

Dentinho, Tomaz; Ferreira, Pedro; Silva, Vasco

Conference Paper

Input Output Tables for the Management of Water Resources in Islands. The Case of Terceira Island.

46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Dentinho, Tomaz; Ferreira, Pedro; Silva, Vasco (2006) : Input Output Tables for the Management of Water Resources in Islands. The Case of Terceira Island., 46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/118209>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

46th Congress of the European Regional Science Association

"Enlargement, Southern Europe and Mediterranean"

Volos, Greece

August 30th – September 3rd 2006

Input Output Tables for the Management of Water Resources in Islands. The case of Terceira-Azores

Pedro Ferreira, Gabinete de Gestão e Conservação da Natureza, Centro de Estudos de Economia Aplicada para o Atlântico, Universidade dos Açores, Angra do Heroísmo, Portugal. azpedro@gmail.com

Vasco Silva, Gabinete de Gestão e Conservação da Natureza, Departamento de Ciências Agrárias, Angra do Heroísmo, Portugal. vrms76@gmail.com

Tomaz Dentinho, Gabinete de Gestão e Conservação da Natureza, Centro de Estudos de Economia Aplicada para o Atlântico, Universidade dos Açores, Angra do Heroísmo, Portugal.
tomaz.dentinho@mail.angra.uac.pt

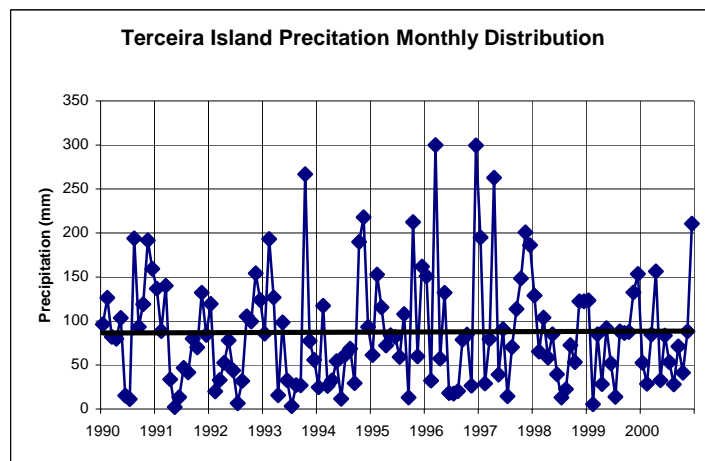
Abstract

Islands are attractive places for tourists and most islands can be, sooner or later, requested by an increasing tourist demand. But islands are also places where natural capital has very defined limits. The aim of this paper is to assess the carrying capacity of islands in terms of water in relation to the tourist demand. We use an Input-Output Table Model and expand it to include the use of water by the different sectors and by the households. The model is estimated for Terceira island in the Azores using cross entropy methods. The structure of the model is obtained from the Input-Output Table of the Region. The data to estimate the model comes from the employment and production of the companies in each island and from the respective water demand and supply. We simulate the model for different levels of water demand and discuss the competitiveness of the islands' tourist sector and sustainability.

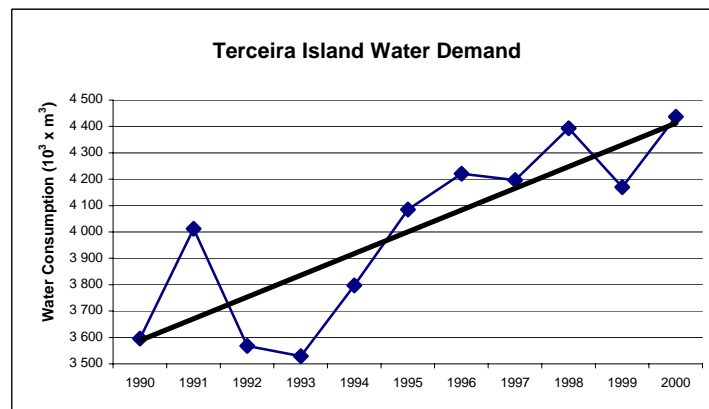
1. Introduction

Many islands are either consuming or are expected to consume more water than their annual renewable supply. This is due, on the one hand, to high economic growth rates associated with tourism development and, on the other hand, to strongly limited water resources. Usually, new sources of water are exploited to cope with the increasing demand, namely through ground water wheels, desalination and water reutilization (Zacharias & Koussouris, 2000; Voivontasa et. al., 2003). However, this poses new problems to tourism competitiveness, to water pollution and to the islands sustainable development (Gossling, 2001; Kent, 2002; Stubbs and Carpenter, 2003).

