agricultural prices, they were fixed before 1990 by the politicians and did not vary throughout the country. Therefore, it is after market liberalization in 1990 that these data on prices are collected by ONASA (1990 to 2003).

Table 2. Characteristics of panel data collected for the agroeconomic valuation model in the Oueme basin.

Parameter	Temp. Resolution	Spatial resolution	Data type/description	Time period
Crop information				
Crop production	Year	Commune/household	Yield/area/production	1987-2003
Cropping system	Year	District/household	Mixed/intercropped/rotation	Available in the survey data
Animal husbandry				
Type of ruminants	Stock estimate per year	Department/Commune	Cattle/goats/etc.	1987-2003
Agricultural Input data				
Fertilizer	Year	National / Commune	Price and Quantity	1980-2003
Pesticides	Year	National / Commune	Price and Quantity	1980-2003
Labour	Year	Commune /household	Price and Quantity	Available in the survey data
Water and Agricultural price				
Water price (Euro /m ³)	Annual	Commune	Statistics	1994-2002
Agricultural prices	Monthly	Commune	Statistics	1990-2003
Water demand				
Crop specific	Year	Commune	Statistics/modelling	Transfer from WEAP Model
Animal husbandry	Year	Commune (1x1 km)	Statistics/modelling	Transfer from WEAP Model
Domestic use			Statistics/modelling	Transfer from WEAP Model
Industry			Statistics/modelling	Transfer from WEAP Model
Scenario variables				
Population	Year	Commune		1979-2002
GNP for industry and growth rate	Year	National	Statistics	1992-2002
GNP for services and growth rate	Year	National	Statistics	1992-2002
GNP for agriculture and growth rate	Year	National	Statistics	1992-2002
Cost of dam building (\$/m ³)			Problem: quantification of side effects	Not available per year
Occurrence of water related diseases	Year	Commune		2003

When the data listed in table 2 were not exhaustive, other useful data for the agroeconomic valuation model in the Oueme basin were also collected (table 3). The partner 6 also requests these data.

Table 3. Other data available and periods

Data types	Time period
Growth rate of GNP	1960-2002
Density of the population	1979-2002
Fisheries production	1987-2001
Fish imported	1987-2001
Shrimp exported	1987-2001
Livestock price	2003
Prevalence of water related human diseases	2003
Prevalence of water related livestock diseases	2003-2004
Migration patterns of livestock	2000-2004
Drinking points for livestock	1985-2001

5.2. File structure for panel data

Data collected from secondary source concern several years. The files of these data are organised in the folder named « OuemeDataAgroEconomic ». This subsection presents the files' structure in this folder.

5.2.1. Crop production

Data on crops are contained in the file "OuemeBasin_Crop_Database_Rivertwin_1987_2003.xls". The format of this file is EXCEL 2000. It contains data for 5 departments (in five separate sheets) that belong to the Oueme basin. The time period is from 1987-1988 to 2003-2004. Each sheet has data for communes (with geographic coordinates) that belong to these departments, with yearly data on:

- a. area (in hectare) under a specific crop;
- b. total production (in ton); and
- c. yield (ton per hectare).

5.2.2. Livestock data

The file named "OuemeBasin_Livestock_Database_Rivertwin_1987_2003.xls" contains data on the different kinds of livestock in different departments within the Oueme basin. The format of this file is EXCEL 2000. The kinds of livestock include: cattle, sheep, goat, pig, poultry, etc. Each sheets has data for communes (with geographic coordinates) that lie

within that department with yearly data on number of livestock. These data concerns the time period from 1987 to 2003.

5.2.3. Agricultural Input data

Data on agricultural inputs (fertilizers and insecticides) are contained in the file "Intrants_Agricoles.xls". The format of this file is EXCEL 2000. It contains four sheets. The first sheet contains the evolution of prices of fertilizers and insecticides from 1980-1981 to 2003-2004. Prices are expressed in FCFA per kilogram for fertilizer and in FCFA per liter for insecticides. The last three sheets contain consumption levels of fertilizers (NPKSB (kg), UREE, PA/KCI) and insecticides (ENDOSULFAN, ACARICIDE, APHICIDE) for various communes during time period from 2001-2002 to 2003-2004. Fertilizer quantity is expressed in kilogram while insecticide quantity is in liter.

