Sustainable Management of Human Water Consumption: a Preliminary Case Study in North-eastern of Portugal

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Abstract

Portugal is experiencing a drought. In April, 2005, about 80% of the country, including our study area, has a severe to extreme drought. Hence, there are a lot of difficulties in regards to the current water needs for human consumption, agriculture, ecosystem, etc. This is a scenario that can repeat itself more often in the future because of the effects of climate change. Proper water management is one of the key issues that can make sustainability practical.

We studied and utilized a multi-dimensional model in order to capture the dynamics of water use in Portugal. To begin with, we used a municipality in the North-eastern part of the country called Bragança. Although it is more humid than the southern municipalities, nonetheless it has had severe water problems this year. We used four different dimensions to understand the sustainability of the water supply system of the municipality. These are: price, quantity of the water used, quality of the water used, and the mode of life. Their values were in binomial form: price (free / pay, as some part of the system operated free of charge), quantity of water (low / high, a threshold was defined to separate the two levels), quality of water (satisfactory / unsatisfactory, as related to the legal norms), and mode of life (rural / urban, a crude first step characterization of this social parameter). The results show that the worst scenario reflects the following situation (free, high, unsatisfactory, rural). And the best is (pay, low, satisfactory, urban). This preliminary study has made the authorities of the municipality more

aware of the problems of the system and a number of them are being solved. However, to make the model more useful towards a sustainable management, its further refinement is underway, to be also applied to other regions.
Keywords: human water consumption, North-east of Portugal, multi-dimensional model, quantity and quality of water, water price, mode of life

1 Introduction

Water - long thought of being a never ending resource – has become one of the major problems of this new century. Either it is too much and causes floods that devastate whatever is on their way or not much of it is available and causes countless human sufferings and deaths. Particularly of great importance is the amount of water necessary in each region for human consumption. Worldwide some 6,000 children die every day from diseases associated with unsafe water and poor sanitation [1]. On the other hand the phenomenon of climate change is affecting more and more the normal water availability of the regions.

The first Earth Day was celebrated in 1970, some 35 short years ago. In the meantime, environment takes great proportions and now sustainability is the greatest challenge before the human race. " …, it was hardly a secret — or even a point in dispute — that progress in implementing sustainable development has been extremely disappointing since the 1992 Earth Summit, with poverty deepening and environmental degradation worsening." [2]

Portugal is experiencing a drought. In April, 2005, about 80% of the country, including our study area, has a severe to extreme drought [3]. Hence, there are a lot of difficulties in regards to the current water needs for human consumption, agriculture, ecosystem, etc. This is a scenario that can repeat itself more often in the future because of the effects of climate change. Water is one of the key factors, if not the key factor, in great parts of Portugal.

In this study, we are trying to understand in a better way the inter-relationships between various players in order to make water management more sustainable for the future.

2 A Preliminary Model

The European Water Framework Directive [4] is a legal instrument in many countries of the European Union. Its articles refer to the necessity of dealing with the price, quantity of the water used and its quality. But water, as essential as it is in all aspects of life particularly for human consumption, is also related to the mode of life of the inhabitants of a region. Hence, these four dimensions formed our preliminary model for assessing the sustainability of water consumption systems in Portugal.

Data and reliable measurements is one of our major problems. Consequently early on we decided to use qualitative data, at least as a first trial, in order to characterize the water systems. A binary approach seemed sufficient to conclude some of our first results. So the dimensions got the following values:

- Price (P): the impact of price on sustainability is very important and indeed an important factor in any management scheme [5]. But besides doing a full range economic analysis and the fact that part of our systems are free, we decided to make a division on those who pay (whatever the amount) and those who use the system for free. Hence the values for this parameter are: free (f) or pay (p).

- Quantity of water used (Q): This is the quantity of water consumed at the level of analysis (parish or municipality). It is of great importance particularly for a country with drought scenarios as Portugal. In order to use a two-valued parameter, a threshold was defined as to be the average value of the water consumed for all the system. A minimum per household or some other values could have been used. In any rate, this threshold water consumption gives the values for this parameter as low (l) or high (h).