Looking at Graphs 1 and 2, estimated for Terceira Island, it is clear that water renewable supply provided by precipitation is quite constant along the years (Graph 1) whereas water demand is increasing sharply (Graph 2).



Graph 1: Precipitation per month in Terceira Island (Source: Instituto Meteorológico)



Graph 2: Evolution of Water Demand in Terceira Island (Source: Instituto da Água)

The aim of this paper is to examine the relationships between water demand and water supply in Terceira island, both of them with strong seasonality. Assuming that exports

are the main drivers of small economies, we try to explain the annual variations of water demand based on an Input-Output model for the island and on the changes of the basic sectors composed by public external support, agricultural exports and tourism. On the other hand, precipitation associated with land cover is the main factor that influences the supply of natural renewable water.

The study of water using input– output tables has been done already (Velasquez, 2006). What seems to be new is the use of Input Output Tables to analyse seasonal effects of the economy on water demand suitable to be related to with the seasonal effects of water supply. This is the approach taken in this paper.

2. Methodological Approach

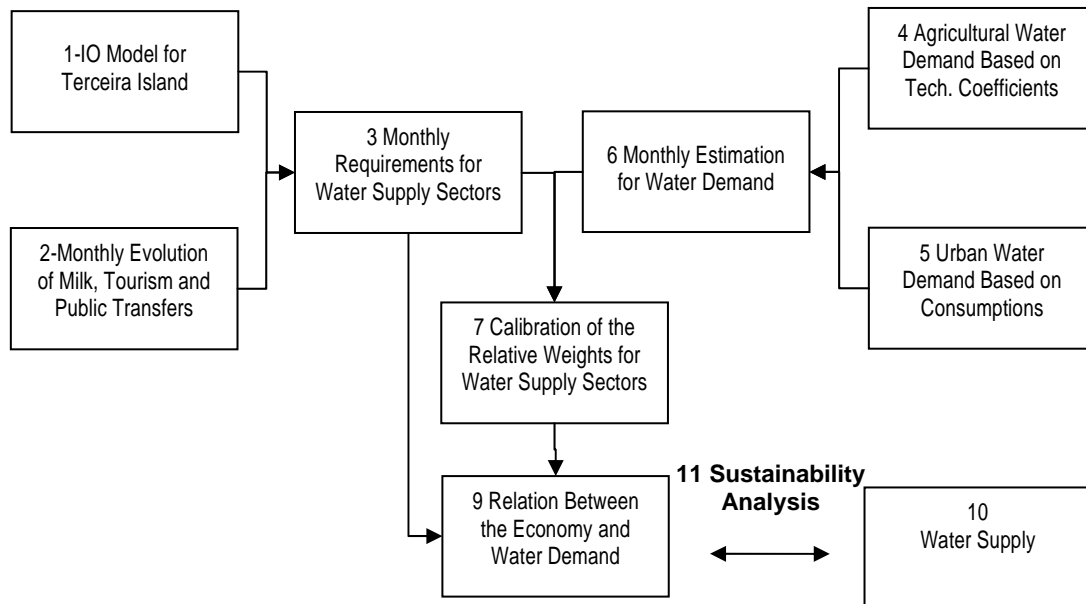


Figure 1: Methodological Approach

The scheme in Figure 1 explains the approach taken:

- First, we estimate the relation between economic activity and monthly water requirements for water supply sectors such as agriculture and water sector (3), using Input-Output Tables for Terceira island (1) and the monthly variation of basic activities such as tourism, dairy production and public support in the island (2).
- Second, we evaluate the water demand (6), based on urban consumptions (5) and estimated agricultural uses (4) and also estimate the water supply based of hydrological data (10).

- Third, we calibrate the relative weights for water supply sectors (7) to adjust the monthly requirements for water supply (3) with the monthly estimation of water demand (6), and define a relation between the seasonal evolution of the economy and the variations of water demand (9),.
- Fourth, we analyse the sustainability of the system (11) through the comparison with the water demand (9) with water supply (10).

