TOWARD DEWATERISATION OF REGIONAL ECONOMIES

François Schneider, Justina Catarino, Anabela Nogueira, Fátima Rodrigues and Cristina Santos

INETI/CENDES, Edifício E, Estrada do Paço do Lumiar, 22
1649-038 Lisboa, Portugal, francois.schneider@ineti.pt

Science for Water Policy: the implications of the Water Framework Directive", 2-4 September 2002, Norwich, UK

Abstract

In parallel to the concept of dematerialisation, the concept of dewaterisation is introduced here. The concept deals with reducing the fundamental sources of water shortages and pollution: reducing water abstraction linked to a region and preventing the introduction of water pollutants within economies. Appropriate indicators taking into account of total water withdrawal and total introduction of water pollutant linked to the relevant environment problems in the area of study need to be developed. Goals of dewaterisation need to be set and supported by the analysis of water metabolism in regions. The solution lies within the limits of so-called “use basins” and not by exporting water problems.

1. Water Framework Directive

The publication of the Water Framework Directive[1] is an important improvement on earlier EU water legislation. The Directive acknowledges a great importance to the safeguard of all water bodies including underground water. Water represents a "heritage that must be protected, defended and treated as such". The main achievement of the Directive is an ambitious timetable to approach a "pristine" situation for all European water bodies by 2027.

Forecasting is about predicting the future state-of-affairs, and backcasting is a way of constructing a desirable future (Robinson 1990, Holmberg 2000). Instead of "forecasting" the result of the present trends, the Directive develops a type of backcasting approach by defining the desired goal, and the intermediate steps to reach it. The backcasting approach can enable to avoid the only focus on "end-of-pipe" measures and planning infrastructures to comply with the trends. However analysis is strongly focussed on monitoring pressures and impacts on river basins and management of water bodies.

2. Preventive Approach

A preventive approach is required too. Fundamental improvements and safeguard of natural water systems also need to incorporate important data on our way of using water. For this reason, the Water Framework Directive calls also for an understanding of water use. The article 5 states: "each member state shall ensure that for each river basin district (…) an economic analysis of water use is undertaken (…)". This is a difficult challenge, because as soon as 2004 the first round of economic analysis of water use needs to be achieved.

Environmental problems linked to water usage are not going to cease as long as we continue to increase inputs in the economy of always more water and more substances that are going to create water problems. Whether or not the problem caused has yet been detected at the level of a river basin, we know that surface and underground water withdrawal is taking water away from ecosystems, that it will increase the amount of water to be treated. Similarly, we know that the use of chemical fertilizers or pesticides create, in fine, nitrogen or phosphorus or pesticides water pollution. We know that detergents and their constituents will go to the water at the end of their use life and heavy metals do not disappear (Raach 1999). Proper treatment is often impossible in times of heavy rainfall in combined sewer systems, and the rainwater and stormwater runoff carry many

[1] http://europa.eu.int/comm/environment/water/water-framework/index_en.html

pollutants too and represents a wasted resource when it falls on a city. We can and should develop water pollution control and wastewater treatment, but we should be aware that they represent only short term and often incomplete curative measures.

As long as the law of mass conservation continues to be valid, the only long-term, secure and often most economical way to avoid transfer of problems is to act at the source. The steps consisting in focussing on the environmental side to find out problems and then to find out remediation measures and to look for responsible entities is a very slow process as water problems may take a long time to appear. Moreover this approach will very unlikely manage to deal with non-point sources and find out all sources of specific water problems.

We suggest here that the methodologies used for the economic analysis of water use should be better defined. Economic analysis should also be about application of the polluter-pay principle and financial incentives. But for these to be successful, as well as for a general successful implementation of the directive, we suggest that the backcasting approach developed at the environmental level should be extended to the socio-economy. We define then the objective in terms of reduction of water use and minimisation of the introduction of water pollutants in the economy in order to comply with the desired environmental goal. This requires the proper development of parameters at the level of society activities. A “factor X” of “dewaterisation” can then represent a target to be achieved.

3. Material Flow Analysis (MFA)

3.1 General framework

For this purpose Material Flow Accounting (MFA) can represents a fundamental tool. Material Flow Accounting is based on the very simple Law of Lavoisier stating the conservation of mass. At the level of each process and at the level of the whole system, inputs are equal to outputs.

The MFA methodology follows four phases (van der Voet 1996):
1. Definition of goals and limits of the system
2. Inventory of flows
3. Modelisation
4. Possible improvements and conclusion.

We will consider two ways of using MFA:
- Development of input indicators for dematerialisation
- Analysis of material metabolism within regions.

Subsequently we shall develop the specific application to Water Flow Analysis (WFA) for dewaterisation and analysis of water metabolism.

At the regional level, the ultimate goal is a dematerialisation through a partial regionalisation of the economy (from the *status-quo* of figure 1 towards the target of figure 2). This results in a reduction of the material flows between the regions and with foreign countries (because of the increased use of regional resources) and within the region (because of the increased resource efficiency of regional products and services) (Hinterberger & Schneider 2001).