- Quality of water used (L): No doubt one of the important dimensions of any water model for human consumption is its quality. Quality is determined according to the national norms in vigour. But norms are of different categories, one being more tolerable than the other, for example a toxic substance. The determination of whether a substance has violated its norms or not, sometimes is very costly and out of reach of some systems. According to these legal specifications, the value of the quality of water used can be satisfactory (s) or unsatisfactory (u).

- Mode of life (M): Different people in different countries have different habits and their water use changes. Such changes can be linked to a number of socio-economic indicators for a full range of types of living. Because Portugal is the 2nd most rural country in the European Union [6], for the time being, two values were used for this descriptor: rural (r) or urban (u).

3 Application

3.1 The study area

Bragança is the name of a North-east Portuguese District (Figure 1), a Municipality and a city. The Municipality consist of 49 parishes, 3 of them being urban and 46 rural [7]. The average area of a parish is 24 km^2 with a population

density that ranges between about 3 and 1560 habitants/km^2. The average temperature is about 12.2 ºC and an average rainfall of about 740 mm. The first canal structure for water distribution dates back to the 1st century A.D. Today the water supply system is divided between the City Hall of Bragança (a central system) and each individual parish. There exist 108 of these independent smaller water supply systems. Also there are those who use wells to get to groundwater for their use.

Figure 1: Localizing the District of Bragança

3.2 Results

The following figures depict some of the results produced for the current case. Figures 2 and 3 give the prices and the mode of life in relation to the population. As can be seen, almost half of the population live in either urban or rural, with the former living in only about 5% of the area of the municipality. It is also typical of all the districts of the country that most of its parishes are of the rural type. Although most of the municipality pays for the water services, but 35% of the population is still using

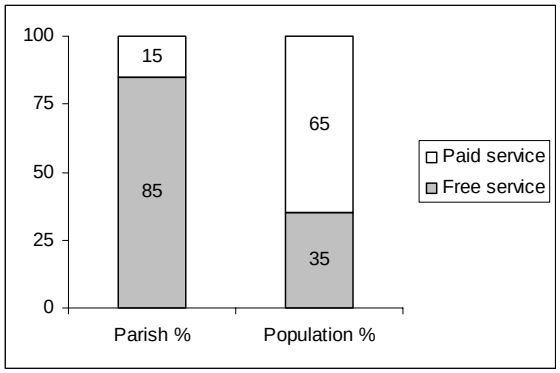

Figure 2: Prices of the water used

free water. This indeed is one of the problems and socially very difficult to solve.

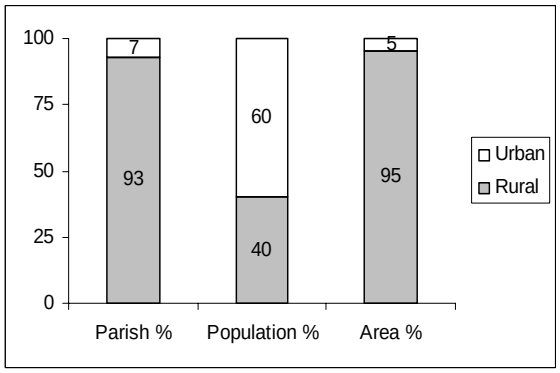

Figure 3: Mode of life in the Municipality

The relations of the quantity of water used are illustrated in Figures 4 and 5. The urban population uses some 5 m^3 per habitant per month of water. On the contrary of the rural area that triples that amount. The weighted average of these two values gives 9 m^3 which has served for comparison purposes.

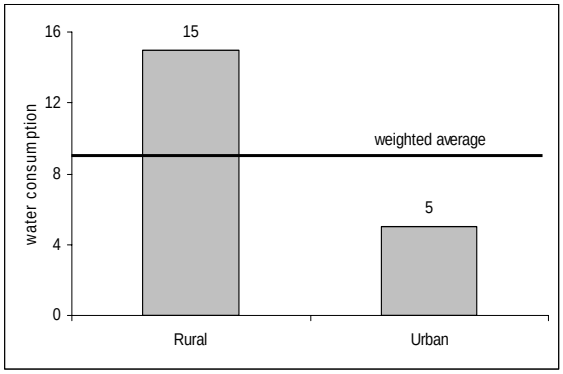

Figure 4: Quantity of water used (m^3 per habitant per month) for different modes of life