3. Data and Results

3.1. Relation between economic activity and water requirements.

In this point we estimate the relations between the economic activity and the water requirements for water supply sectors, such as agriculture and water sector. We start to estimate the Input-Output Tables for Terceira island. Then we pick up the monthly variation of basic activities such as tourism, dairy production and public support. Finally we obtain the seasonal variation of the water supply sectors (Agriculture and Public Water Supply).

The Input-Output Table for Terceira Island

The Input-Output Table (IOT) for Terceira Island was estimated by a method that maximizes the use of all available data (Ferreira, 2005). It's a hybrid method composed by two distinct steps: margins estimation and intersectoral flows estimation.

Sector	Multiplier	Sector	Multiplier	Sector	Multiplier
1	3.11	16	2.24	31	2.75
2	3.54	17	1.87	32	3.49
3	3.44	18	1.03	33	3.40
4	2.50	19	1.02	34	2.99
5	3.03	20	1.03	35	1.87
6	3.24	21	1.08	36	1.02
7	3.02	22	3.74	37	2.88
8	2.95	23	3.47	38	2.68
9	1.77	24	3.43	39	1.93
10	1.23	25	3.22	40	2.44
11	3.41	26	3.44	41	3.31
12	1.59	27	3.40	42	3.31
13	1.00	28	3.45	43	3.28
14	1.08	29	3.26	44	3.29
15	1.13	30	5.22	45	3.26
				Families	3.44

Table 1: Production Multipliers of input-output model with endogenized consumption

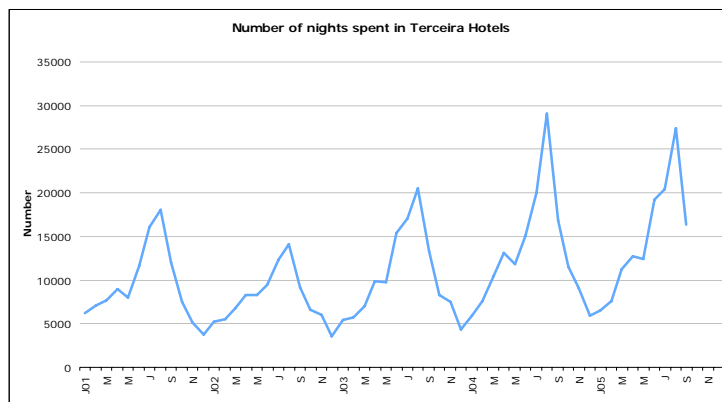
The margins of the matrix were split in as much components as possible and each one was estimated separately. Some of these components were estimated with the bottom-up philosophy, whenever the available data on employment and production permitted. Other components were estimated by indirect methods or top-down. There is a special margin component, which is the intra-island trade. Since there were no available data,

these estimates were obtained with the cross-industry location quotients (Elliott et. al.,1994)

The estimates for the intersectoral flows had to take into account that the archipelago is very heterogeneous because São Miguel Island represents more than 50% of the economy. Therefore we first extract São Miguel from the Regional IO Tables, and then we use the structure from the rest of the Azores as the basic structure to determine the IO Tables for Terceira Island using a cross-entropy techniques (Mesnard et. al., 2004; Herrero et al.,2002). Based on Eurostat methodologies (Eurostat, 2002) we endogenize the final consumption in order to obtain the total effects on the island economy from the variations of the basic sectors. Table 1 presents the Production Multipliers for the 45 sectors considered and also for the endogenized consumption sector, named as “Families”.

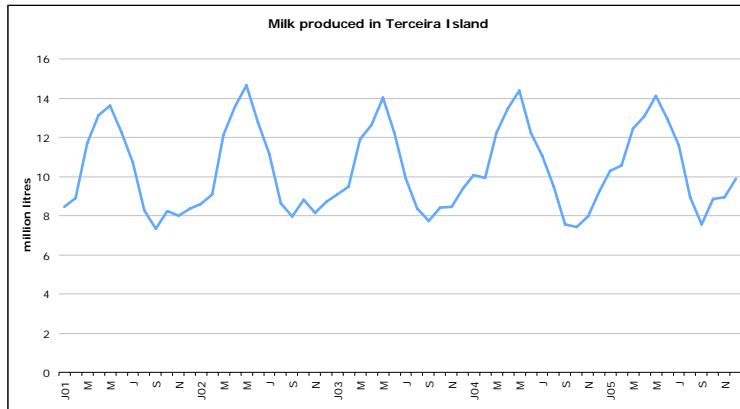
The variation of the basic activities

The next step is to pick up the data from the evolution of the basic activities and to estimate the evolution of the production for the sectors that use directly the water: agriculture and public water supply.

