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THEME 2 : WHAT POTENTIAL FOR WASTEWATER USE IN AGRICULTURE?

Socio-Economic interests of treated wastewater reuse in agriculture: Clermont-Ferrand case study costs-benefits analysis

SOCIO-ECONOMIC INTERESTS OF TREATED WASTEWATER REUSE IN AGRICULTURE: CLERMONT-FERRAND CASE STUDY COST-BENEFIT ANALYSIS

INTERETS SOCIO-ECONOMIQUE DE LA REUTILISATION DES EAUX USEES TRAITEES : ANALYSE COUT-BENEFICES DU CAS DE CLERMONT-FERRAND

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ABSTRACT

Unlike many structuring projects, treated wastewater reuse projects are rarely subject to economic analysis. When they are analyzed social and environmental benefits are often not properly quantified. Here we show that widely used cost-benefit analysis method showing a project's interest from the whole collectivity point of view can be adapted to treated wastewater reuse projects. The remaining evaluation difficulties are more related to the system complexity rather than methodological limits. Indeed, the operator must be able to understand, formalize and imagine constraints and risks associated with different domains like urbanism, agriculture, climate, hydrology and trade. Remaining uncertainties on key parameter values can however be properly considered through scenarios and/or stochastic approaches. We illustrate the implementation of this methodological approach through a Clermont-Ferrand case study where treated wastewater is reused by a collective irrigation network. This case study highlights how economic analysis, dealing with uncertainties, can support decision makers.

RÉSUMÉ

Les projets de réutilisation des eaux usées traitées font rarement l'objet d'analyses économiques. Lorsque c'est le cas les coûts et bénéfices sociaux et environnementaux sont rarement intégrés ou ne sont pas correctement quantifiés. Nous montrons ici que la méthodologie d'analyse coût-bénéfices (ACB) permettant d'évaluer la rentabilité d'un projet à l'échelle d'un territoire peut être adaptée à l'évaluation de projets de réutilisation des eaux usées traitées. La méthodologie ACB employée est bien maitrisée et les difficultés de mise en œuvre sont davantage liées à la complexité du système. L'opérateur doit en effet être en mesure de comprendre, de formaliser et d'imaginer les contraintes et les risques associés à différents domaines tels que l'urbanisme, l'agriculture, le climat, l'hydrologie et le commerce. Les incertitudes résiduelles sur les valeurs de paramètres clés peuvent être prises en compte par l'étude de différents scénarios et/ou par des approches stochastiques. Nous illustrons cette approche à travers l'étude de cas de Clermont-Ferrand où des eaux usées traitées sont réutilisées par un réseau collectif d'irrigation.

Keywords: Cost-Benefit Analysis, Treated wastewater reuse, Irrigation, Risks and uncertainties

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Introduction

Treated or untreated wastewater reuse is a particularly appealing solution in water-stressed areas, and can be implemented to tackle water scarcity but also to recover surface water quality (Asano, 1998; Lazarova et al., 2001). Nevertheless projects need to be sustainable. Economic considerations are then of high importance when assessing the potential of water reuse projects (Asano, 1998) and treated wastewater reuse (TWWR) projects are rarely subject to economic analysis compared to other types of structuring projects. Economic feasibility of TWWR projects still remains insufficiently studied (Molinos-Senante et al., 2011). In part this is because internal and external economic impacts should be properly identified and quantified. While internal impacts may be easily translated into monetary units, externalities are not considered by the market, thus requiring economic valuation methods for their quantification (Molinos-Senante et al., 2011). Consequently, the true benefits and costs of many projects are not properly evaluated (Segui, 2004). Studies carried out in Mediterranean countries (Molinos-Senante et al., 2011; Condom et al., 2012) showed that when external benefits are properly quantified and integrated into the economic analysis the number of economically viable TWWR projects increases. Cost-Benefits Analysis (CBA) for wastewater reuse projects are therefore of growing interest but the methodology has scarcely been carried out in France on TWWR projects.

An agricultural reuse project has been selected in Clermont-Ferrand to assess TWWR profitability. It is by far the largest TWWR project implemented in France with 1 400 Ha equipped for irrigation since 1996. The economic analysis detailed is therefore an ex post assessment.

The CBA methodology, the methods used to sharpen the assessment, and the conditions that make analysis results to support decision-makers are first described. Then Clermont-Ferrand TWW reuse case study is detailed. The objectives are (i) to assess that the CBA methodology is applicable without specific difficulties to TWW reuse projects, (ii) to assess for the economic profitability of the project and to analyze the stakeholders sharing of costs and benefits.