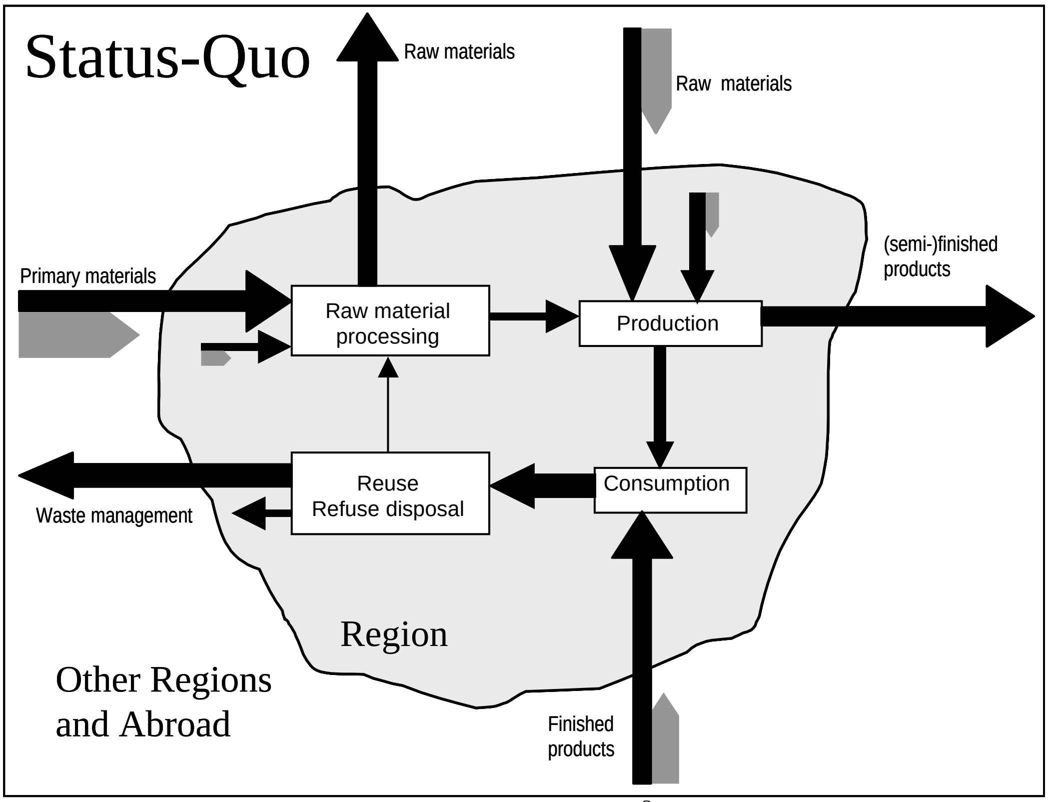

Fig. 1: Regional material flows- Present situation[2] *(Hinterberger & Schneider 2001)*

---

[2] *Black arrows represent material used in the region and grey arrows the ecological rucksack. All waste flows have not been shown for clarity*

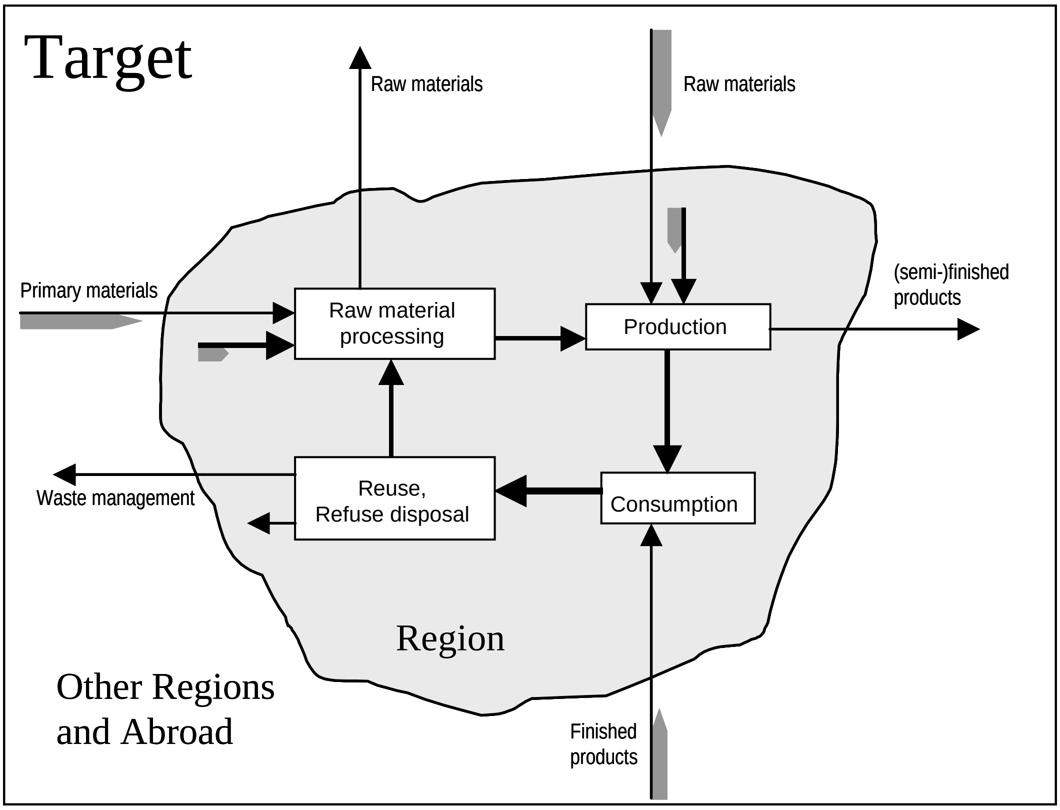

Fig. 2: Regional material flows- Target situation (Hinterberger & Schneider 2001).

3.2 Material Flows Analysis used to develop input parameters for dematerialisation

Schmidt-Bleek (1993) developed the idea of developing an input indicator based on total material flows. This input indicator consists of the sum of extraction within the defined region or system, plus imports from other regions.

Total Material Flows used as input indicator are relevant because:
- They represent a “Source” metrics, and can then be fundamentally preventive
- Data is more readily available
- They provide a comprehensive representation of the impact of human activities on the ecosphere
- They are directionally safe: decreasing inputs result in decreasing outputs and decreasing damages.

Assessment of material flows need to be done at the country level[3] (the macro level), at the level of industries and households (the micro level) or at the level of regions (the meso level). This last level includes river basins or administrative regions (Hinterberger & Schneider 2001).

[3] And ultimately at the world level

The assessment of material flows includes all direct inputs in the form of products but also all indirect inputs associated with the life cycle and the material moved during extraction (hidden flows). A long-term goal is often set as a dematerialisation by a factor 4 or 10 (Weizäcker *et al*. 1998, Schmidt-Bleek 1993).