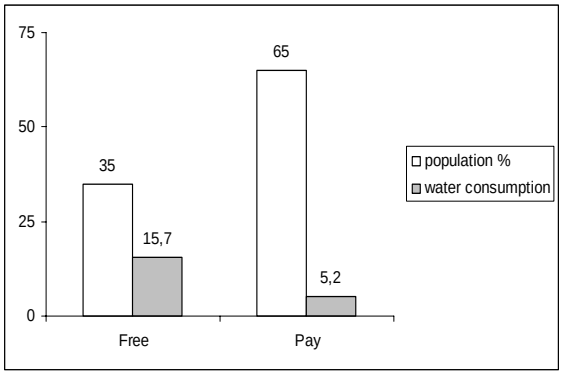

Figure 5: Quantity of water used (m^3 / habitant / month) vs. price

Figures 6 and 7 portray the quality of the water used in the Municipality of Bragança. During last few years, on the average, about 10% of the analyses were found outside of the allowable limits (Legally Unsatisfactory Results). However some of these LURs, are alarming and needed immediate care.

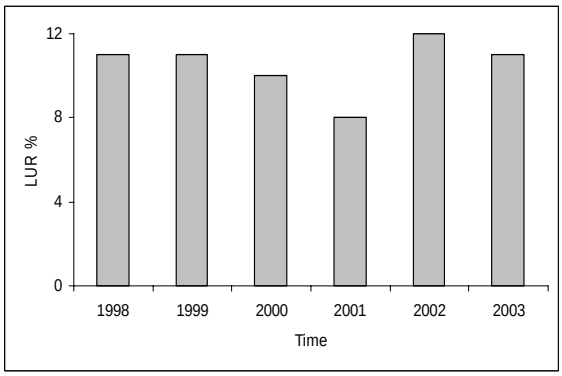

Figure 6: Legally Unsatisfactory Results (violation of the Allowable Limits) for the Municipality of Bragança

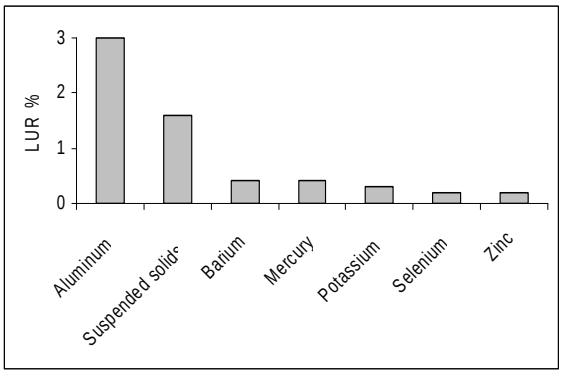

Figure 7: LUR (Legally Unsatisfactory Results, violation of the Maximum Allowable Limits) for a few parameters for the Municipality of Bragança

Residual Chlorine is one of the major problems of the municipality. Almost 75% of analyses showed results outside the Lower and Upper Allowable Limits: LAL of 100 and UAL of 500 mg/L (Figure 8). Its solution is not easy because there are 108 independent water supply systems and the local capacities for handling such situations is very limited, particularly in the rural areas.

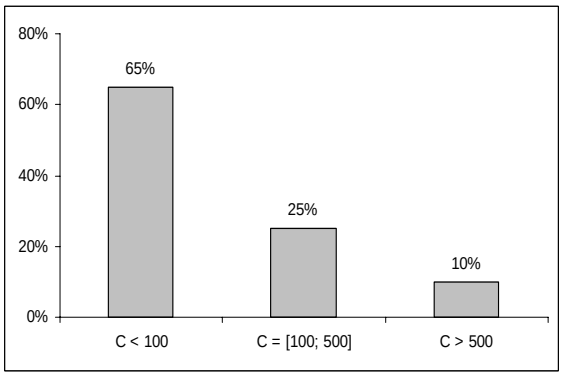

Figure 8: Average concentration of residual chlorine (C, mg/L) for the year 2002 for the Municipality

Figures 9 and 10 show LUR for selected parishes. Gimonde, a rural area showed the worst results. Rossas, having the highest population density, showed results that are alarming. How does a water system grow to be sustainable, such as becoming more resistant to these abnormalities?