5.2.4. Water and Agricultural price

The file named "Prix de l'eau.xls" contains price of drinking water in the urban area. The format of this file is EXCEL 2000. These data concern price that are used by the Benin National Society of Water Resources (SONEB) from 1994 to 2002. The price is expressed in FCFA per cubic meter.

Price of drinking water in rural area is collected during the survey on water constraints in the Oueme River Basin. These data are contained in the file "Prix_eau_village_Benin.xls". This file contains price of water data for village within communes corresponding to five departments in the Oueme basin in the second sheet. It shows if the water was sold in that village, and if yes what quantity (in liters) was sold at what price (FCFA). Sheet 1 explains the variables name used in the second sheet.

The file "Prix_Produits_Agricoles_Benin_1990_2003.xls" contains crop prices for various market places in all departments of Benin. The file contains three sheets. The first sheet contains prices (units: FCFA/kg) of crops for the year 2003. These data for the 2002 are contained in the second sheet while the last sheet contains data for the period 1990 to 2001. The variation of the average of crop prices is shown in figure 2 for the period 1990 to 2003. The curves show that crop prices follow a same evolution that is similar to saw teeth. From 1994 to 1997, crop prices increase quickly.

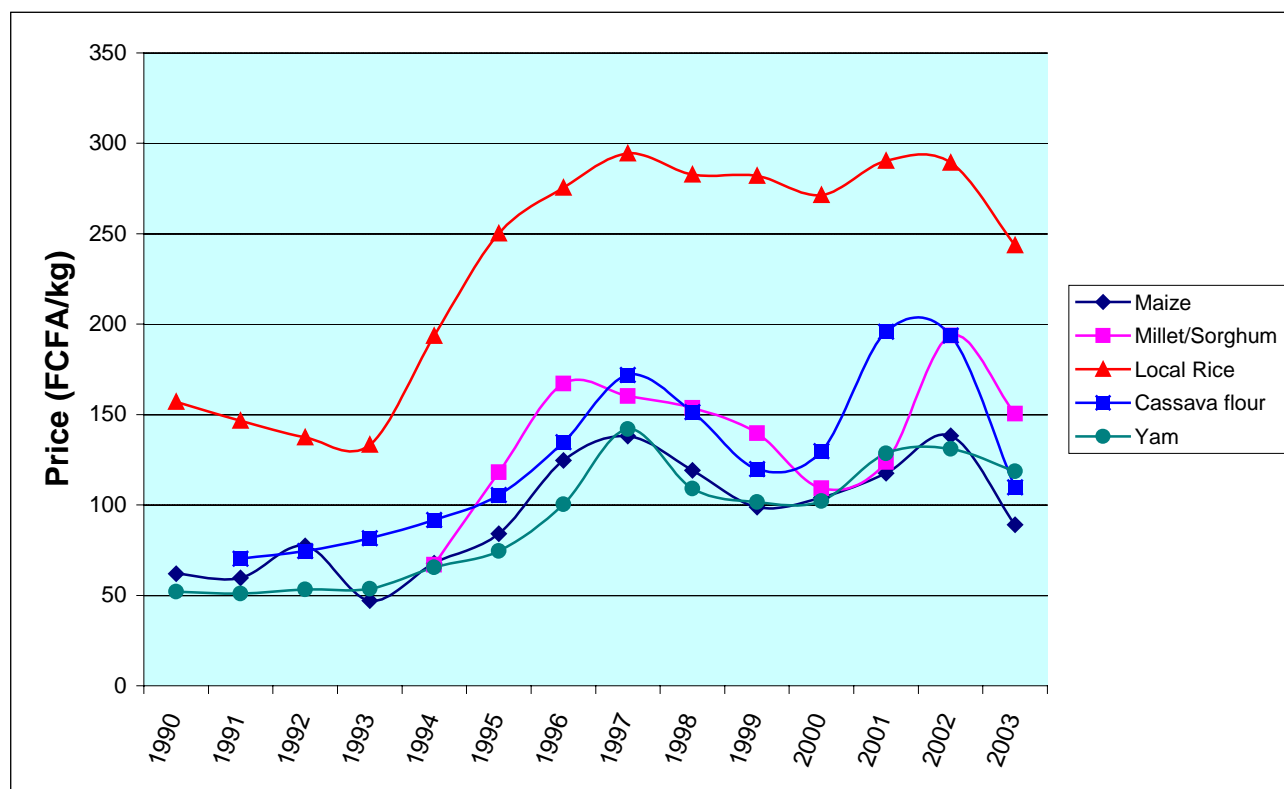


Figure 2. Average yearly price (FCFA/kg)¹ of crops for the period 1990 to 2003 in Benin markets.

This increase is related to the devaluation of the local money (FCFA) that intervened on January 24, 1994. After 1997, crop prices decrease until 1999 and increase again until 2002. The other decrease of crop prices is noted in 2003. This variation shows the high level of risk for farmers.

The figure 3 shows the trend of monthly price of crops for the period 1990 to 2003.

¹ 1 Euro = 655,957 FCFA.