1. Cost-benefit analysis, a method to assess TWWR project's profitability

CBA is one technique used for analyzing projects to determine whether or not they are in the public interest. CBA assigns monetary value to each input and output resulting from the project (Verlicci et al., 2012). This very well-known methodology is rarely carried out for treated wastewater reuse projects. CBAs are implemented (i) to assess projects' economic profitability for a community on a specific territory, (ii) to identify which stakeholders win/lose and the actions to implement to reach win/win solutions. The term "community" designates here all the stakeholders directly or indirectly implicated within the project.

The methodology includes the following successive steps (1) identification of the different reuse scenarios, single option is possible, (2) analysis sphere characterization (geography and stakeholders involved), (3) business as usual scenario (no reuse) characterization (including future charges) (4) time line setting (from 30 to 50 years), (5) costs and benefits identification and assessment for the reuse and business as usual scenarios (6) net benefits and Net Present Value (NPV) calculations (considering discount rate) to compare scenarios, (7) sensitivity analysis of NPV to the main parameters.

Once they have been estimated all future costs and benefits need to be assessed in present value before being summed (steps 5). To integrate the preference for the present into the analysis the discounting principle is used. A discounted cost or benefit (Xd) is then calculated using a discount rate as follows:

$Xd = Xt / (1+d)^t$ with Xt a cost or a benefit in year t, Xd the discounted value of Xt, and d the discount rate.

The Net Present Value (NPV) is then equal to the sum of differences of discounted costs and benefits between the 2 compared scenarios (e.g. reuse and business-as-usual scenarios).

$NPV = (SBd^{proj} - SCd^{proj}) - (SBd^{bau} - SCd^{bau})$ with SBd the sum of discounted benefits, SCd the sum of discounted costs, "bau" characterizes the business as usual scenario, "proj" characterizes the scenario with project.

Most of costs and benefits are easy to identify and to monetize (added value, investments, charges, etc.) but some are more difficult to assess like knock-on effects on upstream and downstream chain or employment evolution. Some other costs and benefits are also difficult to monetize like the environmental externalities and the individual satisfaction but requires the implementation of more complex and time-consuming methods. Specific economic methods are developed to assess all those costs and benefits. Mastering economic concepts and time to carry them out are then needed.

2. Clermont-Ferrand treated wastewater reuse case study

An ex-post analysis was carried out on a TWWR project implemented in 1996 in Clermont-Ferrand. Only two scenarios are here compared: the implemented TWW reuse scenario and a counterfactual business-as-usual scenario. The time line is set to 50 years, from 1996 to 2045. The main stakeholders involved are the sugar factory, the farmers' association and funding agencies (EU, state, region, department, water agency, others). The wastewater treatment plant (WWTP) owner and manager are neutral. The discount rate used in France for public project is 2.5%.
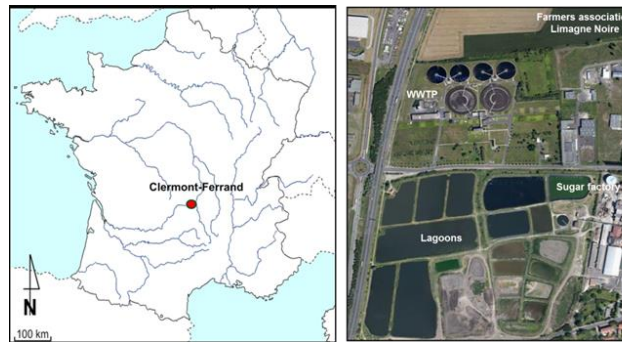
Fig 1: The area under study in Clermont-Ferrand

2.1 The TWW reuse scenario

In Clermont-Ferrand, the Limagne Noire farmers' association have used the TWW since 1996 from the Clermont-Ferrand major wastewater treatment plant (WWTP) of which capacity is around 425 000 EH. 1 400 Ha of agricultural land is equipped for irrigation with 700 Ha irrigated each year in rotation. Seed maize, maize for consumption and beetroots are the major irrigated cultivated crops within the perimeter. The farmer's association and the distribution system (network and pumps) were specially created at the beginning of the project.

Domestic wastewater is treated in the WWTP using activated sludge, specific denitrification and dephosphatation processes. TWW is then supplied for free by the Clermont-Ferrand urban district, owner of the WWTP, to the farmers. To comply with the French regulation on water quality for TWW irrigation a complementary treatment is required before use. The method involves 12 Ha of lagoons, property of the sugar factory. In winter the sugar factory uses the lagoons for storage of its effluents before spreading on the perimeter using the distribution system. Then in early springs when lagoons are empty they are used as tertiary treatment and storage of TWW before irrigation.