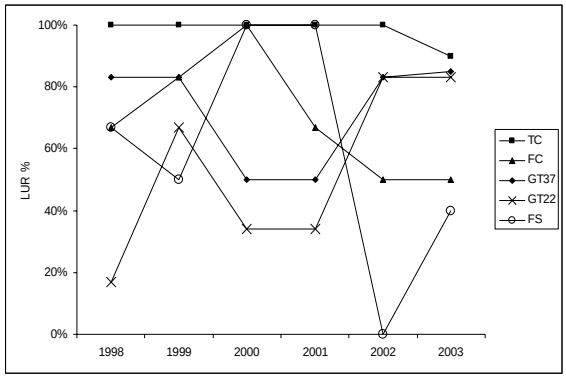

Figure 9: LUR in the parish of Gimonde, a rural area with the worst quality results

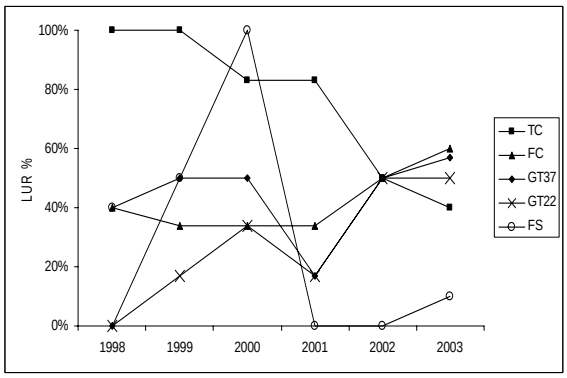

Figure 10: LUR in the parish of Santa Comba de Rossas, a rural area with the highest population density

Table 1 shows the relationships between the 4 dimensions discussed in this paper. It also shows these relations for an ideal water supply system. To better understand the table, make questions based on the first column. For example: In an urban area (Mu), should we use high quantity of water (Qh)? Table shows that for the municipality in study, the answer is not defined because some use high quantity and others low. However in an ideal system, the answer should be "No" (N). Of course there should be care in how Qh has been defined.

Table 1: Relationships of the 4 dimensions used in characterising the water supply systems of the Municipality of Bragança vs. an Ideal System

	Pf	**Pp**	**Ls**	**Lu**	**Ql**	**Qh**
Ls	-/N	Y/Y				
Lu	Y/N	-/N				
Ql	-/N	Y/Y	Y/Y	-/N		
Qh	Y/N	Y/Y	-/-	Y/N		
Mr	Y/Y	Y/Y	Y/Y	Y/N	-/Y	Y/N
Mu	-/N	Y/Y	Y/Y	-/N	Y/Y	-/N

However to analyse Table 1, it should be noted that it portrays a bi-dimensional function and consequently some apparent contradictions. In reality the policies for sustainable development of the systems should be defined in response to multiple factors. Anyhow, for the Municipality of Bragança, the Table found some problems that needed solutions.

4 Conclusions

Sustainable planning is the greatest issue of our time. Conceptually very easy and appealing but trying to put it in practice and manage systems have proved and will continue to prove very difficult. The fundamental reason for such an apparent discrepancy is the extreme complexity inherent in a sustainable system, hence holistic and unified approaches are very necessary.

Water touches almost everything in our civilization. It is a complex phenomena coupled with another multifaceted issue – climate change. Consequently water resources management is one of the key problems in the world of sustainable development. It is obvious that not only quantity and quality of the water used for human consumption are of paramount importance, but the prices and the economy of the services as well as the mode of life of the individuals play important roles. Particularly in drought situations, like Portugal, groundwater becomes a strategic resource and its sustainable use equally strategic [8].

Our case study with the Municipality of Bragança, showed that a rather cursory analysis of the parameters of the water supply system can indicate severe

problems, that the local population, politicians and institutions were not aware. It is important to analyse the systems in multiple dimensions through proper indicator development. It was found that the free water accessible by a sizable portion of the municipality is unsustainable and although the values for the year 2003 shown above are not final, the trend indicates an unsustainable system. Residual Chlorine is indeed one of the major problems and the authorities now are determined to deal with it.

5 References

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