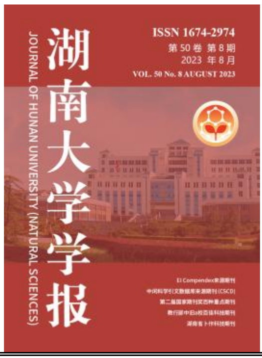

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Development of a Social Accounting Matrix: A Tool for Assessing Water Policy in Tunisia

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Abstract: This paper presents the procedures for constructing a social accounting matrix (SAM) for Tunisia for 2015, called SAM-WATER 2015. The general structure of the matrix, the stages of development, and the different sources of data used are presented. The purpose of this matrix is to provide an up-to-date database that can be used by Computable General Equilibrium (CGE) models to simulate the socioeconomic impact of Tunisian water policy, and in particular irrigation water, to address the many problems that this sector suffers. Furthermore, this research focuses in particular on the role that recycled wastewater, as an unconventional water source, can play in this policy. The main features of this research are twofold. First, the production factor account of this matrix includes two types of water: raw water (for agricultural and non-agricultural use) and treated wastewater. Second, the activity account distinguishes between agricultural branches that use only raw water and those that use both raw irrigation water and treated wastewater. In addition to these agricultural branches, the activity account explicitly includes the production and distribution of the drinking water sector. In total, SAM-WATER 2015 includes 24 production activity accounts, 24 goods and services accounts, 6 production factors, 4 institutions, 1 tax and duties account, and a capital accumulation account. This disaggregation allows us to gain insight into the water cycle in Tunisia, which in turn allows us, through the scenarios envisaged in the CGE models, to examine the socioeconomic impact of the water policies in Tunisia.

Keywords: social accounting matrix, water management, treated wastewater, agricultural activities.

社会核算矩阵的开发：评估突尼斯水政策的工具

摘要：本文介绍了构建突尼斯2015年社会核算矩阵(萨姆)（称为萨姆-水2015）的程序。介绍了该矩阵的一般结构、发展阶段以及所使用的不同数据源。该矩阵的目的是提供一个最新的数据库，可计算一般均衡（通用电气工程师协会）模型可以使用该数据库来模拟突尼斯水政策（特别是灌溉用水）的社会经济影响，以解决该政策面临的许多问题。行业遭受损失。此外，本研究特别关注回收废水作为非常规水源在该政策中可以发挥的作用 。这项研究的主要特点 是双重的。首先，该矩阵的生产要素账户包括两种类型的水：原水（农业和非农业用水）和处理后的废水。其次，活动账户区分了仅使用原水的农业部门和同时使用原灌溉水和处理后的废水的农业部门。除了这些农业部门外，活动账户还明确包

括饮用水部门的生产和分配。萨姆-水2015总共包括24个生产活动账户、24个商品和服务账户、6个生产要素、4个机构、1个税收和关税账户以及1个资本积累账户。这种分解使我们能够深入了解突尼斯的水循环，进而使我们能够通过通用电气工程师协会模型中设想的情景来研究突尼斯水政策的社会经济影响。
关键词：社会核算矩阵、水管理、废水处理、农业活动。

1. Introduction

Due to its geographical location between the Mediterranean Sea in the north and the desert in the south, Tunisia is considered one of the countries with a semi-arid and arid climate over most of its territory, with the risk of drought threatening it, like many countries in the world, due to the climatic changes our planet is undergoing [1]. This aridity is characterized by limited (with an average of no more than 296 millimeters (mm)/year between 2004 and 2012, for example) and variable (with a difference of up to 1400 mm/year between a wetland in the north of the country and an arid Saharan region in the south) rainfall [2]. The volume of Tunisian potential conventional water resources is estimated at 4840 million m3 (Mm3)/year, of which 2700 Mm3/year is surface water and 2140 Mm3/year is groundwater. This potential is unevenly distributed across the country, with 60% located in the north (mainly surface water), 18% in the center (mainly shallow to moderately deep water), and 22% in the south (mainly deep water) [3]. Regarding the salinity of these waters, according to [4], a large part of these resources, especially underground (deep and moderately deep), are of mediocre quality. In fact, according to these authors, only 28% of these waters can be considered to be of good quality (salinity below 1.5 grams/liter). As for surface waters, contrary to the first type, 72% have good salinity. On the other hand, per capita water availability is approximately 400 m3 per year, well below the poverty line of 1000 m3. This figure is expected to fall to 350 m3 by 2030 [5].