Initial investments (distribution system, irrigation material, lagoons rehabilitation and sanitary studies) were 59% subsidized in 1996. The project initiators were the farmers. Their activity's sustainability relies on contracts with the local seedling company which requires the use of irrigation as a prerequisite of the contracts. The farmers' association budget is balanced; all costs are distributed between the 50 association members. The sugar factory takes over part of the maintenance and energy cost proportionally to the transiting volumes. The reuse scenario is described in Figure 2.
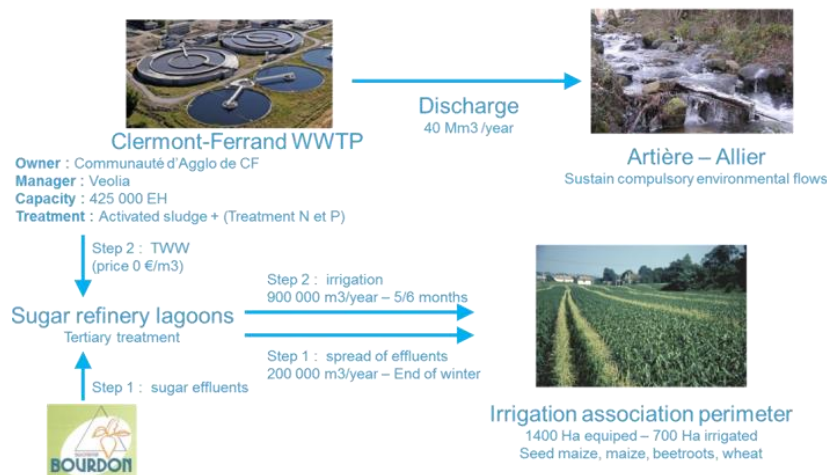

Fig 2: Reuse scenario

2.2 The business as usual scenario

This scenario is counterfactual (hypothetical), the situation as it would have been without reuse from 1996 to 2045 must be projected. In 1996 only a few farmers used the Bedat river whose irrigation potential was only for 200 Ha located nearby the river. We considered that farmers would have kept using it to irrigate 200 Ha without affecting it in terms of quality as we could not figure out the impacts. Irrigated seed maize surfaces would have significantly decreased. We also considered that the rain-fed crops in the remaining perimeter (1 200 Ha) would have stayed similar to a non-irrigated adjacent perimeter. The sugar factory would have sent at a high cost (1.9 €/m^3) its effluent for treatment to the adjacent WWTP. The business-as-usual scenario is described in the schematic Figure 2.
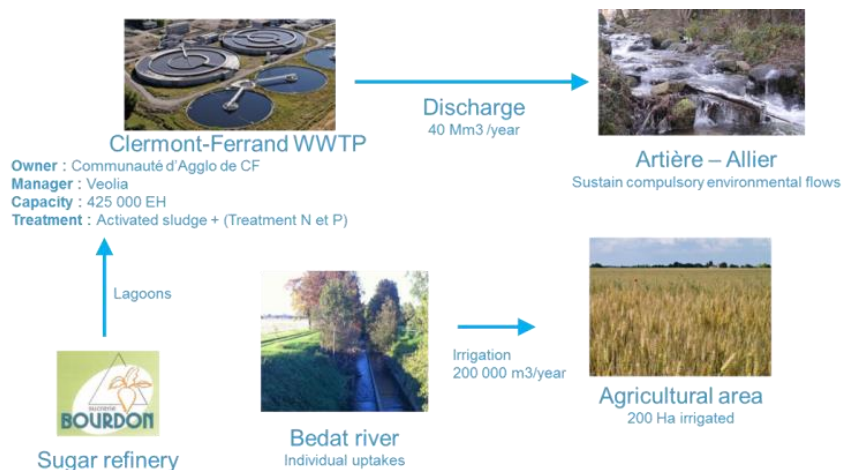
Fig 2: Business-as-usual scenario

2.3 Assessment parameters and NPV calculations

The main parameters used for the assessment (main costs and benefits) are (i) the investments (irrigation material, lagoons rehabilitation, distribution network, etc.); (ii) the annual charges (operational and maintenance costs, energy costs, etc.); (iii) the agricultural gross margin and yields; (iv) the avoided costs of treatment for sugar factory effluents in reuse scenario; (v) the subsidies from funding agencies (Department, Water Agency, State, EU) in reuse scenario. The compared farmers' gross margin for production was assessed at 60.6 M€ in the business-as-usual scenario and 73.3 M€ for the reuse scenario. The crop rotation for the 2 scenarios is detailed in Figure 3.
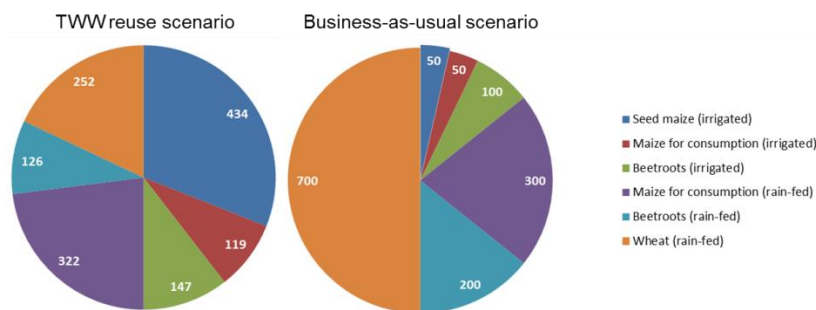