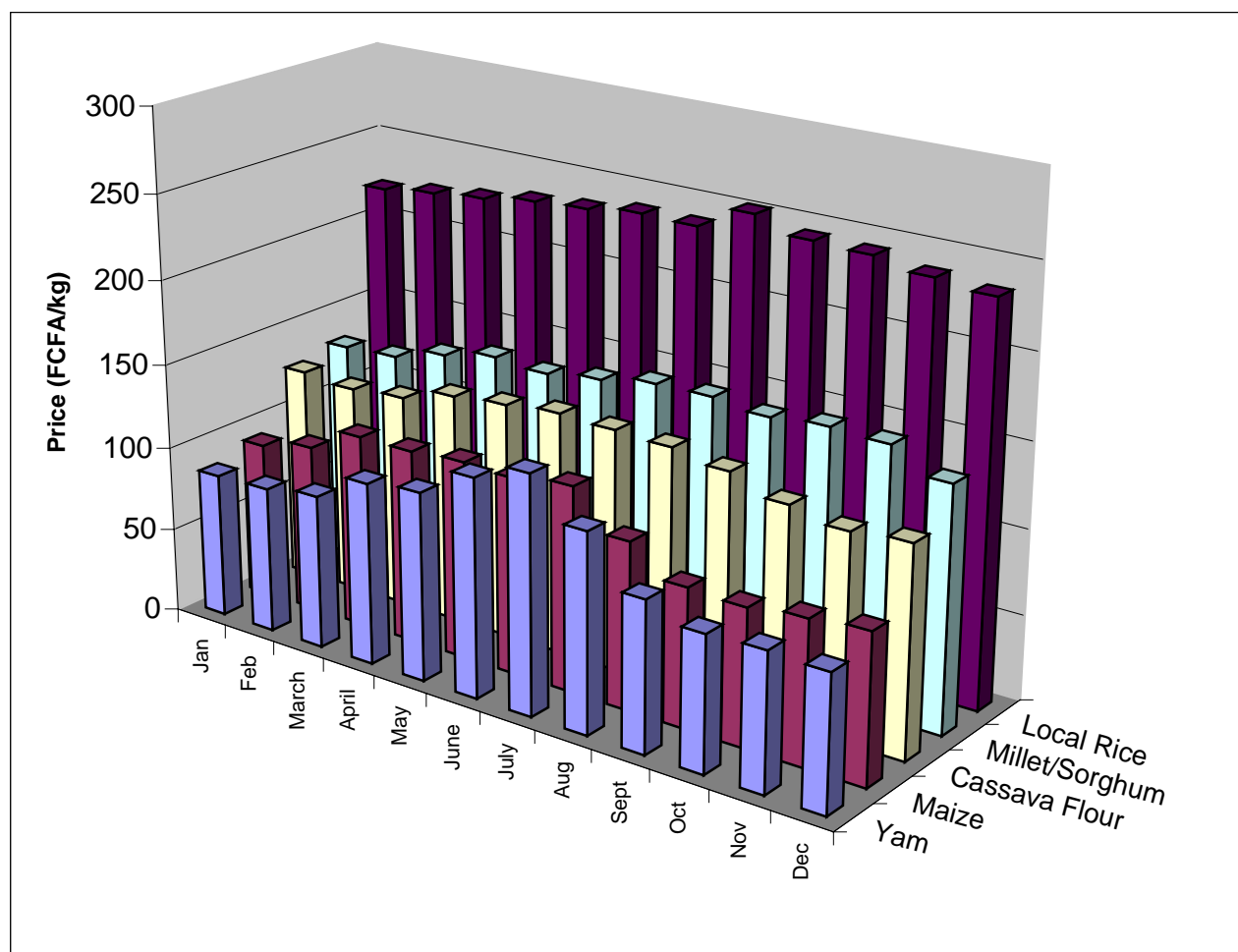


Figure 3. Average monthly price (FCFA/kg) of crops for the period 1990 to 2003 in Benin markets.

5.2.5. Population and density

The file "OuemeBasin_Population_RIVERTWIN" contains data on population for communes lying within the Oueme basin. The format of this file is EXCEL 2000. It has two sheets. The first sheet contains data from the census in 1979, 1992 and 2002. This sheet contains also data on commune area (km²) and their geographic coordinates. The population density (inhabitants/km²) exists also in this first sheet. The second sheet contains an estimation of population from 1972 to 2002 based on the census data.

5.2.6. Gross National Product data

Gross National Product (GNP) data are contained in the file "PIB_Benin.xls". The format of this file is EXCEL 2000. It contains three sheets. The first sheet contains the Benin GNP

growth rate from 1960 to 2001. The second sheet shows data on the value of GNP (in billion of FCFA) from 1992 to 2002. This sheet presents also the growth rate of the GNP. The data are organized by sector and sub-sector. Data are given for three sectors: primary sector (with crop production and animal production as sub-sector), secondary sector (with sub-sectors food industry, energy and so on) and the tertiary sector (with sub-sectors such as trade and transport). In this sheet, the GNP is expressed in constant prices. The last sheet has the same structure like the second file but the GNP is expressed in current prices.

5.2.7. Livestock price

