# DEFINING THE DISCOUNT RATE TRAJECTORY FOR THE EVALUATION OF WATER STRESS MITIGATION POLICIES AND PROJECTS

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## 1. Introduction

Policy appraisal is an important element of applied economic welfare analysis that combines economic theory and practice to inform policy decision making. The purpose of a project's economic analysis is to evaluate its efficiency and its effects on social welfare. Typically a policy will be applied if the economic benefits from its implementation outweigh the total costs from designing and applying the policy. Furthermore, when several policies are evaluated, ideally the one that maximizes the benefits on aggregate welfare should be identified and implemented. Policies and especially those relating to environmental decisions are not to be assessed for the effects they have in a single period. These policies entail streams of costs and benefits for decades or even centuries. This chapter deals with the evaluation of long term policies and the controversies arising therein. We discuss the existing justifications for using a declining discount rate when evaluating long term projects and then we proceed to discuss the estimation of declining discount rates (for an application of declining discounting in a policy making context see Groom et al 2002). Drawing from case studies from the *AquaStress* Integrated Project, we stress the importance of declining discount rates on water resources management.

## 2. Cost Benefit Analysis and Discounting

The main tool for conducting policy comparisons and quantifying the economic impacts of alternative policies is Cost-Benefit Analysis (CBA). CBA in principle weights the costs relative to the benefits of a policy according to a number of criteria. If the criteria are satisfied then the policy passes the CBA test and is proposed for implementation.

The most commonly applied benchmark for CBA states that the Net Present Value (NPV) of the project under evaluation should be positive. This amounts to the sum of the discounted stream of benefits associated with the project over its economic life being greater than the sum of the discounted stream of costs as indicated from equation 1:

$$NPV = \sum_{1}^{T} \frac{B_t}{(1+r)^t} - \sum_{1}^{T} \frac{C_t}{(1+r)^t} > 0 \qquad (1)$$

where $B_t$ is the benefit from the policy at time $t$, $C_t$ is the cost of the policy at time $t$, $r$ is the discount rate and the project's economic life is $T$ years.

An important and controversial parameter in equation 1 that can significantly alter the results of the CBA is the discount rate $r$. Common practice sets the discount rate to be a positive constant related to the real interest rate of the economy under consideration.

Standard exponential discounting utilizing a constant discount rate is so far the primary instrument used for translating future returns in present value terms. This approach is used in applied CBA and for project appraisal. The most common critique in opposition to constant discounting is that it biases policy decisions against interventions to long-run environmental problems with extremely long horizons, typically in the hundreds of years (Gollier et al, 2008). These policy interventions typically require large investment costs in the short run, while the benefits are obtained in the distant future. As a result, benefits of long term environmental policies are undervalued and the CBA criteria of positive Net Present Value (NPV) and Internal Rate of Return (IRR) are not satisfied.

The undervaluation of future benefits from environmental policies by constant discounting in principle amounts to under-representation of future generations' welfare in current decision making. With costly long term environmental projects current generations refuse to undertake the costs because due to constant discounting future benefits appear to be insignificantly small. Furthermore, the decisions made in the present on the basis of CBA may leave future generations exposed to potentially destructive risks in the future such as environmental disasters like climate change (Koundouri, 2008; Groom et al 2005; Pearce et al 2003)

## 3. Justifications of declining discounting

The debate on what the appropriate social discount rates should be often points to the direction of non-constant discounting. Specifically it is argued that social discounting should be a decreasing function of time. With a time-declining discount rate costs and benefits accrued in the distant future are calculated with a greater weight than they would under constant discounting. Declining long run social discounting is supported by a multitude of arguments relating to a varied number of reasons. In this section we summarize the most popular justifications for the application of declining social discounting in applied welfare analysis.

Experimental evidence in behavioral and experimental economics, suggest that individuals discount the future at a declining rate. Furthermore, the discounting function used can be approximated by a hyperbolic function. Experimental evidence indicate that individuals attach relatively higher discount rates to returns that are closer compared to relatively lower discount rates to returns that are farther in the future (Ainslie, 1992; Lowenstein and Prelec, 1992; Cropper and Laibson, 1992). Regarding social discount rates, Henderson and Bateman (1995) report discretionary discounting rules applied by the US and the UK governments that depart from the application of a common exponential social discount rate in every project undertaken by the government. This implies that the government recognizes that failures in capital mobility result in different opportunity costs of capital in different sectors of the economy and hence in different discount rates. This pattern, according to Henderson and Bateman (1995) can be viewed as evidence that the underlying social discounting is hyperbolic.