3.3 Material flows used for understanding of regional metabolism

Material Flow within regions is dealing with the inherent complexity of material use in order to understand processes within the system and to improve them.
This approach enables to find out the areas where the most urgent measures need to be taken being aware of interdependence of actors.

4. Application of MFA to Water - WFA

4.1 Generalities

4.1.1 Goal definition

Our general goal is the design of a strategy of dewaterisation based on prevention of local and global pollution as well as minimisation of water consumption. The idea is then to move from the *status quo* (figure 3)-where important flows of water are taken from the natural environment and returned after use- to the target of dewaterisation (figure 4). For this we need the appropriate tool.

We suggest applying MFA methodology with water (WFA). Water has a special status in MFA. It is in weight the single most important resource used within the anthroposphere. Although it is a resource fundamental to life, it is often not taken into account because it would make other flows look irrelevant. We give a special attention to this component. WFA develops a global overview of water problem. Keeping in mind that one should be aware of possible transfers of impacts to soil, air or other materials.

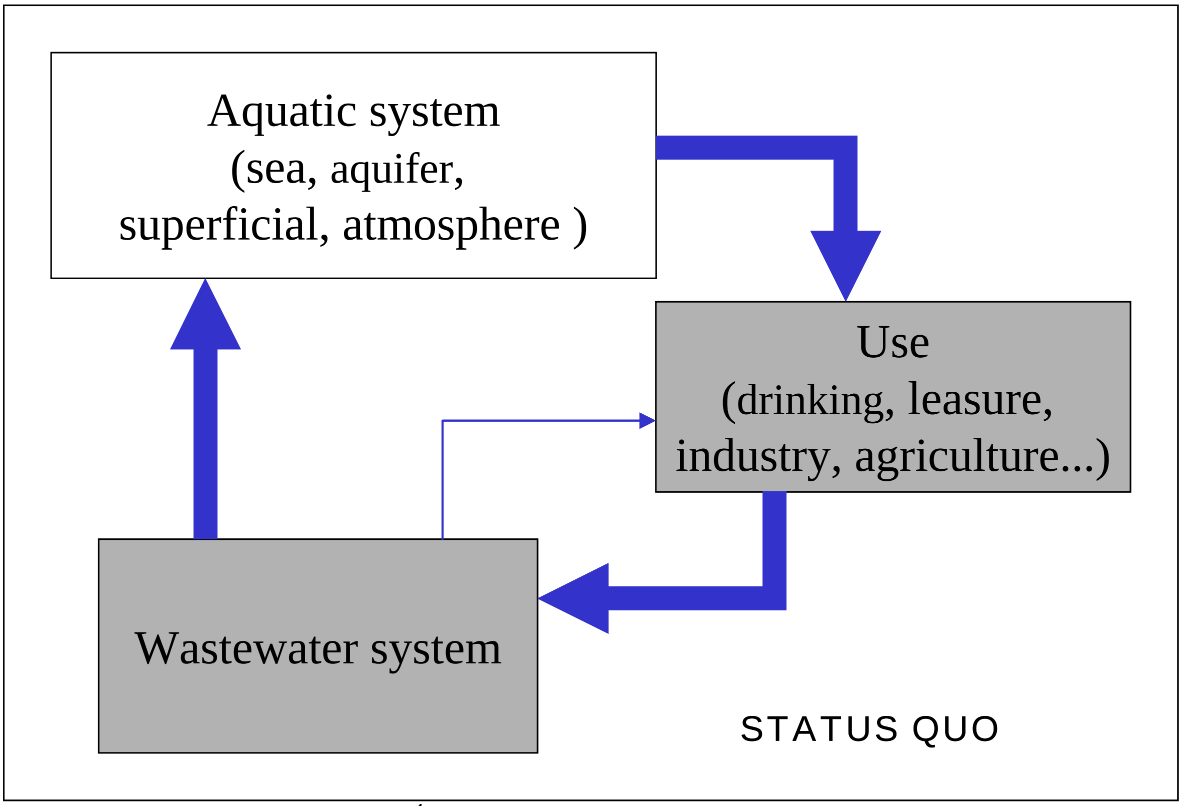

Fig. 3: Water flows- Status Quo[4].