The file "Prix des animaux d'élevage.xls" contains in the first sheet monthly prices of various animal types for the year 2003. Animal types include cattle, sheep, goat, pigs and poultry. The second sheet contains livestock price for three months but in various markets in Benin.

5.2.8. Fisheries production, import and export

These data are contained in the file named "Fisheries_data". This file has an EXCEL format and contains two sheets. The first sheet contains the production of fish in Benin from 1987 to 2001. Data are provided for fish from both inland water and sea. The fish imported and shrimp exported data are contained in the second sheet. These data are also provided for the period 1987 to 2001.

5.2.9. Prevalence of water related livestock and human diseases

These data are contained in three files named: "Maladies des animaux d'élevage_Eau_2003.xls", "Maladies des animaux d'élevage_Eau_2004.xls" and "Maladies_humaines_Eau.xls".

The file "Maladies des animaux d'élevage_Eau_2003.xls" contains data on prevalence of water related livestock diseases for year 2003. Sheet 1 contains data on prevalence within departments Atacora/Donga, Atlantique/ Littora, Borgou/ Alibori, Mono/ Couffo, Oueme/, Plateau and Zou/ Collines. Data includes number of herds, morbidity, mortality, immunization for each disease type within all departments. Sheet 2 contains data on water related livestock diseases that are noticed in the slaughterhouses. These diseases concern cattle, sheep and goat and pig in all above-mentioned paired departments. In addition, total number of the above animal types is also given in different above-mentioned department pairs.