Fig 3: Crops rotation for the 2 scenarios (Area in Ha)

NPV results are presented in Figure 4. Economic NPV of the reuse project is positive and around 10 M€, the project is sustainable for the community and it was worth subsidization. The 2 stakeholders involved (farmers and the sugar factory) also get a financial positive NPV. Our results could not account for the possibility that agricultural land would be used for other activities in the business-as-usual scenario. However we project this would not have negatively impacted the NPV.
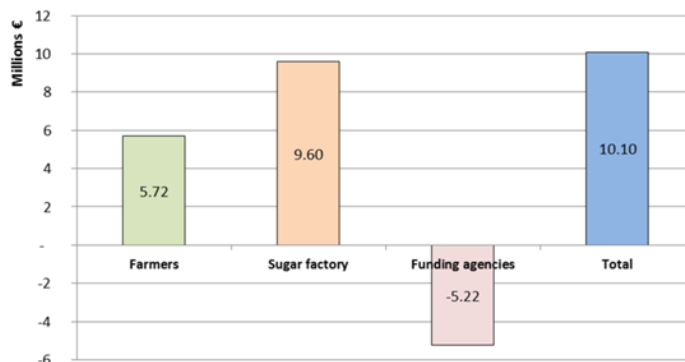

Fig 4: NPV of the different stakeholders

The NPV of the project would be still positive without public subsidies and the benefit sharing among the two agents is largely in favor of the sugar factory.

2.4 Sensitivity analysis using Monte-Carlo method

Since the CBA is an ex-post one, some differences exist between the original plan and the observed situation. A sensitivity analysis has therefore been carried out to assess the NPV dispersion and to test the robustness of the deterministic results above. A Monte-Carlo method has been used (successive 10 000 random draws for the values of some parameters).

The following parameters were randomly drawn between specific lower and upper limits: (i) agricultural products price variation [-30%; +30%]; (ii) seed maize area variation [-30% ; +10%]; (iii) energy price increase rates [0% ; +5%]; (iv) sugar factory effluents treatment costs [-20% ; +30%]; (v) irrigation equipment life-time [-30% : +30%]; (vi) crop water needs [-10% ; +20%]. Results dispersion is presented in Figure 5.
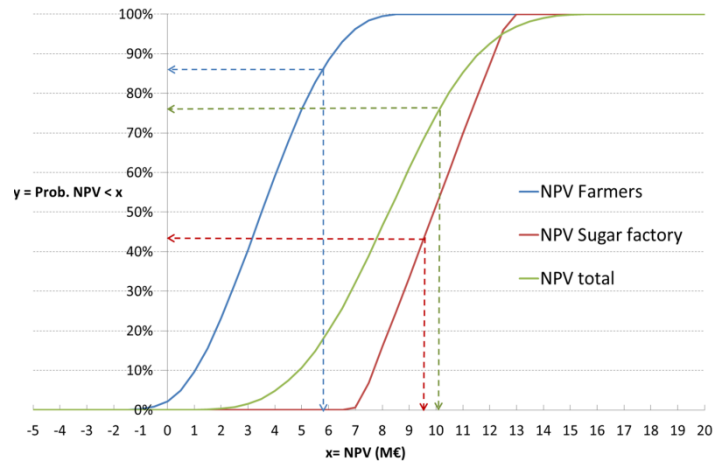

Fig 5: Sensitivity analysis using Monte-Carlo method

No combination of parameters leads to negative NPV for the sugar factory and for the community, while only 3% would lead to a negative NPV for farmers. NPVs are below the deterministic NPVs calculated before in almost 85% of the cases for farmers, 43% for the sugar factory and 76% for the community.

3. Conclusion

CBA methodology enables us to make a value judgement on the economic profitability of TWWR projects and to seek for opportunities to increase development of TWWR projects. Economic profitability has been demonstrated with the Clermont-Ferrand case but economic incentives could be implemented to allocate equally the collective net benefit. Some benefits and costs are difficult to quantify such as the advantages for the community and for farmers to maintain agriculture on the territory and to reduce risks. The sensitivity analysis is necessary. It demonstrates here the robustness of the deterministic results calculated during the CBA.

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