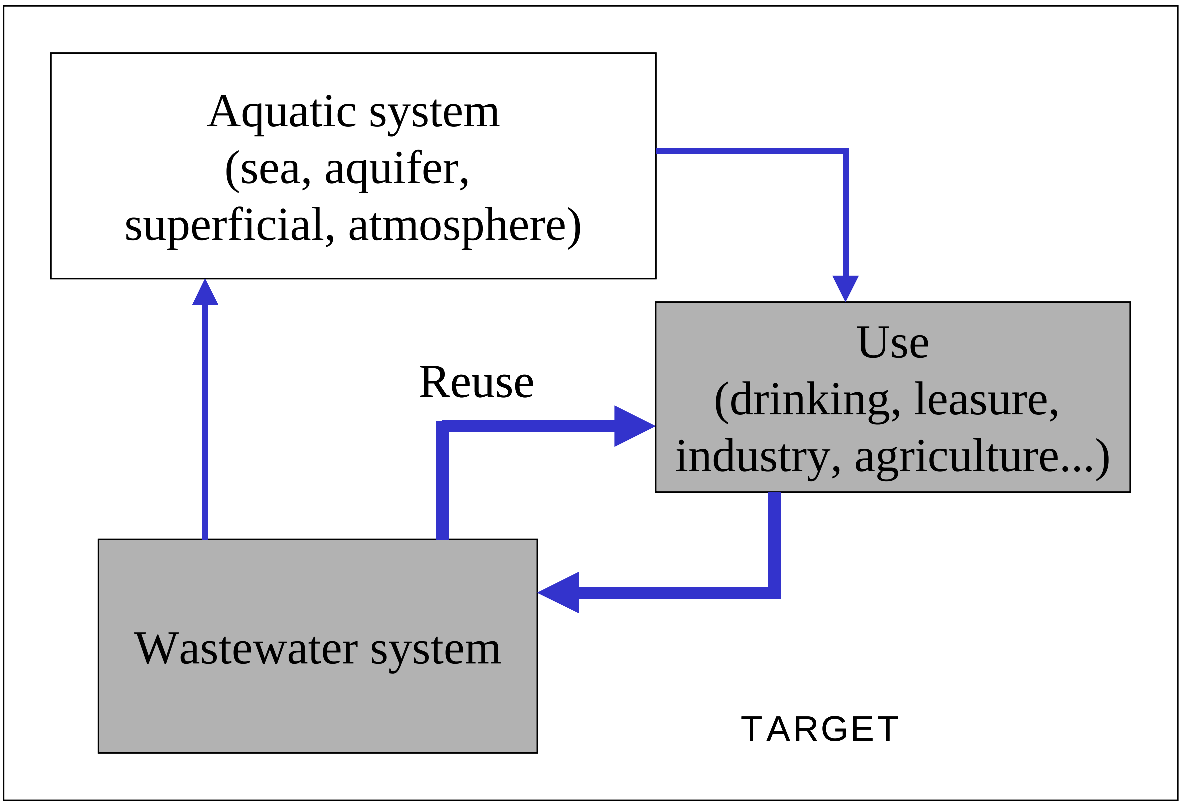

Fig. 4: Water flows- Target.

---

[4] *Arrows represent water flows and grey boxes the water systems in the economy.*

4.1.1.1 Limits of the system

For the geographic limits, we do not consider the river basin, but suggest a compromise between the “water use basin” and administrative limits. The “water use basin” corresponds to the processes of water collection, use, treatment, reuse and disposal linked to a specific distribution or sewage system. In fact two basins are possible, the “withdrawal basin”, which is all the flows linked to a given water withdrawal and the “sewage basin” which is all the flows linked to a given point of discharge in the environment (figure 5). It is important to have in consideration the administrative limits for the access to statistical data on imports of products and water to and from the region chosen.
Three aspects are important:

- Minimisation of imports/export
- Access to statistical data
- Organisational structure of regional networks

Wastewater system might correspond quite well to the river basin, as is the case of systems developing along the Trancão river basin near Lisbon (Brito *et al.* 2001). Or it might correspond to several river basins like in the Guia zone (figure 6). These two previous examples are cases of multi-municipal water management. The relevant system might be very decentralized as in the case described by Bertaglia *et al.* (2002).

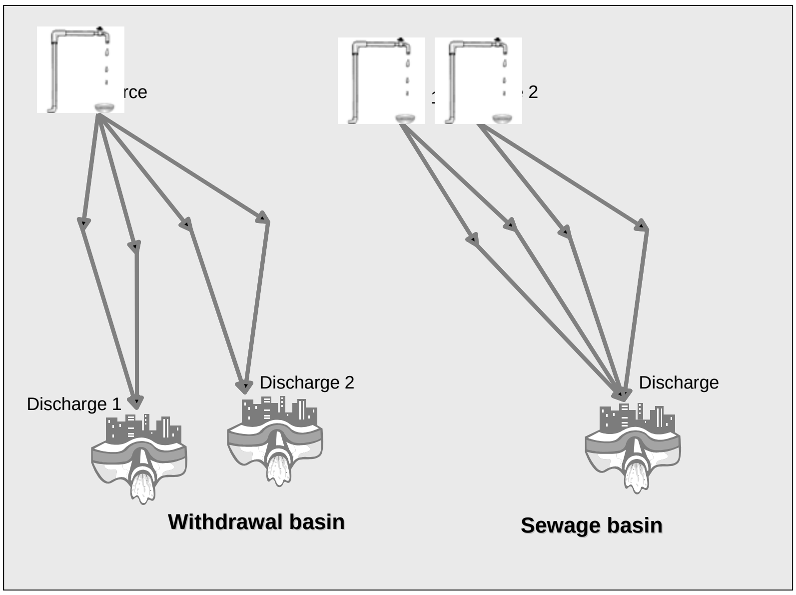

Fig. 5: Withdrawal basin and sewage basin as regions studied

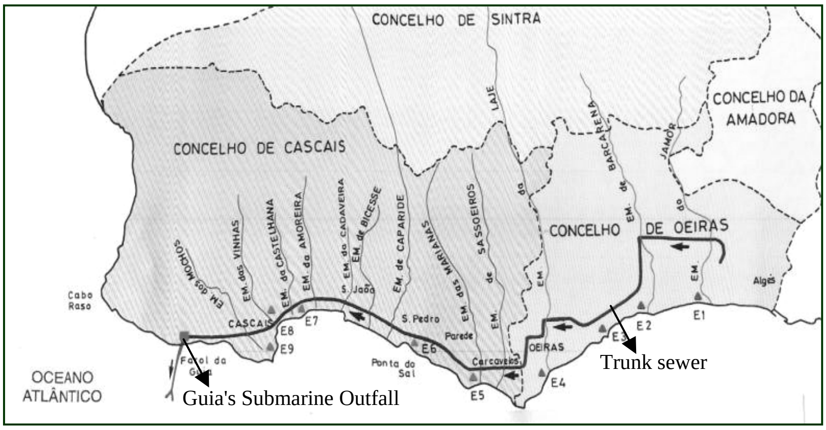

Fig. 6: Example of a sewage basin near Lisbon (Santos et al. 2002)

4.1.1.2 Processes and flows considered

Relevant processes to be considered in the water analysis need to be identified including water treatment, use, collection, drain, transport, storage, wastewater treatment and discharge. Sometimes simplifications need to be made. Do we take into account of direct water abstraction from private wells? Is rainwater taken into account? Do we take into account of households, industry or agriculture? Do we take into account of water consumption and pollution in other regions linked to imports of products in the region?