The file “Maladies des animaux d’elevage_Eau_2004.xls” contains data on water related livestock diseases for the year 2004. This file contains three sheets. Sheets 1 and 2 contain the same data like the file “Maladies des animaux d’elevage_Eau_2003.xls” and have the same structure. The last sheet contains the total data number of sick animals in the sheets 1 and 2.

The third file named “Maladies_humaines_Eau.xls” contains data on rate of water related human disease occurrence (per 10000 inhabitants) and corresponding rate of mortality for various departments in Benin. The file contains four sheets. The first sheet contains data on various water related human diseases. Data includes rate of incidence and rate of mortality (per 10000 inhabitants) for each disease type within different sanitary zones. Data are from the year 2003. Here, the sanitary zones are referred to communes groups as defined by the Ministry of Health (MSP). Sheet 2 contains data on diarrhea related diseases. Data on rate of incidence and rate of mortality is given for each disease type within various departments (Alibori, Atacora, Atlantique, Borgou, Collines, Couffo, Donga, Littoral, Mono, Oueme, Plateau and Zou) and also for Benin. Sheet 3 contains data for the same diarrhea related diseases like the Sheet 2 for the same set of departments but the data includes cases (per 1000 inhabitants) and rate of morbidity. Sheet 4 contains data for the same departments as in Sheets 2 and 3 on rate of morbidity of diarrhea related but for different age groups in various departments. The figure 4 shows the incidence of cholera disease in Benin and in the Oueme basin in the year 2003.

5.2.10. Migration patterns of livestock

Data on migration patterns of livestock are contains in the file “Transhumance.xls”. The file format is EXCEL 2000. It contains five sheets. Each sheet contains data for a specific year (2000-2004). Then, data are provided for five years (2000 to 2004). Data in each sheet are organized by departments and communes. Data concern origin (place), the place of settlement, number of animal herds, number of cattle, sheep and the total number of animal.

5.2.11. Drinking points for livestock

The file “Inventaire des points d’eau.xls” contains the list of water structures (dam, etc.) in departments Atacora and Donga in the first sheet. These data concern water structures that are built between 1985 and 2001. Data are provided for their locations, year of realization, capacities and financing source. The second sheet contains data like sheet 1, but with more

details on the various kinds of water conservation systems or structures and concerns Borgou and Alibori departments.