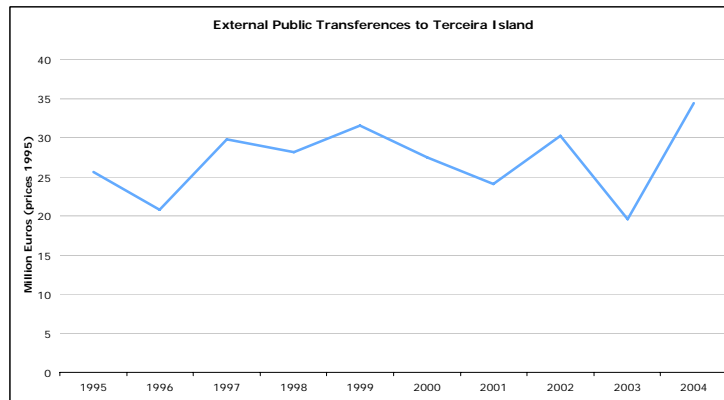


Graph 3: Nights Spent in Terceira Island Hotels (Source: SREA)

As we can see from Graphs 3, 4 and 5 both tourism and dairy are very seasonal. Tourism has a peak in August and Dairy has another peak in May. Therefore it is expectable the production of each one of the sectors related to water supply would have some seasonality.

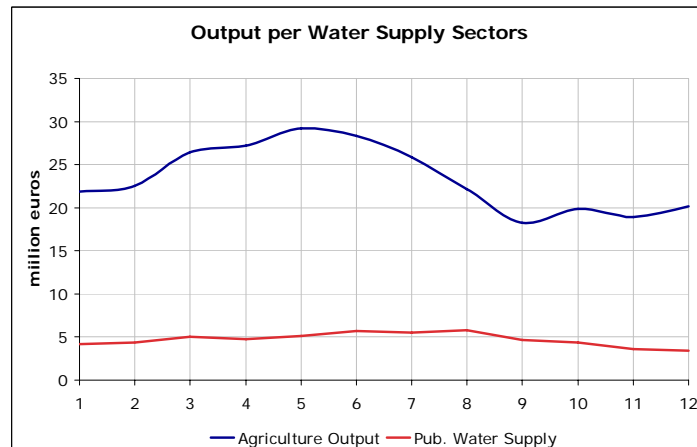


Graph 4: Milk produced in Terceira Island (Source: SREA)



Graph 5: External public transferences for Terceira Island (Source: DREPA and UAC)

Actually there is some seasonality in the production of the public water supply and a strong one associated with the agricultural sector.



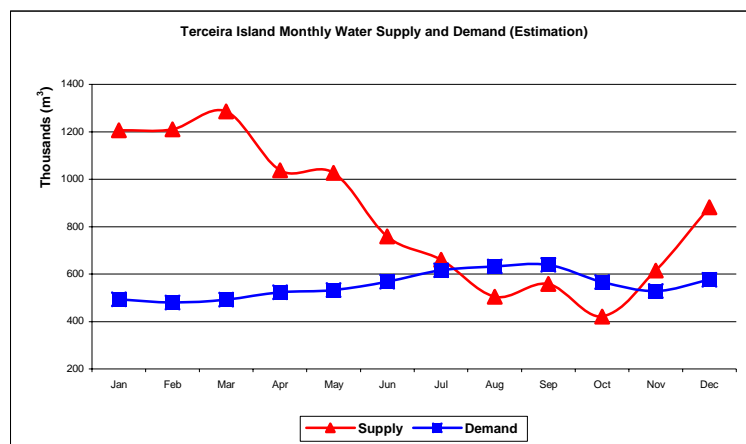
Graph 6: Monthly Output per Water Supply Sectors (Agriculture and Public Water Supply)

3.2. Evaluation of water demand and supply.

The evaluation of the water demand for Terceira Island is done both for the urban sectors and for agriculture. For the urban water demand we use actual data from the public water services of the two existing municipalities (Angra do Heroísmo e Praia da Vitória). For the water demand of the agricultural sector, we use technical coefficients for water consumption on bovine cattle. We do so due to the lack of information on the

agricultural use of public fountains. The use technical coefficients relate the type of animals with a capitation of water per day, making relatively easy to obtain a total amount of water consumption for the dairy farming, considering the availability of information on the number of animals and their type. Notice that the number of animals vary along the year and irrigation practices are insignificant in Terceira Island (Graph 7).