Declining social discount rates are also supported by ethical arguments that support the idea of increasing the weight of future generations' welfare on the current generation decision making. This is an intergenerational equity argument and is based on Chichilnsky (1996, 1997). In this case a declining discount rate in a sustainable growth setting is consistent with axioms requiring current generations to take into account future generations' welfare.

A further justification for declining discount rate is uncertainty about future economic, environmental and other conditions. Weitzman (1998, 2007) formalizes the relationship between social discount rate and time. He finds that the socially efficient discount rate declines with time when the agents seek to maximize their Net Present Value from investing in a risk free project and a project with uncertain risk. Gollier

(2002a, 2002b, 2007) indicates that the pattern of discounting rates in time will depend on the assumptions about future economic growth and the coefficient of relative risk aversion. Thus, uncertainty over future economic growth can lead to declining discount rates

## 4. From theory to practice: The empirical estimation of the optimal trajectory of DDR

The aforementioned studies bring to light some interesting issues concerning the characterization of the future path of interest rates. In the theoretical studies of Gollier and Weitzman, it is mainly persistence combined with uncertainty that leads to decline in discount rates over time. The existence of persistence is an empirical question and it is the degree of persistence in the series that determines the rate of decline of the certainty-equivalent rate (CER). This section discusses how we can empirically estimate a schedule of DDRs based on available historical data.

Given the belief that past interest rates are informative about the future, an econometric analysis of an interest rate model can result in an empirical profile of declining discount rates that can be used in cost benefit analysis (Groom et al, 2007). Groom et al (2007) use a parameterization of the real interest rate in terms of an AR and a GARCH model. Hepburn et al (2008) estimate AR and regime-switching models for various countries in order to derive the certainty equivalent discount rates.

The aforementioned models of interest rate determination require the utilization of structural models to describe the behavior of interest rates. In other words, the term structure of interest rates is determined by exogenous variables (e.g. growth). There are reasons to believe that such models are well-suited for short-term horizon forecasts but not for long-term forecasts. First of all, in the context of structural models, we need long-term forecasts of all the variables that determine the interest rates in order to calculate the projected values of the interest rates. From an empirical point of view, this can create estimation problems due to the possible variation of the parameters of the model. Moreover, the researcher is obliged to perform the analysis based on the period where data for all variables are available. This can result in the loss of important information. Finally, the accuracy of the interest rate forecasts of a structural model can be very poor if (i) any of the assumptions underlying the model is violated and/or (ii) the forecasted values of the variables that determine the interest rates are inaccurate. Given all these limitations of the structural models, we choose to describe the behavior of interest rates in the context of univariate time-series models. Our analysis is based on the assumption that the past behavior of interest rates can reveal useful information about the future dynamics of the series. The utilization of a univariate model allows us to extend the estimation sample using long historical data that cover more than 200 years in some cases. This allows us to capture many historical events that affect the stochastic characteristics of the interest rate series.

### 4.1 The *certainty-equivalent discount factor* and the *certainty-equivalent forward rate*

Discounting future consequences in period *t* back to the present is typically calculated using the discount factor $P_t$, where $P_t = \exp\left(-\sum_{i=1}^{t} r_i\right)$ when continuously compounded in discrete time. When the discount rate r is stochastic, the expected discounted value of a dollar delivered after *t* years is:

$$E(P_t) = E\left(\exp\left(-\sum_{i=1}^{t} \tilde{r}_i\right)\right) \qquad (1)$$

Equation (1) defines the certainty-equivalent discount factor, and the corresponding certainty-equivalent forward rate for discounting between adjacent periods at time t is equal to the rate of change of the expected discount factor:

$$\tilde{r}_t = \frac{dE(P_t)/dt}{E(p_t)} \qquad (1^*)$$

where $\tilde{r}_t$ is the instantaneous period-to-period rate at time t in the future.[1] The expected discount factor defined in equation (1) assumes risk neutrality. Our focus is on the determination of the stochastic nature of $\tilde{r}_t$ through the observed dynamics of the process. We first choose the optimal econometric model to describe the real interest rate of the countries under scrutiny and then generate a series of DDR for each country based on the simulation procedure introduced by Newel and Pizer (2003).