The types of flow to be included need to be chosen. We consider the flows of H_2O, but also the flows of dissolved and transported substances in relation with the relevant environmental problem in the region (N, P, C, heavy metals…). A general process and flow diagram is then elaborated.

4.1.2 Inventory

In this phase, we identify and quantify the flows of water in the region. The time-scale is in principle one year. The collection of data needs to consider separately the information relative to measurements and monitoring on-site (existing or to-be-developed) and the statistical data at local, regional or national or even international levels. A first approximation is made with data easily accessible, and in link with the selected problems. Data is refined in an iterative fashion from most controllable source to the least. Sometimes, when statistics are lacking, on-site observations are the only solution (Binder 1997).

4.1.3 Modelling

After the inventory, different scenarios of transformation of the water system are defined. These contribute to the clarification and transparency of the modelling. The modelling enables to simulate the effects of different political measures, serving as a base for fundamental decisions.

4.1.4 Improvement analysis

The results are analysed in order to find out:

- Best measures to improve the system
- Limits of the study
- Possibilities for improvement of the methodology.

4.2 Total water flows

The study of total water flows enables to have a first global picture of the problem in the region as developing a parameter in order to define objectives. An input indicator takes into consideration the water extractions within the region and direct or indirect water imports (figure 7).

The processing of 1kg of cotton requires 10 tons of water; one car tyre requires 190 tons (Environment Canada 1986 in: Van de Worp 2002). This represents what we could call the "water ecological rucksack" or "water hidden flows", which are the consumptions of water made in the life-cycle of products but that do not compose the product. Data linked to the German water rucksacks are made available online by the Wuppertal Institute[5]. A very rough simplification consists in considering that indirect water flows are similar in different regions. In principle importation is a wrong way of solving water problems.

The inventory phase includes an inventory of "extractors" (pumps, …) and the rates of extraction. The rainwater collected for use should be considered separately, because its use is less problematic.

[5] http://www2.wupperinst.org/Projekte/mipsonline/

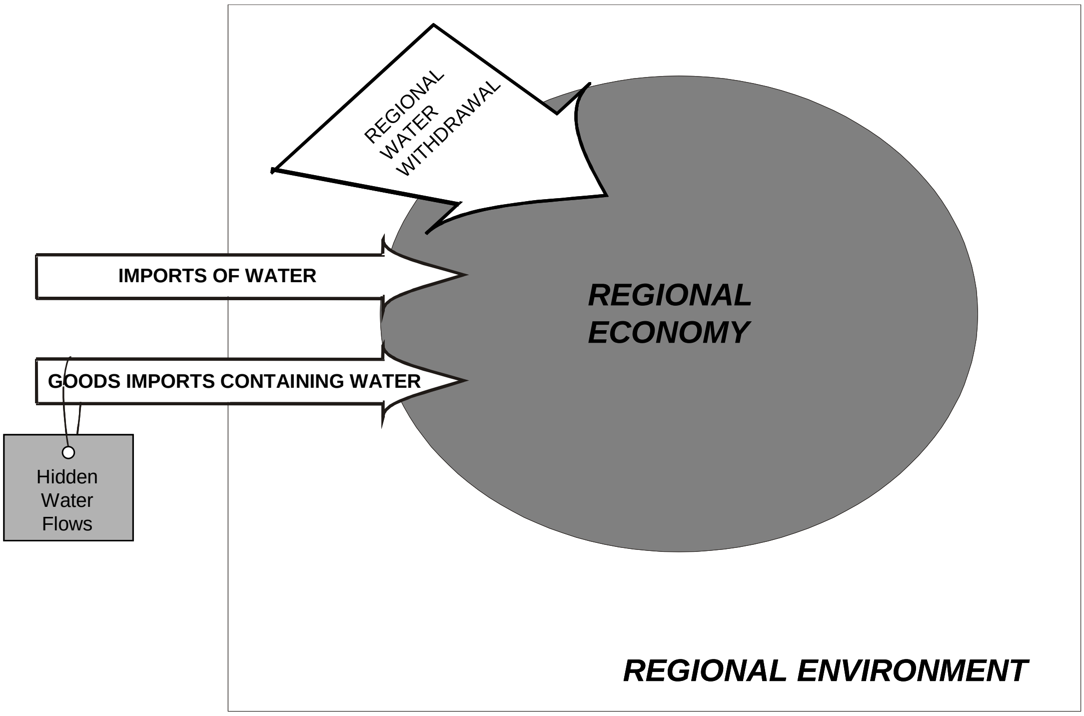

Fig. 7: Total Water Inputs linked to a regional economy

A more elaborated study would take into consideration the outputs too, to have a full material balance between total inputs and the total outputs (figure 8).