In addition to these natural conditions, the situation has been aggravated by several other problems that have negatively affected the water sector in Tunisia, such

- Virtual stagnation of the mobilization of water resources.
- Corresponding widening of the gap between the high cost of water mobilization and its very low price.
- The ever-increasing demand for water due to demographic growth and rising living standards.
- The enormous waste of water.

The situation in this sector clearly shows that the water policy implemented by the Tunisian authorities for decades, based essentially on water supply management (WSM) through the mobilization of surface and deep water, can lead to a state of chronic imbalance between water supply and demand [5]. To address this situation, and with the aim of bringing water demand into line with supply, Tunisian policymakers have launched several programs [6] focusing on:

First, reinforcing existing policies by producing other non-conventional water sources through wastewater treatment, desalination of deep brackish water and seawater, and artificial recharge of aquifers, and by implementing awareness campaigns against water wastage and technical leaks.

Second, the adoption of another policy based on water demand management (WDM) alongside the current policy. The objective was to encourage the rational and efficient use of available water resources.

Many university researchers [5], [7]-[8] and organizations (Tunisian Institute of Strategic Studies, Tunisian Institute of Competitiveness and Quantitative Studies …etc.) concerned with the domain of water resources in Tunisia have focused on the evaluation of the effect of different demand management instruments and their achievement in terms of resource sustainability under technical, economic, and social aspects, and have presented many solutions to overcome the problems related to this sector.

This is the background of our work, whose main objective is to describe the steps necessary to elaborate a SAM for Tunisia for the year 2015 (which we have called SAM-WATER 2015), which can be used as a reference database to study, through CGE models, the socioeconomic impact of water policies adopted by Tunisia.

Our contribution in this work, compared to work related to the Tunisian context, is on two levels:

- On the one hand, we have disaggregated “water”, considered as a primary factor of production, into two types: raw water (used in agricultural and non-agricultural sectors) and recycled wastewater.
- On the other hand, the activity account distinguishes between agricultural activities that use only raw water and those that use both types of water. In the same account, we also specified the production and distribution of the drinking water sector.

The remainder of this paper is organized as follows: The next section is devoted to a literature review of works aimed at developing a SAM, particularly those related to the Tunisian economy. This is followed by a general presentation of the SAM and its main characteristics. The third section describes the methodology used to construct the macro-SAM. This section is divided into two parts. The first part explains the structure of the aggregated matrix used in this research to construct the macromatrix for Tunisia, called SAM-WATERmacro 2015. The second part highlights the main difficulties encountered, mainly in the construction of the sub-matrix of inter-institutional transfers. Finally, the balancing operation of the macromatrix is discussed. The last section describes in detail the procedure for disaggregation several accounts from the macromatrix to construct the micro matrix called SAM-WATERmicro 2015. This section presents the assumptions, calculations, and estimation methods used to complete this operation.

2. Literature Review

Today, CGE models are considered one of the methodological approaches to evaluate water policies applied in countries in a general equilibrium context. In recent years, there has been an unprecedented increase in the use of models related to this field. These models were developed to analyze the economy-wide effects of changes in water management, whether political or physical. Water policy was first analyzed using a CGE model in [9]. They utility of reducing agricultural water use to solve drainage problems in California’s San Joaquin Valley was studied. Other studies analyzed the effects of water reallocation [10].

Since the social accounting matrix (SAM) is the reference database for the calibration of CGE models, in the case of the treatment of water management issues, it must include additional statistics on the flow of this resource that are not found in the national accounts and could be obtained from other sources of information. This requires the development of an SAM that includes both economic and environmental data [11]-[12]. The main feature of this type of matrix is the consideration of water as both a primary factor of production and a productive activity [12]. This has become a common practice in recent years [13]-[14]. On the other hand, several authors have recently studied, through CGE models, the economic impact of using, besides raw water, other non-conventional water sources, such as desalinated seawater and treated wastewater, based on SAMs that integrate these types of water in the production factor account [12], [14]-[15].