As far as data is concerned, for our estimation, we use long-run series of market interest rates. Social discount factors are prices of future consumption relative to consumption today. The relative price of future consumption could be calculated from the risk-free long-term interest rates. However, there are at least four arguments for the inappropriateness of simply using market prices: (a) market imperfections, (b) the super-responsibility of the government to both current and future generations, (c) the dual role of the members of the present generation in that in their political role they may be more concerned about future generations than their day-to-day activities on current markets would reveal, and (d) the argument that individuals may be willing to join in a collective savings contract, even though they are unwilling to save as

[1]In our simulation exercise, we calculate the certainty-equivalent forward rate based on the discrete approximation of equation (1*), that is $\tilde{r}_t = [E(P_t)/E(_{t+1})] - 1$.

much in isolation. Although some of these positions generated heated argument, the overall view emerged that the real risk-free *market* interest rates provide an inappropriate conceptual basis for social discounting. However, the alternative of using the shadow price on capital in order to convert the magnitude of future effects to their consumption equivalents, is not currently used by policy makers, reflecting a mix of practicability and the view that the real risk-free interest rate and the shadow discount rate are quite close in magnitude. Hence, we use data on market interest rates for our empirical estimation.

In particular, we generate DDRs for Australia, Canada, Germany, the UK and the US based on each country's optimal estimated model as suggested by Hepburn et al. (2006) for the first four countries and Groom et al. (2007) for the US. Afterwards, we construct the aggregate (global) DDR as a weighted average rate of the DDRs of the individual countries, which we use in the cost benefit analysis conducted in section 6 of the chapter. The estimation procedure is outlined in detail in Gollier at al. (2008).

## 5. Declining discounting for Water Related Projects in Europe.

In this section we discuss the implications of applying declining social discount rates for the various case studies presented in this book. The case studies are diverse in terms of geographical location, institutional influences, water stress causes and affected economic sector. As indicated in the introductory chapter of the present volume, these case studies were defined within the *AquaStress* Integrated Project funded by the 6$^{th}$ Framework Program. In terms of geographical location the case studies range from Northern Africa (Morroco, Tunisia), Mediterranean Islands

(Cyprus), Southern Europe (Italy, Portugal), the Balkans (Bulgaria) and Central Europe (Poland). In terms of institutions available, economic conditions and development level they cover market economies (Cyprus, Italy, Morroco, Portugal, Tunisia,) and formerly centrally planned economies (Bulgaria and Poland). Economic sectors causing or influenced by water stress include agriculture (Cyprus, Morroco, Portugal, Tunisia,) and industry (Bulgaria, Poland). Case studies look at water stress due to the over-utilization of common pool water resources (Cyprus, Morroco, Portugal, Tunisia), water quality degradation by agricultural and industrial runoff (Cyprus, Bulgaria, Portugal), risk of non-sustaining the ecological and environmental functions of a river (Italy), and flood risk (Poland). Finally the case studies examine the effects of water stress and the attempts to mitigate it on the general population (Bulgaria, Cyprus, Italy, Poland) and farmers (Cyprus, Morroco, Portugal, Tunisia,).

a. Declining discounting and aquifer recharge with treated wastewater: implications from Akrotiri, Cyprus

Severe droughts over the past decade and overexploitation of natural water resources including surface and especially groundwater in Cyprus has lead to extreme manifestations of water stress. It is approximated that aquifers in Cyprus are mined down to 15% of their capacity. Furthermore, coastal aquifers are under severe threat of seawater intrusion. Coastal aquifers in Cyprus are primarily used for supplying water for irrigation and at a lesser extent for domestic use. As a result groundwater depletion and the subsequent seawater intrusion will have severe effects on the already stressed in terms of profitability agricultural sector. The effects of water stress are also expected to be severe in terms of the environmental damage caused by desertification. The impacts of water stress are expected to be felt across the society, both by the agricultural and urban population of Cyprus, since the effects on use and non-use values are expected to be significant.