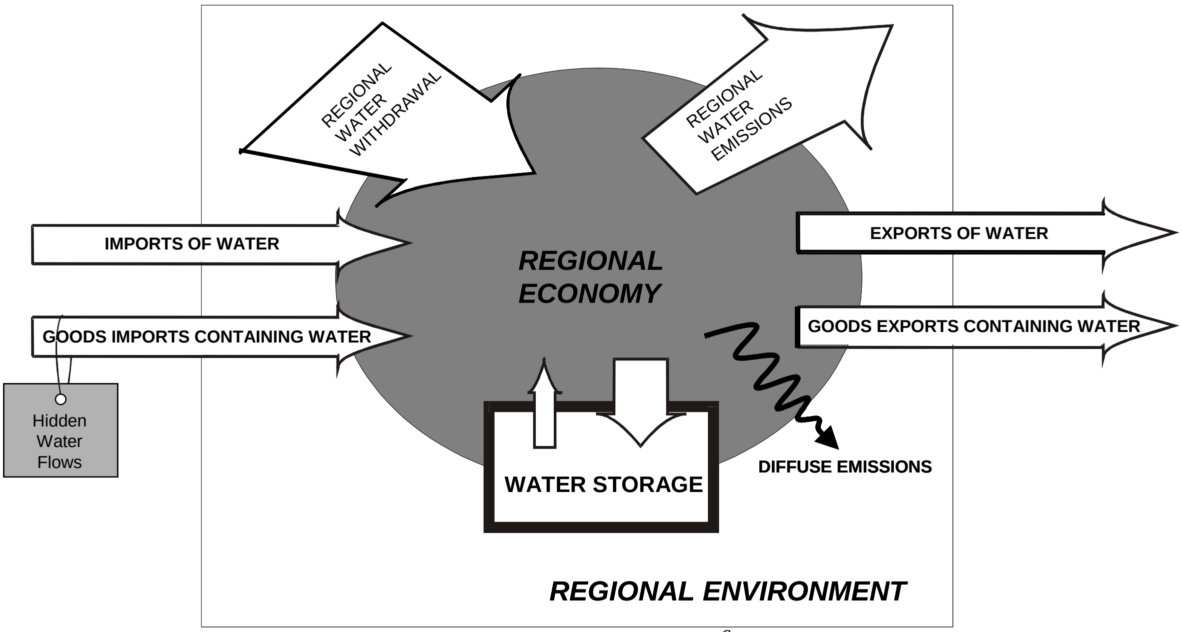

Fig. 8: Total Water Flows linked to a regional economy[6]

[6] Figure inspired of Weisz & Schandl 2001

4.3 Water metabolism in regions

WFA may be used to analyse the metabolism of water in the region in order to link water extractions and introduction of water pollutant to specific activities. The figure 9 develops a picture of the water flow within the region chosen.

Further specific conditions of water use in the "use basin" specifying the quality of water use and characterise it according to the local situation of extraction may be important to consider (Owen 2001). This could for example include information on the degree of mixing of the wastewater (mix of rainwater, municipal and industrial, mixing of black and greywaters in household effluents, numbers of inhabitants, of companies…).

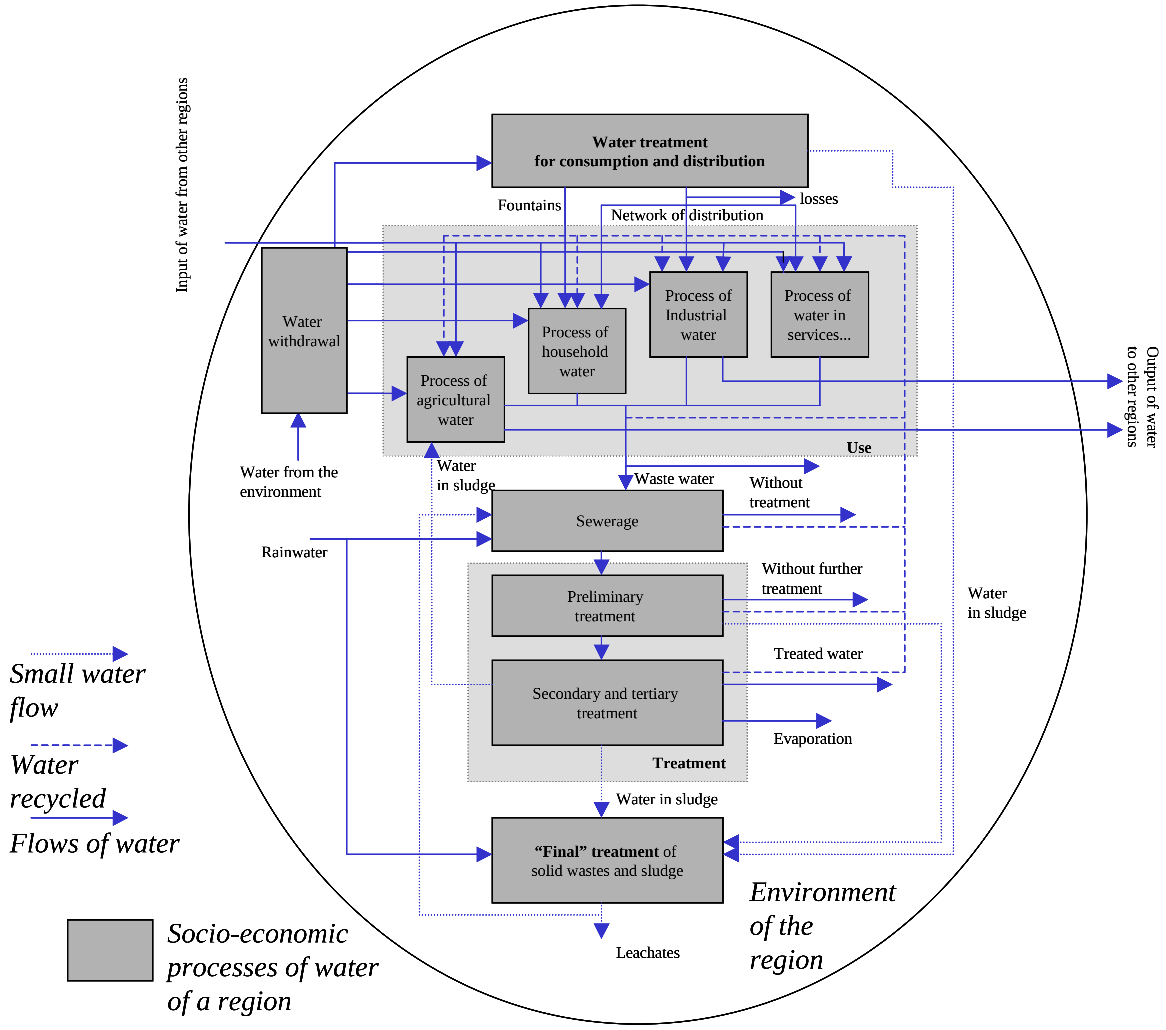

Fig. 9: Metabolism of water in the socio-economy of a region

The analysis is not only about measuring water cycles within the economy but also about the metabolism of the relevant substances. According to the regional problems, one should also develop the Substance Flow Analysis of materials transported by water (figure 10).