Let us now turn to research related to the implementation of a SAM for the Tunisian economy. We will begin our presentation with an overview of works not directly related to water. In this context, it can be said that despite their small number, these studies have produced matrices that can be used in many fields. Examples include, but are not limited to, work on the evaluation of government policies in the area of foreign trade [16], or in the area of poverty reduction and regional development [17]. In developing an SAM for the Tunisian economy for 1996, the first author focused his disaggregation of the accounts in this matrix mainly on the rest of the world account. This allowed him to study the relationship between Tunisia’s foreign trade with its main partner (the European Union), its neighboring countries, and other countries in the world. As for the second author, he was able to construct a regional matrix to assess the effectiveness of the state’s efforts to reduce economic and social disparities between the different regions of the country. In the context of these regional matrices, all the stages involved in the construction of a regional matrix for Tunisia for 2015, consisting of 513 rows and 513 columns were discussed in [18]. This matrix is composed of 46 economic sectors and products, 13 categories of primary factors of production, 15 types of households, and 7 regions. In the same context, a matrix for the Médenine region in southeastern Tunisia was constructed, which can be used as a database to assess the impact of climate change on the economy of this region [19]. A consistent methodology for the construction of a financial SAM for the Tunisian economy for 2006 was provided in [20] to produce a CGE model that addressed the link between the real economy and the financial sector.

The second part of this literature review presents work directly related to water. In this context, we will present work that leads to SAMs that allow the evaluation of agricultural policies that have a direct impact on the water sector, since agriculture is the leading water-consuming sector in Tunisia. According to [18], there are only two articles on this topic. The main objective of the first article was to help policymakers reform Tunisian agriculture to cope with the high costs of Tunisia’s political anchorage to Europe in the early 2000s [21]. To achieve this objective, the authors used a CGE model calibrated on the basis of a SAM for 1995. This matrix was composed of 18 agricultural sub-sectors to better examine the impact of the reforms that this sector and the economy in general would undergo at that time. The second article aimed to document the various steps taken to construct the Tunisian SAM for 2012 [8]. More specifically, it describes the estimation methods and the type of data used to construct the SAM, with a particular focus on the agricultural and food sectors. In addition to the disaggregation of the different sectors of the Tunisian economy, particularly the agriculture and food sector, the SAM also presents a regional disaggregation into three agro-ecological zones [8].

The last part of this literature review recalls works that have been integrated in SAMs, water either in the account of production factors or in the account of activities. Perhaps [4] is the only research concerned with the Tunisian context, which in its SAM for 2003, included irrigation water and the drinking water industry, respectively, as a primary factor of production and as a productive activity.

3. Methodology

3.1. General Presentation and Main Features of the SAM

The SAM is a particular representation of the macroeconomic and mesoeconomic accounts of a socioeconomic system, recording transactions and transfers between all economic agents in the system [22]. It is an accounting framework that provides a quantitative picture of all economic transactions, recorded in terms of value, that occur between various agents (including the rest of the world) and between the branches of activity of an economic system over a given period of time, usually a year. In its standard format, it aggregates information from the accounts of the System of National Accounts in a single table.

The SAM has three main characteristics. First, it is presented in the form of a square matrix. Revenue cash flows for each account are shown in rows and expense cash flows are shown in columns. Each cell of the matrix corresponds to a transaction, making it easy to identify the relationships between agents. The underlying principle of double-entry accounting requires that row totals equal column totals for each account. Second, it describes the links between employment, income distribution, and the structure of production based on a complete description of the production accounts for each economic activity, the production factor account, and the institutional sector accounts. Finally, it is remarkably flexible, particularly in terms of the level of disaggregation of institutional units, sectors of activity, and factors of production. Furthermore, the SAM can map only the real flows of an economy, just as it can integrate its financial flows or its non-economic production activities, or even its survey data on household income and expenditure, depending on the problem under study. The objectives of constructing a social accounting matrix are threefold. First, it provides a comprehensive and coherent framework for organizing information and data on a given economic system for policy analysis [23]. Depending on the intended purpose, this framework makes it possible to compile macroeconomic, mesoeconomic, and even microeconomic data to describe the main macroeconomic balances of the economy, the income and expenditure of economic sectors, and the distribution of income among different categories of households and other institutional units. Second, the SAM allows the representation of interdependencies and circular flows of income between factors, production, goods, and economic agents. Third, it provides an accounting framework for parameterizing CGE models for impact studies.