The evaluation of the potential water supply for Terceira Island is achieved taking into consideration the monthly flows coming out from the springs of the island. Many of the existing springs supply have measuring devices that register their flow, and the others despite the lack of such detailed data, have information regarding their flows, usually a Winter flow value and a Summer value. Taking into consideration the small dimension of the island, we use the distribution of the springs with monthly values as a reference for the other, thus we obtained an evaluation of Terceira Island water supply (Graph 7).



Graph 7: Terceira Island Monthly Water Supply and Demand

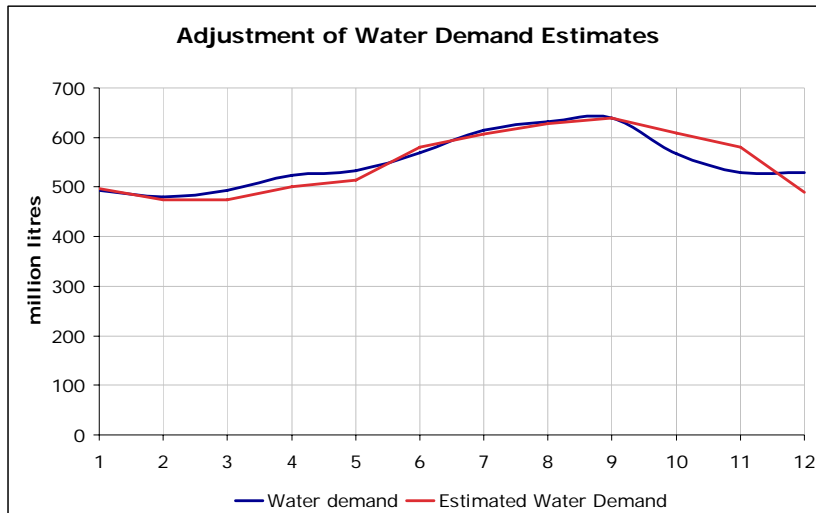
From the analysis of Graph 7 it is possible to see that there is a period of water shortage from August until October where the supply of water must recruit the input from ground water.

3.3. Adjustment of water demand to economic activity.

The question now is how to relate the water demand with the economic activity. We do that through the calibration of the relative weights for water supply sectors (Graph 6), to adjust these monthly requirements for water supply with the monthly estimation of water demand (Graph 7), and define a relation between the seasonal evolution of the economy and the variations of water demand (Graph 10).

Two previous adjustments are made. The first is done to relate the production for each one of the water supply sectors with the water demand. For this we multiply the series of Graph 6 by the ratios of Annual Output of Water Supply Sector to the associated

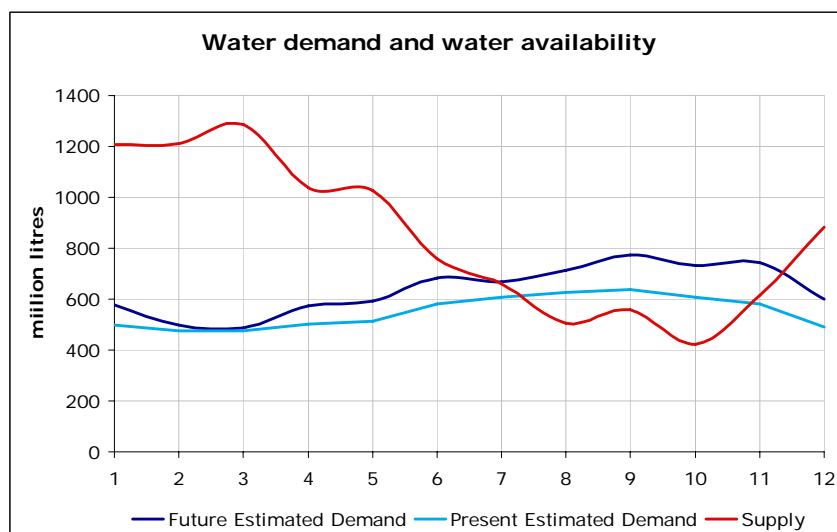
annual water consumption. The second adjustment is a made to phase the two series. Actually, since the peak of the water supply sectors is tree months in advance of the peak in the water demand we shift the variation of the economy for three months later. This can be accepted since the multiplier effects implicit in the Input-Output Tables takes around three months to develop. Finally the weight between the two economic derived series is calibrated in order to minimize the sum of the square errors between water demand in (Graph 6) and water demand associated with the economic model.