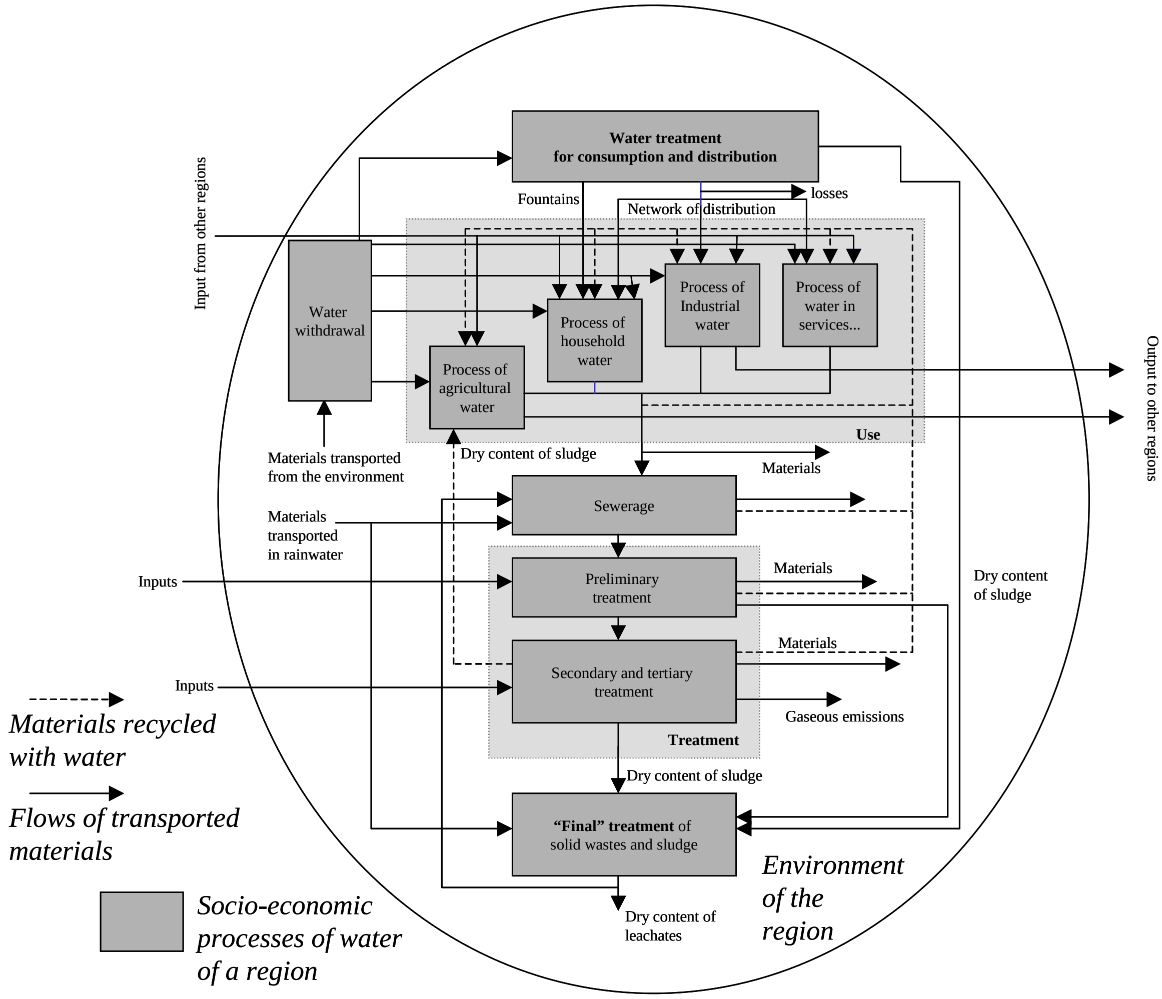

Fig. 10: Metabolism of water transported materials in the socio-economy of a region

The analysis delivers some answers to different questions:

- What is the rate of water reuse?
- What is the rate of pollutants' reuse?
- Where do we locate inefficiencies?
- What are their causes?
- How can they be avoided or minimised?
- Who should be involved?

4.4 Importance of applications to sustainable water management within the socio-economy

This type of analysis can make the link between different types of production, water use and water problems, and can then represent an important decision making tool. Countries in phases of important infrastructure building as in Portugal have a potential to develop more efficient water systems from the beginning. The analysis takes also most importance in areas of water scarcity, which is an important aspect in Portugal in summer.

It can enable an identification of the different fractions arriving at the water treatment plant and identify the contribution of different companies or other water user for each type of pollution. It can help to identify the sources of diffuse pollution and help at the dimensioning of infrastructures and a better knowledge of future dynamics.

In general, a decentralised on-site system may be more effective and efficient because of the lower quantities of water, higher concentrations, lower variability and better reusability of water and materials (Van de Worp 2002).

Some of the possible improvements that may come from the development of applications are (LNEC & ISA, 2001):
•Reduction of consumptions
•Rainwater collection
•Local consumption
•Reuse in other processes
•Internal recycling
•External recycling
•Flow separation
•Closed water cycles
•Dry composting techniques (Bertaglia 2002)
•Cascade recycling (Schneider 1996)
•Coupling urbanism with water (Van Eeten *et al.* 2000)•Development of prevention programs and environmental training

5. Conclusion

Studying the water bodies and outputs to the environment is important, but we argue here that in order to succeed, an important work at the societal level to modify the way we use water is necessary. We need an important focus on reducing the *un*sustainable use of water. Water is the basis for life and in order to act in consequence, water systems need to become sustainable, and as we supported here *dewaterised*. This means: reducing water withdrawal and reducing the input in the economy of materials that will create water pollution by the development of dewaterised systems. We recommend that economic analysis be based on developing input indicators and tools supporting an important dewaterisation of economies and in general that Material Flow Accounting become more widely used as a decision and policy-support tool.