The construction of an SAM involves two main steps. In the first step, a macro SAM is estimated mainly using aggregated information from the national accounts. The accounts in this matrix are then disaggregated to the desired level of detail. This second step produces a micro-SAM, which is generally not balanced because the use of different data sources leads to inconsistent receipts and payments. It is then necessary to balance the SAM using balancing techniques such as Racking-Ration (RAS) and Cross Entropy (CE) [24].

The first task in developing an SAM is to design its structure. In addition to a standard structure, many specific structures can be introduced depending on the disaggregation of accounts. The structure chosen must consider two key aspects: the objectives of the analysis and the availability of data.

3.2. Methodology for Constructing Macro-SAM

3.2.1. Structure of the MacroSAM–WATER 2015

In this research, we refer to the SAM of the PEP-1-1 model [25]. This model was developed by members of the P.E.P. (Partnership for Economic Policy) research group. Figure 1 shows a diagram of the steps required to construct SAM-WATER 2015.

During the construction phase of our SAM, detailed statistical information was available for 2015 and 2020. However, we preferred to use 2015 data because of the exceptional nature of 2020 in terms of rainfall. In 2020 and 2021, Tunisia experienced two consecutive years of drought, which particularly affected the country’s water capacity and agricultural production. On the other hand, 2015 seems to reflect an average rainfall, which more accurately reflects the structural characteristics of production and trade in Tunisian agriculture and the agro-food industry.

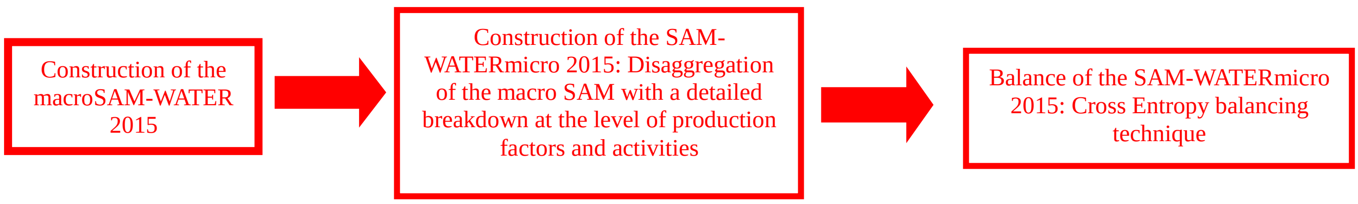

Fig. 1 Diagram of the steps necessary for the construction of the SAM-WATER 2015

On the other hand, in describing this matrix, whether at the macro or micro level, we will focus on certain stages that, in addition to the effort required to gather information, require a more in-depth analysis to achieve the objectives set. In this context, it should be noted that in some cases of imprecision, lack or absence of information, we were forced to make theoretical assumptions, use estimates, or rely on data available in other studies to overcome these problems.

The aggregate form (or macro-SAM) of an SAM (Table 1) does not provide details on the individual accounts in the matrix. It is based on macroeconomic totals that can be extracted directly from the United Nations System of National Accounts (SNA).

Table 1 Macro-SAM structure (SAM inspired by the PEP-1-1 model [25])

	Factors	**Agents**	**Taxes**	**Rest of the World**	**Activities**	**Products**	**Accumulation**
Factors					Remuneration of factors		
Agents	Factor income of agents	Inter-agent transfers	Net taxes on products + customs duties	Transfers from the rest of the world to institutions	Payments from institutions (Taxes and indirect taxes Net of subsidies)		
Taxes						Net taxes on products + customs duties	
Rest of the World	Rest of the World factor income	Transfers to the Rest of the World				Imports at CIF prices	
Activities						Production	
Products		Final Demand			Intermediate consumption matrix		GFCF + Stocks variation
Accumulation		Agent savings		Funding needs/capacity			

3.2.2. Difficulties Encountered in the Construction of the Macro SAM-WATER 2015

To construct the Tunisian SAM-WATERmacro 2015, we began by collecting data mainly from:

- Supply and Use Table (TRE) [26]: This table provides information on the production, exchange, and consumption of goods and services.
- Integrated Economic Accounts Table (TCEI) [26]: From this table, we extracted data on the distribution of income from factors of production, inter-institutional transfers, and savings.

