


**Should we invest in small systems of reclamation  
and reuse wastewater? Some tools for  
wastewater project analysis.  
Luis Seguí and Oscar Alfranca\***


Department of Agri-Food Engineering and Biotechnology; Technical University of Catalonia, Av. Canal Olímpic s/n, 08860 Castelldefels (Barcelona), Spain. [oscar.alfranca@upc.edu](mailto:oscar.alfranca@upc.edu)

\* Corresponding author: Phone: +34 935521227; Fax: +34935521121; E-mail address: [oscar.alfranca@upc.edu](mailto:oscar.alfranca@upc.edu)




**Should we invest in small systems of reclamation and reuse wastewater? Some tools for wastewater project analysis.**

1. Introduction.
2. Materials and methods.
3. Results and discussion.
4. Conclusions.




The main objective of this methodology is to evaluate whether constructed wetland investments are profitable under the well-known criteria of cost-efficiency analysis, cost-benefit analysis, and the net present value.




Wetlands present some effects on environment that are not usually considered by free market (such as landscape or biodiversity).

These values should have to be accepted in the economic-environmental evaluation of wetlands.



No clear empirical evidence exists to support private economic profits from the use of reclaimed water for environmental restoration projects in wetland areas.




In fact, Krotscheck and Narodslawsky (1996) pointed out that although there are many reasons to encourage ecotechnologies (such as wetland restoration via the use of reclaimed water), market forces continue to lead development in a different direction.



In this paper, the economic value of a local created wetland is calculated considering these “non-market” variables.

The methodology is developed using indirect economic valuation techniques such as the travel cost method.




The travel cost method is widely used to estimate the value of natural resources, particularly in recreational sites (Azevedo et al., 2003; Gurluk and Rehber, 2008; Vesterinen and Pouta, 2008).




Travel cost methodology includes private costs and external costs and benefits in the general context of a cost-benefit analysis.


The main principle behind is the recovery of costs of water services as stated in the European Water Framework Directive.




The positive environmental values related to restored and created ecosystems, (such as wetlands), are covered extensively in the literature (Mireri et al., 2007; Mitsch and Jorgensen, 2004).




The European Union Water Framework Directive (European Parliament, 2000) provides the background information of the methodology used in this paper to calculate the price of water.



According to the Water Framework Directive, member states should consider the recovery of the costs of water services, including the environmental and resource costs and the essential polluter pays principle.



Travel costs are taken as a proxy variable to estimate the economic and environmental value of natural resources, which cannot be found in free markets.




The method is based on the expenditures of households in order to reach these sites.

These expenditures are considered to be a proxy in order to measure willingness to pay for the recreational activity.




## **2. Materials and Methods**


The wetland was created in the peri-urban park of Can Cabanyes (Granollers, province of Barcelona, Catalonia, northeast Spain).



This is an area severely impacted by human activities: it is located near a highway, an old landfill site, a large conventional urban wastewater treatment plant (Granollers), a solid waste treatment plant, and a frequently used racetrack.




The wetland began operating in April 2003 and receives a pumped flow of secondary effluent (from Granollers WWTP), which ranges from 100 to 250 m<sup>3</sup>/day.



In order to establish the opportunity cost, the total number of visitors is incorporated: A total of 17,760 people visited the wetland and the park from June 2006 to January 2007.

Most of visitors came from Granollers and surrounding towns.

Most of visitors walk to the park or go with bikes.



The wetland has planted shallow zones (water depth is between 0.3 and 0.4 m), unplanted deep zones (water depth of 1.5 m), and a small island (surface area of 550 m<sup>2</sup>).

The wetland was planted with an amalgam of *Phragmites australis* and *Typha latifolia*.




Environmental costs and benefits are estimated using the Travel cost method.

Travel costs are usually calculated as the sum of transport costs, recreational costs and opportunity costs.



In this study, in the travel cost method only opportunity costs are considered.