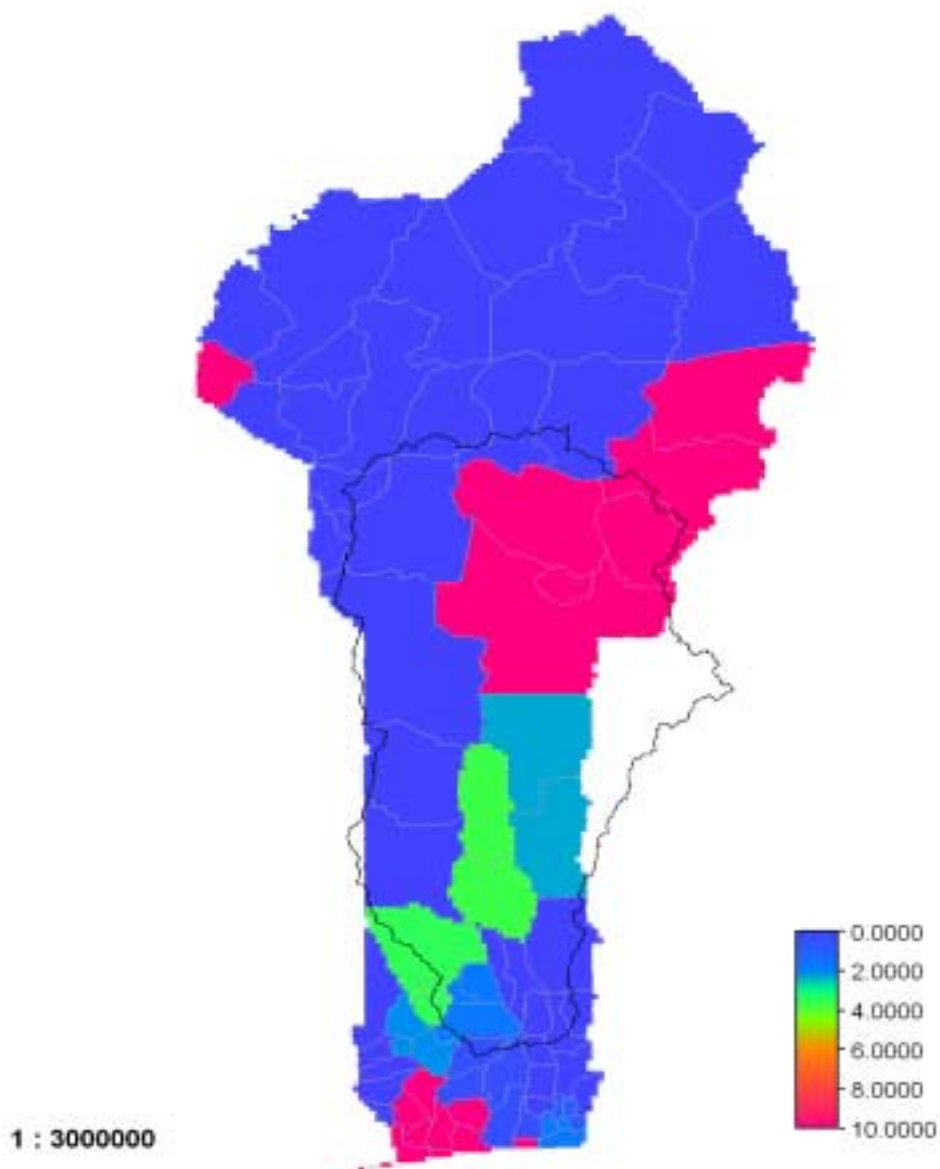


Figure 4. Incidence (per 1000 inhabitants) of cholera disease in Benin and in the Oueme basin in 2003.

5.3. Database of survey

Survey data are also stored in the folder named « OuemeDataAgroEconomic ». This section presents the structure of three databases related to the survey. Two databases contain data on village level while one database concerns household data.

5.3.1. Village level data

The first village level data concerns agro-economic data that are contained in the file named “AgroEconomicDataVillage_1.xls”. This database contains around 1430 agro-economic variables for 55 villages in the departments of the RIVERTWIN’s study area in Benin (Figure 5). The file has EXCEL 2000 format. It contains seven sheets. The first sheet named “CODES” provides the meaning of the variables contained in other sheets. This sheet has data in three rows: the first row is about the code of the variable, the second row gives the meaning (description of the variables) and the third row concerns the unity or the value of the variable. The others five sheets contain agro-economic data with the variable names or codes in the first line. Data types contained of this database are explained in the subsection 4.2.

The file named “AgroEconomicDataVillage_2.xls” contains the second village level data. These data are related mainly to the water availability and water management in the survey village in the Oueme river basin (Figure 6). Economic data are also provided. Data are collected in 28 villages in 17 communes of the RIVERTWIN’s study area in Benin. The file contains two sheets. The first sheet named “CODES” provides the meaning of the variables contained in other sheets and has the same structure like the first sheet of the file “AgroEconomicVillageData_1.xls” whose description is in the preceding paragraph. The second sheet contains data with variable name in the first line. These data concern mainly the various kind of water infrastructure available in the village, other infrastructures, water price, presence of comity for water management, quantity of water consumption in a household, presence of lowland and vegetables production system in dry season.