In developing the submatrix of inter-institutional transfers, we focused on transactions whose flows between agents are not directly included in the TCEI. This is the case for transactions related to property income, other current transfers and capital transfers. For the remaining elements of the sub-matrix, namely social contributions, social benefits in cash, 'social transfers in kind' and 'non-produced assets', the flows recorded between economic agents are taken directly from the TCEI. In the first cases, we encountered difficulty because we cannot establish an explicit correspondence between the payer and receiver of flows for a given transaction. In general, this problem arises whenever, for a single transaction (e.g. property income), there are several payers of expenses and several receivers of income. And since the TCEI only shows the global amounts received and/or paid by/for each agent (following this operation), it does not allow us to identify the amount paid (received) by one agent to (from) another agent. In other words, for operations of this type, we can't know "who gives what to whom". To solve this problem, we applied the income imputation method proposed in [27]. The results obtained for flows between economic agents are presented in Table 2.

Table 2 Submatrix of transfers between institutions (in thousands of DT) (The authors' elaboration)

	Household	**Firms**	**Government**	**Rest of the world**
Household		4893100	17303300	3094300
Firms	857500		1238300	925700
Government	16209300	1664100		1287600
Rest of the World	162300	2748000	519800	

3.3. Balance of the MacroSAM–WATER 2015

The aggregated matrix presented in Table 3 is unbalanced because of the diversity of information sources. In its aggregated form, our matrix consists of 11 row and 11 column accounts: two production factor accounts (Labor (L) and Capital (C)), four institutional units (Households (H), Firms (F), Government (GOV) and Rest of the World (RoW)), one activity account, one product account, two tax accounts (Direct Tax (DT) and Indirect Tax (IT)), and one accumulation account.

To balance this matrix, we used the cross-entropy balancing technique. This method (originating from information theory) is used to construct a balanced SAM from information estimated with errors from different sources. The main contribution of this approach compared to others (such as the Racking-Ration procedure) is its flexibility, which allows incorporating additional information into the unbalanced matrix and constraints to fix the values of a few variables whose sources are credible and relevant [28].

Table 3 Unbalanced macroSAM-WATER 2015 (in thousands of DT) (The authors' elaboration)

	L	**C**	**H**	**F**	**GOV**	**DT**	**IT**	**RoW**	**Activities**	**Products**	**Accumulation**	**Total**
L									34040100			34040100
C									43075500			43075500
H	34040100	27034400		4893100	17303300			3094300				86365200
F		13181000	857500		1238300			925700				16202500
GOV		2860100	16209300	1664100		7889400	6242400	1287600	1290000			37442900
DT			4092200	3797200								7889400
IT										6242400		6242400
RoW			162300	2748000	519800					44044716,4		47474816,4
Activities										148099175		148099175
Products			60672800		16511300			32457775,8	69693574,6		16893100	196228550
Accum			4371100	3100100	1870200			7551700			81700	16974800
Total	34040100	43075500	86365200	16202500	37442900	7889400	6242400	45317075,8	148099175	198386291	16974800	

With respect to our research, it should be noted that we relied on [29] to balance our macro-SAM. This balancing operation was performed using an algebraic entropy minimization program on the General Algebraic Modeling System (GAMS) software, whereby constraints are introduced in this program) the values of certain variables (such as government spending) from the unbalanced matrix are kept within the new matrix. The result of this operation is shown in Table 4.

3.4. Methodology for Constructing Micro-SAM

The disaggregated form (or SAM-WATERmicro 2015) differs from SAM-WATERmacro 2015in that it reveals the microeconomic structure of the corresponding macrototals. Disaggregation is generally developed in relation to the question under study and the availability of information.

The construction of the SAM-WATERmicro 2015 required the collection of a large amount of information from different sources, such as publications of the Ministry of Agriculture [30]-[32], publications of the National Institute of Statistics (INS) in particular those linked to the National Survey of Household Expenditure, Consumption and Living Standards for 2015 [33], publications of the National Water Exploitation and Distribution Company [34], (SONEDE, 14-18), publications of the National Sanitation Office [35], World Bank studies, academic research (doctoral thesis, articles), enterprise surveys, etc. The advantage of disaggregation is that it makes possible to identify a country's microeconomic structure. The advantage of disaggregation an SAM is that it simplifies and diversifies the interpretation of the interdependencies of the different accounts. On the other hand, the disadvantage of this operation lies in the imbalance caused by data inconsistency. To overcome this problem, we used the Cross Entropy technique, as we did for the macro matrix, based on a more complicated program (on GAMS software) than the one used in the macro SAM-WATER 2015 balancing case.