This is because transport and recreational costs are supposed to be very low.



Opportunity costs were estimated with the wages visitors could not receive because of the time spent in the visit to the park.

The minimum interprofessional wage for Spain was chosen as a proxy.

In Spain, Minimum Interprofessional Wage is 18.03 €/day.  
(Instituto Nacional de Estadística, 2006)



Assuming that visitors spend an average time of 1.5 hours in the park (Villanueva, 2007), the opportunity cost was estimated to be of 3.38 €/visitor.

Time travelling includes the time tourists spend travelling to the park.

In order to establish the price of reclaimed water for private, social, and environmental uses, an optimisation process for both private and external costs and benefits can be applied using the following equation:

$$\text{MAX } B_T = \sum_{n=0}^n (AVR_n * SP_n) - (IC_n + OMC_n + FinC_n + T_n) + (PE_n - NE_n) - OC_n$$

where:

$B_T$  = total benefit (€);

$AVR$  = annual volume of reclaimed wastewater (used in our case for wetland creation) (m<sup>3</sup>);

$SP$  = reclaimed wastewater price (€/m<sup>3</sup>);

$IC$  = capital investment Costs (€);

$OMC$  = operational and maintenance costs (€);

$FinC$  = financial costs (€);

$T$  = taxes (€);

$PE$  = positive externalities of the impacts (€);

$NE$  = negative externalities of the impacts (€);

$OC$  = opportunity cost (€);  $n$  = year.

Table 1. Externalities in the surface flow constructed wetland created in the peri-urban.

Impacts	Impact description	Identification		Periodical distribution		Quantification	
		Negative (Costs)	Positive (Benefits)	Negative (Costs)	Positive (Benefits)	Negative (Costs)	Positive (Benefits)
Hydraulic infrastructure	Reclamation and reuse of wastewater	Production and distribution of reclaimed wastewater		Initial investment and constant among time		48 000 m <sup>3</sup> /8 reclaimed wastewater	
Environment	Water receiving bodies pollution		Improveme nt of water quality		Constant among time		Reduction of nutrient and faecal bacteria pollution and bacterial pollution
	Wetlands and rivers habitat		Preservation and recovery of wetland ecosystems		Constant among time		Increase in biodiversity and improvement of the landscape

$$MAX B_T = \sum_{n=0}^n (VAR_n * PV_n) - (CI_n + CEM_n + CFin_n + IMP_n) + (EP_n - EN_n) - CO_n$$

$B_T$  = Total Benefit;  $VAR$  = Annual Volume of Reclamation Water;  $PV$  = Selling Price of Reclamation Water;  
 $CI$  = Investment Costs ;  $CEM$  = Maintenance and Operational Costs;  $CFin$  = Financial Costs;  $IMP$  = Taxes;  
 $EP$  = Positive Externalities of the impacts;  $EN$  = Negative externalities of the Impacts ;  
 $CO$  = Opportunity Cost;  $n$  = Year

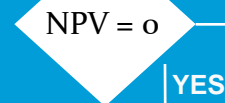
$$NPV = -I_0 + \sum_{n=1}^n \frac{FNE_n}{(1+i)^n}$$

$NPV$  = Net Present Value  
 $I$  = Initial Investment  
 $FNE$  = Net Revenue  
 $i$  = Discount rate  
 $n$  = Year of discount