In order to mitigate the decrease in the water table and prevent seawater intrusion in the Akrotiri aquifer it is proposed that tertiary treated wastewater from the nearby cities and towns, is pumped in the aquifer to maintain hydrological stability. The implementation of this policy is expected to have effects reaching to the very distant future: once the aquifer is recharged the aquifer water will not be suitable for domestic use ever again. On the other hand the recharge will satisfy a large part of the agricultural water demand by maintaining water quality in terms of salinity and agricultural employment to their current levels.

Since the effects of the recharge are to be nearly permanent, in order to assess the full extent of benefits from aquifer recharge it is necessary to account for costs and benefits in the distant future, beyond the economic life of the project which is usually taken to be between 20 and 50 years. The benefits from recharge should account for future generations of farmers that will be able to work in agriculture as a result of the recharge. Furthermore there are far reaching benefits from the recharge relating to the water balance in the region that will mitigate at some extent the desertification of the area. On the costs side, the opportunity cost of the aquifer water not being suitable for human consumption for the distant future should be accounted for.

Given the extremely long term horizon of the impacts from the aquifer recharge, the argument for employing declining discounting becomes more compelling given the justifications presented in section 3 of this chapter. Significant costs and benefits will be borne in the distant future by generations yet to come.

Applying constant discounting in this case would discriminate against them since their costs and benefits would be considered immaterial from today's perspective. On the other hand with declining discounting, future costs and benefits will play a more significant role in today's policy making.

b. Flood risk management and industrial water management: implications from Przermsa, Poland

The Upper Silesia region of Poland has been a center of the mining industry for over 200 years with some of the world's largest bituminous coal mines located in the area. Heavy industry has over the years significantly affected water quality and quantity available in the region. In terms of water quality, industrial water users ranging from coal miners to steel manufacturers discharge wastewater in the rivers. These wastewaters are often rich in heavy metals, chlorides, sulphates, suspended matter, $BOD_5$ and nitrates. Heavy industry has also caused important changes in the morphology of the local landscape by eroding riverbanks, making the area susceptible to severe floods even after light rainfall. As a result the intervention of the local industry to the natural processes has influenced both the water cycle as well as increased the risk of severe flooding in the surrounding area. Nevertheless, the erosion of river banks and flooding has caused a positive externality: new ecological habitats have been created in floodlands that are now considered worthy of conservation.

In order to mitigate water stress and flood risk and at the same time maintain biodiversity and enhance the recreational value of the riverbanks, a number of complex policies should be implemented that have far reaching effects both in terms of the timing of costs and benefits and in terms of the effects these policies will have on the local population. These policies include installations of wastewater treatment plants in industrial water users, removal of concrete barriers and constant monitoring of the water conditions.

The choice of the appropriate policy instruments should take place after the conduct of the appropriate cost benefit analysis. Installation of wastewater treatment plants, realignment of riverbanks and measures to protect biodiversity are usually costly to implement and maintain. However, the benefits they generate are not confined to the financial life of the project but extent to the future. As an example consider the installation of wastewater treatment plants in local industrial units: the benefits from those do not confine to the 20 to 50 years these projects are designed for but due to the decreased aggregate concentrations of pollutants they carry longer into the future. Furthermore, activities to decrease the flood risk while maintaining biodiversity may generate significant benefits in the very long term, also in the light if climate change and the expected future increase in extreme weather phenomena.

Under a constant discounting approach, many of the long term benefits will be undervalued in CBA. This could result to the cancellation or postponement of the implementation for policies designed to improve water quality, reduce flood risk, improve recreationalism in the area and conserve biodiversity. On the other hand, a declining discounting profile could better translate distant future rewards in current monetary terms by allocating them a more significant weight.

c. Industrial water management: the case of Kremikovzti steel Plant in Bulgaria

Kremikovzti AD steel plant in the Iskar catchment in Bulgaria is one of the foremost industrial installations in the country with immense economic significance for the wider region and the country as a whole. As an indication the steel plant is responsible for approximately 2% of the annual Bulgarian GDP, 10% of the country's exports to the EU while around 1000 businesses in the country are either suppliers or clients of the steel plant. On the negative side the plant is considered to be the largest polluter in the region carrying the legacy of centrally planned management that paid less attention to local environmental conditions compared to overall industrial progress.