Table 4 Balanced macroSAM-WATER 2015 (in thousands of DT) (The authors' elaboration)

	L	**C**	**H**	**F**	**GOV**	**DT**	**IT**	**RoW**	**Activities**	**Products**	**Accum.**	**Total**
L									34040100			34040100
C									43075500			43075500
H	34040100	27001339,1		4883303,02	17079245,4			3396490,86				86365200
F		13154711,2	810430,055		1221769,98			1015588,79				16202500
GOV		2919449,68	16013949,7	1674441,21		7889400	6244522,49	1446954,83	1254182,06			37442900
DT			4065036,11	3824363,89								7889400
IT										6244522,49		6244522,49
RoW			157774,02	2753957,81	518368,17					42965846,1		46395946,1
Activities										148099175		148099175
Products			61412616,3		16814931,2			32457775,8	69729392,5		16894827,3	197309543
Accum			3940672,24	3066434,07	1808585,2			8079135,83			79972,6575	16974800
Total	34040100	43075500	86365200	16202500	37442900	7889400	6244522,49	46395946,1	148099175	197309543	16974800	

3.4.1. Description of MicroSAM-WATER 2015

In general, the analysis of the allocative and distributive effects of water policies requires the distinction of several primary factors of production and activities.

The micro SAM-WATER 2015 includes seven disaggregated accounts, which are presented in Table 5:

➢ *The factors of production account:* This account is disaggregated into six factors of production, namely: salaried labor (n-salaried labor, capital, raw water (for both agricultural and non-agricultural use), recycled wastewater, and land. This fine disaggregation of primary production factors allows for a better characterization of production technologies and an appropriate representation of intra- and intersectoral resource allocation. In this context, we should also emphasize the added value of using two types of water resources in the SAM we have developed. Indeed, this ensures the availability of data on the flows of recycled wastewater used in some agricultural sectors in Tunisia.

➢ *Activity account:* This account includes twenty-four economic sectors, fourteen of which constitute agricultural branches. Given that the agricultural sector is the largest user of water in the country (with a volume consumed equal to 2722 million m³, or 75% of withdrawals in 2020 [6], we have attempted to further disaggregate this sector. In this context, agricultural activities using only raw irrigation water (represented by the following sub-branches: vegetables, dates, other fruits, other agriculture plus forestry) have been separated from those using recycled wastewater alongside the latter (represented by the following sub-branches: Soft wheat, Durum wheat, Other cereals, Fodder, Citrus fruits, Olives, Peach trees, Pomegranate trees, Henna, Tobacco). A more refined representation of this sector would allow us to consider the specific characteristics of Tunisian agricultural processes in our matrix, to capture the substitution and/or complementarity relationships between the various primary factors of production and, in particular, to examine, through the scenarios envisaged in the CGE models, the role that recycled wastewater can play in replacing raw irrigation water in the event of a shortage of the latter. The remaining non-agricultural economic sectors were classified according to their water consumption and relationship with the agricultural sector. For this purpose, the following sectors were considered:

- *Agri-food industry (AFI):* the upstream sector related to irrigated agricultural production activities. This sector, which has been separated from the manufacturing sector, is represented in our matrix by the following sub-industries: milk, flour milling, oils, canned foods, sugar, beverages, and other AFIs.
- *The drinking water production and distribution sector:* This sector is the second largest consumer of raw water in Tunisia, with an exploited volume of 817 million m^3, or 23% of the total volume of water consumed in 2020 [6]. This sector has been separated from the non-manufacturing sector.
- *The non-manufacturing industries and market services sector (INMSM):* an aggregate sector that includes the economic sectors that consume the most water after the agricultural sector and the drinking water production and distribution sector (mining sub-sector, energy sub-sector, hotels and restaurants, etc.).
- *Manufacturing industries and non-market services sector (IMSNM):* an aggregate sector representing economic activities that do not have a direct relationship with water, such as the mechanical and electrical industry sub-sector and the textile, clothing, and leather industry sub-sector.