$$IPM = VAR * PMV$$

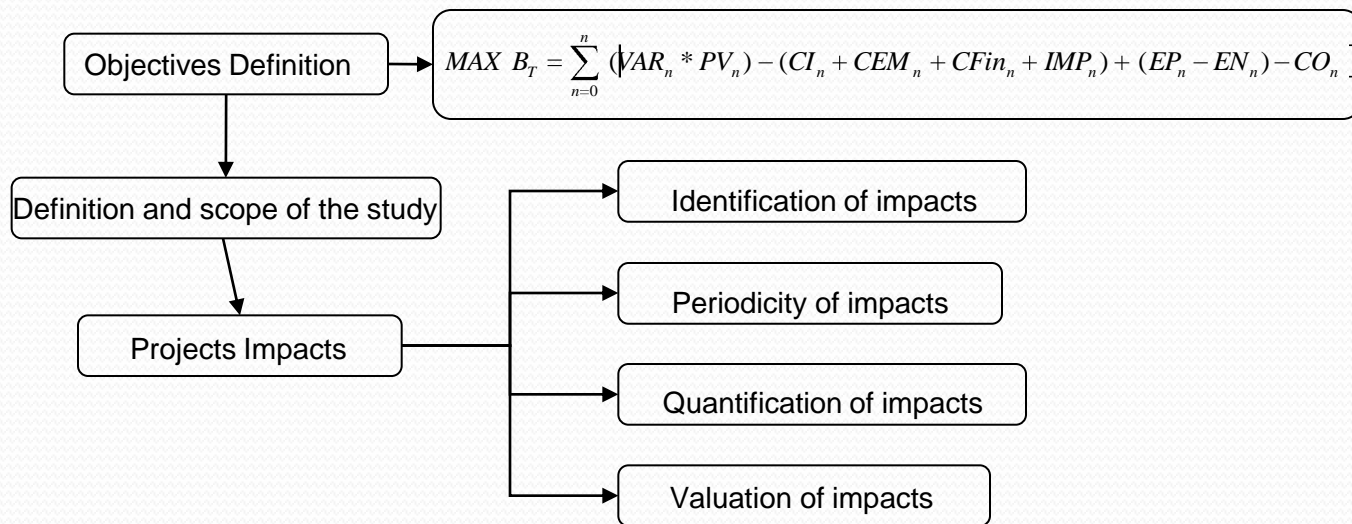
$IPM$  = Minimum Private Revenue  
 $VAR$  = Annual Volume of Reclamation Water  
 $PMV$  = Minimum selling price


$$PMV + \Delta$$




$$PMV = Cost/m^3$$

# Methodology. Stages for the economic analysis of reclamation and reuse wastewater projects





All the estimated costs and benefits are included to calculate a final benefit from the implementation and operation of the constructed wetland in the park at Can Cabanyes.



The final water price, which would recover all costs related to water that flows through the wetland, is calculated as the sum of private and environmental costs.


Table 5. Estimated prices of the water of the surface flow constructed wetland created in the peri-urban ( ). For calculations costs were corrected for 2006. Note that the water price is calculated by means resting negative costs to positive costs. Capital depreciation was calculated considering a life-span of the system of 20 years.

	<i>Without capital depreciation</i>		<i>With capital depreciation.</i>	
	Negative (costs)	Positive (revenues)	Negative (costs)	Positive (revenues)
Hydraulic infrastructure. Costs and benefits	0.50		0.54	
Environmental. Costs and benefits.		1.25		1.25
Total costs and benefits effects.	0.50	1.25	0.54	1.25
Water price (€/m <sup>3</sup> )	0.75		0.71	

## **Results and Conclusion**

The value of the wetland is expressed in terms of the price of the water that flows through the system, which is estimated to range from 0.71 to 0.75 €/m<sup>3</sup>.

The value of positive externalities (1.25 €/m<sup>3</sup>) is bigger than private costs (from 0.50 to 0.54 €/m<sup>3</sup>).



These results constitute empirical evidence that created wetlands in peri-urban parks can be considered to be a source of positive externalities when used in environmental restoration projects focusing on the reuse of treated wastewater.

Main results of this paper are:

1. The influence of the hydraulic infrastructure depreciation costs on the private costs of constructed wetlands is rather small.
2. Investments costs of constructed wetlands in comparison with operation and maintenance costs are low (less than 10% of total private costs), when the life-span of the wetland is considered.
3. According to results little influence exists of hydraulic infrastructure depreciation costs on private costs of constructed wetlands (less than 10%).