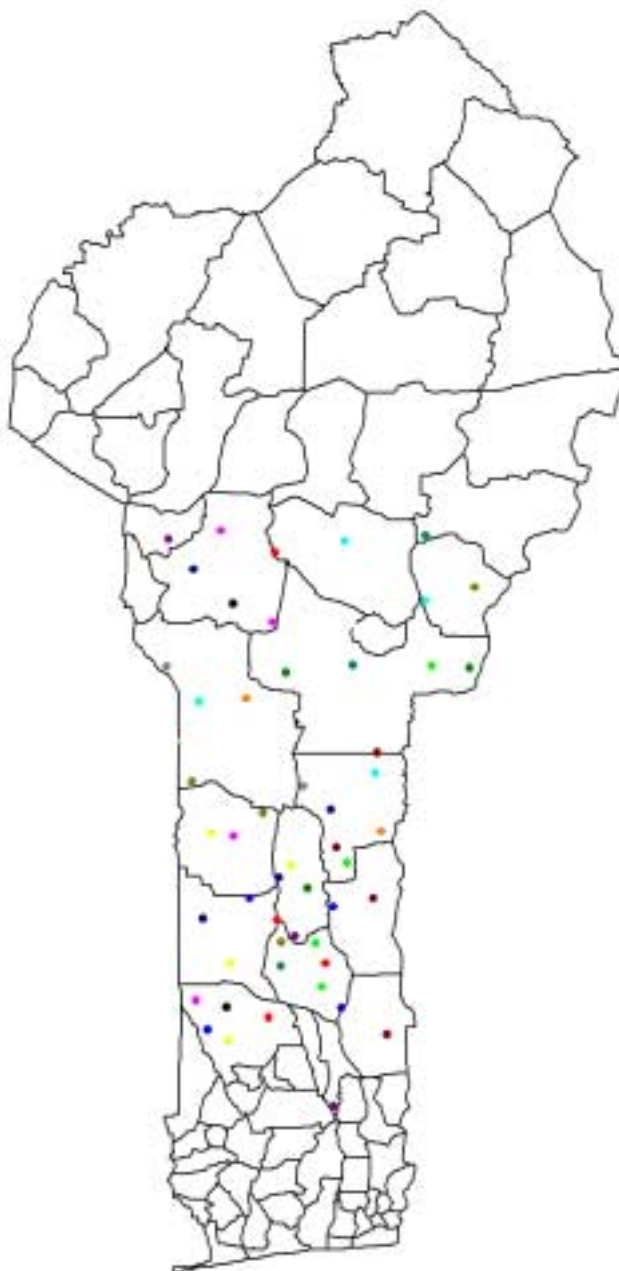


Figure 5. Geographic location of survey villages for agro-economic data in 2004 and 2005.

5.3.2. Household level data

This household data concerns agro-economic data in relation to water resources. These data are contained in the file named “AgroEconomicDataHousehold.xls”. The file format is EXCEL 2000. The file contains 3 sheets. The first sheet named “CODES” provides the meaning of the variables contained in other sheets and has the same structure with the first sheet of the two first files whose description is in the preceding sub-section. This database contains around 523 agro-economic variables and water use data. Data concerns 999 households in all Benin. These data are contained in the second and third sheet of the file. For each household, data are collected for the years 2002-2003 and 2003-2004 and concern characteristics of household (household size (in hectare), household manpower, matrimonial status and gender of household head, etc.), cultivated crops (production and income from crop sold), livestock production (number of animal heads, number of animal sold and the income from animal sold), meat and fish production, income from non-farm activities, agricultural input (labor, equipment, fertilizers, insecticides, seeds, land, water, etc.), source of financing and expenditure (food and water and non-food).

6. Conclusion

The report presents the various kinds of data that are collected for construction of the database on agroeconomic conditions in relation to water availability in the Oueme basin, which is one of the three basins concerned by the RIVERTWIN project. The main aim of the construction of this database is to develop an agro-economic valuation model for water resources and to estimate an economic water supply model in the Oueme basin. Though Oueme basin has the lowest data availability at the beginning of the project, the objective 4.5 of the RIVERTWIN allows having a great database on agroeconomic data composed not only with secondary data but also with primary (survey) data. This allows providing data for various levels: household, village, commune, department and national. This database contains also data on water availability, economy and management in the Oueme basin.

Data contained in this database are already available and are now used for the building of the agroeconomic model in the Oueme River Basin.



Figure 6. Geographic location of survey villages for water availability and management in 2004 and 2005.

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