Table 5 Micro-SAM structure (SAM inspired by the PEP-1-1 model [25])

+	**Factors**	**Agents**	**Taxes**	**Rest of the World**	**Activities**	**Products (domestic market)**	**Exports**	**Savings/Investment**	**Stocks Variation**	**Total**
Factors					Remuneration of factors					Total Factor Remuneration
Agents	Factor income of agents	Inter-agent transfers	Net taxes on products + customs duties	Transfers from the rest of the world to institutions	Payments from institutions (Taxes and indirect taxes Net of subsidies)					Institutional resources
Taxes						Net taxes on products + customs duties				
Rest of the World	Rest of the World factor income	Transfers to the Rest of the World				Imports at CIF prices				Recipes from the Rest of the World
Activites						Production for the domestic market	Export at FOB prices			Total revenue from activities
Products (domestic market)		Final Demand			Intermediate consumption matrix			Investment	Stocks Variation	Total local use of goods
Exports				Exports						
Savings/Investment		Agent savings		Funding needs/capacity						Total savings
Stocks Variation										
Total	Total factor income of the institutions	Institutional expenditure			Activity expenses	Total domestic supply		Total investment	Stocks Variation	

- The agents' account includes five institutions: first, Tunisian firms, which have relations with an aggregated region known as the Rest of the World (RoW); second, the government agent (GOV), which allows us to consider its interventions in economic activity; and third, two types of households: urban and rural.
- The tax account: in our research, we have used three types of taxes: direct taxes, indirect taxes on products, and indirect taxes net of subsidies related to the different activities.
- The account of products is destined to the local market: this account includes twenty-four types of products (the same products as the branches of activity considered as mono-product).
- The export products account: this account contains twenty-four types of products.
- The accumulation account is divided into two elements: savings/investment and stock variation (SV).

4. Results

4.1. Disaggregation of MicroSAM-WATER 2015

This section focuses on the different assumptions and calculation methods used to disaggregate the intermediate consumption sub-matrix and estimate the income from the different primary factors of production.

4.1.1. Development of the Intermediate Consumption Sub-Matrix

The intermediate consumption of the different agricultural activities was obtained both from the technical sheets of agricultural activities published by the Ministry of Agriculture [31] and from some unpublished studies by the the National Institute of Statistics. We also used agricultural sector data available in the 2003 matrix of [4].

On the other hand, to obtain the percentage of intermediate consumption of non-agricultural activities in relation to the Gross Domestic Product (input-output coefficient), we used data essentially taken from the Tunisian SAM for the year 2015 described in [8] and [18].

4.1.2. Estimation of the Income of Factors of Production

The value added of each activity (obtained by subtracting total intermediate consumption from gross production) is divided among the remuneration of the different factors of production. An SAM with several primary factors of production is an essential element in the analysis of the impact of different scenarios. The problem is that the Supply and Uses Table (TRE) divides Value Added only between compensation of employees and Gross Operating Surplus (GOS). This means that the latter aggregate includes income from other primary factors of production (capital, n-salaried labor, raw water, recycled wastewater, and land). As a result, we need to look for other sources of information and make some assumptions that will allow us to divide this GOS between the remuneration of each of these factors.

➢ *Estimating income of non-salaried labor:* Income of non-salaried labor is not recorded in official macroeconomic statistics. Based on [33], we account the number of laborers by category (family or salaried) for each activity. Following [4], we assume that non-salaried agricultural labor can be assimilated into family labor and unskilled salaried labor, and that it is paid at the guaranteed minimum agricultural wage. For the estimation of non-salaried labor in non-agricultural sectors, we have relied on [18] in the absence of more recent information.

➢ *Estimated income from farmland:* Compensation for land is calculated on the basis of its rental value multiplied by the area devoted to each crop.

➢ *Estimated income from water:* The SAM distinguishes between two types of water: raw water and recycled wastewater.

Raw water can be used for both agricultural and non-agricultural purposes:

- *Irrigation water:* The income of an agricultural sector from this type of water is determined by multiplying the total amount of water consumed by this sector [30] by the price per cubic meter of water, which is equal to 0.11 Tunisian dinars (DT). Table 6 summarizes the remuneration of irrigation water for different agricultural purposes.

- *Raw water for drinking water production and other non-agricultural activities:* The revenue from this type of water is easy to deduce, since we only need to multiply the quantity of raw water supplied by the National Water Exploitation and Distribution Company by the price per cubic meter of water, which in this case is equal to 0.515 DT, since this water is not subsidized by the State.