6. References

Bertaglia, M., Roosen, J., Országh, J., Gerin, P., 2002. Economic and Environmental Analysis of Domestic Water Systems: A Comparison of Centralised and On-site Options for the Walloon Region, Belgium. *In these proceedings*

Binder, C. *et al.*, 1997. Regional Water balance as a tool for water Management in developing countries. *Water Resources Development*, 13 (1), 5-20

Brito, M.F., Morbey,M.A.., Picado, A, Mendonça, 2001. "An ecotoxicologically based monitoring program in waste-water discharge control." *11th Annual Meeting of SETAC Europe*, Madrid, 6-10 Maio 2001

Catarino, J., Lança, A, Silva, L., Mendonça, E., Picado, A., Fernandes, A., Peneda, C., Pinho, N., 2001. New Environmental Technologies in Leather Industry - Wastewater decontamination. *11th Annual Meeting of SETAC Europe*, 6-10 May 2001, Madrid

Catarino, J, Mendonça, E., Picado, A., Andrade, N., Almeida, M., Anselmo, A., Partidário, P., Costa, J.N., Mata Torres, J.L., 1999. Valorização de subprodutos numa indústria agro alimentar. *6ª Conferência Nacional sobre a Qualidade do Ambiente*, Lisboa 20-22 Outubro, 1º Vol, p 593-598

Duarte, A. P., Peneda, C., Ventura, F.; Rocha, C.; Saraiva, C., Catarino, J., Frazão, R., Fernandes, F.; Lança, A.; Marçal, M.; Maia, A.; Trindade, P. 2001. Sustainable Production Programme in Setúbal Region (PROSSET) – Final Results. *Proceedings of 7th European Roundtable on Cleaner Production*, 2-4 May, Lund, Sweden

Hinterberger F. & Schneider F., 2001. Eco-Efficiency of Regions: Toward Reducing Total Material Input, Workshop paper. *7th European Round Table for Cleaner Production* (ERCP) 2001, Lund, Sweden

Holmberg, J: and Robert, K.-H., 2000. Backcasting from non-overlapping sustainability principles a framework for strategic planning. *International Journal of Sustainable Development and World Ecology*, Vol. 7

LNEC & ISA, 2001. *Programa Nacional para o uso eficiente da Água (National Program for the Efficient Use of Water),* Versão Preliminar, Ministério do ambiente e do ordenamento do território, Instituto da água, http://www.ambiente.gov.pt/docs/pnuea.pdf

Owens, J.W., 2001. Water resource in LCA. *Journal of industrial Ecology,* 5 (2): 37-54

Raach C, Wiggering H, Bringezu S, 1999, Stofflussanalyse Abwasser – eine Abschätzung der Substanzflüsse deutscher Kläranlage, (Substance Flow Analysis of waste water, estimation of substance flows in German water treatment plants). *Wasser 92*: 11-35

Ribeiro, C., Peneda, C., Catarino, J., Barroca, P., Lança, A , Correia, A , Rosado, P., Ramos, J., Baião, P., 1998. Cleaner technologies in a Portuguese pharmaceutical industry (Hovione): A Case Study. *5th European Roundtable on Cleaner Production*, Lisboa

Robinson, 1990. Future under Glass: a recipe for people who hate to predict, *Future*, 22(8): 820-843

Santos, C., Catarino, J., Marques, E., Figueiredo, Z., Trancoso, A., Marecos, H., Neves, R., 2002. Monitoring sea water around the disposal area of guia submarine outfall. 2nd *International Conference on Marine Waste Water Discharges*, Istanbul, 16-20 September

Schmidt-Bleek, F., 1993. "*Wieviel Umwelt braucht der Mensch - MIPS, das Mass für oekologisches Wirtschaften*", Birkhaeuser, Basel, Boston, Berlin

Schneider, F., 1997. *Analyse des réemplois, recyclages, valorisations de déchets par l'étude de systèmes cascade (Analysis of Reuse, Recycling, Waste Recovery involving the Study of Cascade Systems)*, PhD thesis, INSA de Lyon, 1997, 318p.

Van der Voet, E., 1996. *Substances from cradle to grave - development of a methodology for the analysis of substance flows through the economy and the environment of a region - with case studies on cadmium and nitrogen compounds*. PhD Thesis CML, Leiden, The Netherlands.

Van Eeten M.J.G., de Bruijn J.A., van der Voort H.G., van Bueren E.M., 2000., *Koppelen met water: Samenwerking en samenhang in stedelijkwaterbeheer [Coupling with water: Cooperation and coherence in urban water management]*. Delft: Eburon Publishers. ISBN 90-5166-818-X.

Van de Worp, J.J.M., 2002.Sustainable water management in industry In :, Ed Lens, P.,Hulshoff Pol, L., Wilderer, P., Asano, T., *Water recycling and resource recovery in industry.* IWA publishing, Wageningen, The Netherlands.

Weizäcker, E., Lovins, A., Lovins L.H., *Factor 4 – Doubling wealth halving resource use.* Earthscan, 1998

Weisz, H., Schandl, H., 2001. *Material Flow Accounting (MFA), Concepts and methods.* ISIE Pre Conference Workshop, Leiden, Institute for Interdisciplinary Studies of Austrian Universities, Department of Social Ecology.

INETI/CENDES is dedicated to the development of sustainability in Portugal with a focus on the private sector. In the area of sustainable water management it has developed water-monitoring projects (Santos *et al.* 2002, Catarino *et al.* 2001) and projects of efficient use of water in industry (Duarte *et al.* 2001, Ribeiro *et al.* 1998, Catarino *et al.* 1999). The INETI/CENDES proposes now to develop the analysis of material and water flow accounting at the regional level.