Graph 8: Adjustment of Water Demand Estimates

3.4. Analysis of the System Sustainability.

The Azores islands have high precipitation. The reason why there can be problems of water quantity is due to the fact that the islands are relatively small and the capacity to keep water is not great.



Graph 9: Water demand and water availability for two scenarios

In Graph 9 it is shown that an increase of 50% percent of the tourism flow, similar to the one that occurred in São Miguel Island from 2002 until 2006 due to the introduction

of charter flights, will increase the months with water shortage from three to five. The shortage can be even worse since the water consumption per tourist is around 375 l/day, which compared to the normal assumed consumption per inhabitant (80 l/day to 150 l/day) (Plano Regional da Água, 2001).

4) Conclusion

Tourism has become one of the main export activities of the Azorean islands, promoting and diversifying an economy strongly dependent on external public transferences and on the dairy exports, and stimulating a greater appreciation for the natural environment. But not all is good news, since tourism is also responsible for a greater use of some of the natural resources of the island, mainly water. In this paper we try to illustrate this situation showing how a raise in tourism can lead to an increase shortage of spring water from three to five months.

We also show how to disaggregate Regional Input-Output models into suitable zone for environmental analysis, such as islands, and how to use these tools to study the seasonal variations of water demand and water availability. In future works we intend to include different sources of water - surface water, ground water, sea water - and their respective costs, in order to assess the benefits, costs and risks associated with the tourist development in small islands with limited water resources.

Bibliography

Direcção Regional de Ordenamento do Território e dos Recursos Hídricos & Instituto da Água (2001). "Plano Regional da Água: Relatório Técnico".

Elliott M. V., A. T. Flegg and C. D. Webber. On the appropriate use of location quotients in generating regional Input-Output Tables. *Regional Studies*, 29(6):547-561, 1994

Eurostat. The ESA 5 Input-Output Manual: compilation and Analysis. European Commission, 2002

Ferreira, P. "Desagregação pelas Ilhas da Matriz Input-Output dos Açores. Tese de Mestrado em Gestão e Administração". Departamento de Economia da Universidade dos Açores (2006).

Gössling, S. "The Consequences of tourism for sustainable water use on a tropical island: Zanzibar, Tanzania." *Journal of Environmental Management* 61 2001 179-191.

Herrero, R. A., García, A. S. and Carvajal, C. R.. Spatial Projection of Input-Output Tables for Small Areas. 42nd Congress of European Science Association, 2002

Jeffrey Stubbs & Clive Carpenter -Water in Small Island Countries. WWForum. (2003) http://www.adb.org/Documents/Events/2003/3WWF/3WWF_Small_Islands_Report.pdf

Kent, M., Newnham, R. and Essex, S. "Tourism and sustainable water supply in Mallorca: a geographical analysis." *Applied Geography*, 2002, 22pp. 351-374.

Laboratório Nacional de Engenharia Civil (2001). “Desenvolvimento de um Inventário das Águas Subterrâneas dos Açores: Relatório Final.

Mesnard, L.. Biproportional methods of structural change analysis: a typological survey. *Economic Systems Research*, 16(2):205-230, 2004

Rodrigues, Francisco Cota “Hidrologia da Ilha Terceira (Açores – Portugal)”. Universidade dos Açores (2002).

Voivontasa, D. Arampatzisa, G. Manoli E., Karavitisb C., Assimacopoulos D.. “Water supply modeling towards sustainable environmental management in small islands: the case of Paros, Greece”. *Desalination* 156 (2003) 127-135

Velazquez, Esther. “An input–output model of water consumption: Analysing intersectoral water relationships in Andalusia” *Ecological Economics* 56 (2006) 226–240

Zachalrias I. and Koussouris T. “Sustainable Water Management in the European Islands”. *Phys. Chem. Earth (B)*. Vol. 25, No. 3, pp. 233-236,2000.