Treated wastewater: To calculate the government's revenue from this type of water, we proceeded in the same way as for irrigation water. The problem here is that the data on the consumption of this factor per hectare, which we obtained from the various annual reports of the National Sanitation Office [35], were only available for six of the ten agricultural sectors that use this water. For the remaining four sectors, we used the amount of irrigation water consumed per hectare (Table 7).

Table 6 Income from the "irrigation water" factor (The authors' elaboration)

Activities	Irrigated area (in hectares)	Water consumption in m^3/hectare	Water consumption in 1000 m^3/hectare	Total water consumption in 1000 m3	Average price (DT/m3)	Consumption in value (DT miles)
Soft wheat	145	2000	2	290	0.11	31.8
Durum wheat	41110	2000	2	82220	0.11	9044.2
Other cereals	2865	2000	2	5730	0.11	630,4
Forages	57800	3000	3	173400	0.11	19074
Vegetables	152000	5500	5.5	836000	0.11	91960
Citrus fruits	26170	7500	7.5	170105	0.11	18711.55
Olives	115820	3000	3	347460	0.11	38220.6
Dates	51900	9500	9.5	493050	0.11	54235.5
Grenadiers	8160	6000	6	48960	0.11	5385.6
Peach trees	11230	6000	6	67380	0.11	7411.8
Other fruits	14920	5000	5	74600	0.11	8206

Continuation of Table 6

Henna	540	5000	5	2700	0.11	297
Tobacco	1500	5000	5	7500	0.11	825
Other Agriculture and Forestry	91440	3500	3.5	320040	0.11	35204.4

Return of physical capital: Finally, the return on physical capital is obtained residually.

Table 7 Revenue from the "recycled wastewater" factor (The authors' elaboration)

Activities	**Irrigated area (in hectares)**	**Water consumption in 1000 m^3/hectare**	**Total water consumption in 1000 m^3**	**Average price (DT/m^3)**	**Consumption in value (DT miles)**
Cereals	2990	2	5980	0.02	119.6
Fodder	2554	3	7662	0.02	153.24
Olives	500	3	1500	0.02	30
Citrus	200	7.5	1500	0.02	30
Grenadiers	250	6	1500	0.02	30
Peach trees	300	5	1500	0.02	30
Tobacco	136	3.5	476	0.02	9.52
Henna	80	3.5	280	0.02	5.6
Total	7010		20398		407.96

5. Conclusion

In this paper, we described the steps taken to develop an SAM for the Tunisian economy in 2015, called SAM-WATER 2015. This matrix, which brings together economic data and data on raw water flows (for agricultural and non-agricultural use), and drinking water, represents a numerical reference base that can be used by CGE models dealing with the Tunisian context to evaluate the water policies adopted in this country, particularly those related to irrigation water. In this study, we have studied the two stages necessary to construct this SAM. In the first stage, a macromatrix was constructed on the basis of data collected from the national accounts. In the second stage, we defined the assumptions and estimation methods needed to disaggregate the latter accounts and construct a micro-matrix with 90 rows and 90 columns. Compared to other publications that studied the water situation in Tunisia, in particular those of Chokri Thabet, who included only raw irrigation water in his SAM, SAM-WATER 2015 includes two types of water in the factor of production account, namely raw water and recycled wastewater, and makes a distinction in the activity account between agricultural branches that use only raw water and those that use recycled wastewater in addition to this type of water. In the same activity account, we explicitly introduced the economic sector related to the production of drinking water. These findings allowed us to gain a better understanding of the water cycle in Tunisia, which in turn will allow us to assess, through the scenarios expected in the CGE models, the economy-wide impact of the policies applied to the water sector in Tunisia.

One of the difficulties we encountered in constructing our matrix was the partial unavailability of environmental data on water flows, particularly recycled wastewater. This meant that we sometimes had to use simplifying hypotheses or resort to data that may be relatively old or lacking in precision. All this leads us to propose, as a research perspective related to the Tunisian context, the need to develop an Environmentally Extended Social Accounting Matrix based on the System of Environmental Economic Accounting (SEEA), published by the United Nations in 2014. This system provides an accounting framework that links environmental and economic data while respecting the definitions and principles of the System of National Accounts. Another no less important research prospect is the introduction of desalinated seawater as another type of this resource in the production factor account.

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