To mitigate water stress caused by industrial activity in the area a number of measures have been proposed ranging from the renovation of the plant's cooling towers and the adjustment of water flow in the production process to the more technologically advanced wastewater treatment. These are measures that are expected to improve the production efficiency of the steel plant. However, in a CBA these are not the only benefits that should be included since these actions will reverse the negative externalities caused by the plant's operation. Then CBA of the policies should try to evaluate the social costs against the social benefits from their implementation. The social costs in this case primarily involve the private cost of the steel plant for implementing the water stress reducing policy. On the other hand, the social benefits include the private benefits to the plant from improved efficiency and the benefits that relate to the improvement of the environmental conditions and the mitigation of the water stress relating to water quality. The latter are accrued by the general population residing in the wider area. Hence, social CBA is the appropriate method instead of private CBA, which would just take into account the private costs and benefits of the steel plant.

Contrary to the private costs and benefits that whose stream ends when the plant stops operating, the social benefits from pollution decrease carry long into the future. Using a constant discount rate as already argued will militate against the future benefits that include improved water quality and availability for the growing population of the region. Under a constant discounting it is very likely that the private firm may not find it efficient to implement the improved production methods. In this respect the application of a declining discount profile is essential to achieve the actual social optimum.

d. Declining discount rates and agricultural practices: evidence from Morocco, Tunisia and Portugal

Agriculture is the single most important consumer of water in a number of countries. Due to the importance of the availability of water resources, agriculture is often one of the hardest hit sectors from water stress. At the same time archaic agricultural management practices can exaggerate water consumption and cause a variety of water quality issues by over-utilization of nutrients in the production process. Finally the common pool resource nature of surface and groundwater make it more susceptible due to potential free riding farmers that overexploit the resource. CBA can be useful to assess the economic rationality of farmers' behavior and examine the extent at which measures on the modification of agricultural practices can be efficiently applied for the mitigation of water stress.

In the Guadiana region of Portugal water stress relates to agricultural activity in both ways described above: farmers suffer from water stress due to the lack of it and at the same time cause water stress by increasing demand for irrigation. In order to maintain or even improve current conditions agricultural management plans among other things aim to decrease fertilizer use, implement wastewater reuse and change cropping patterns. This way both surface and groundwater resources can be conserved.

In the Merguellil valley in Tunisia water stress relates to the overexploitation of aquifer water resources from the local farming population. The common pool resource nature of groundwater is the main factor contributing to water shortages. This can be attributed to the limited monitoring of water usage and the institutional gaps that allow uncontrolled use of water resources. As in other cases refered to befor a mix of technical and socioeconomic tools is proposed for rationalizing water use. These involve the installation of water meters and independent authorities to monitor them as well as the introduction of more efficient pricing systems.

Similarly to the previous two cases the Tadla region in Morocco faces water stress partly created by agriculture that affects the primary sector of production threatening the continuation of agricultural activity in the region. The main approach proposed is yet again a modification of agricultural practices and activities so as to use water as efficiently as possible. These include changing irrigation technology to minimize water loss in agriculture, modifying cropping patterns and creating the institutions necessary for efficient water management.

The three cases mentioned in this section share at a large extent common problems regarding agricultural water management. As a result the water stress mitigation options are similar across them.

The importance of the choice of the discount rate is extremely important for the decisions on modifying agricultural change and initiating institutional changes. The introduction of new agricultural practices, rotating crop patterns and the installation of water meters involve substantial costs in the short run but the bulk of their benefits in enjoyed in the distant future. This is because farmers so not immediately adjust to the new conditions. Furthermore, these changes ensure the continuation of agricultural activities for future generations. Similarly the establishment of authorities and institutions to manage water use may involve substantial costs both in terms of monetary expenditure but also in terms of political backlash. Their benefits on the other hand will largely come in the distant future and will be attributed to the survival of agriculture in the region under examination. With these considerations, it becomes easier to argue in favor of declining discount rates. Declining social discounting will increase the weight on the distant benefits and improve their importance on political decision making.

e. Declining discount rates and environmental conditions: Minimum vital flow for the Flumendosa region in Italy

Maintaining the flow of rivers is an important aspect of river management policy. The level of river flow has an important role to play in sustaining the environmental and ecological conditions of a river, as well as the wider region in which the region is located. Furthermore, it poses a significant constraint to which agricultural and domestic water management must adhere to. Sustaining the minimum vital flow of a river however involves substantial long-run costs and benefits that should be appropriately weighted in a cost benefit analysis in order to determine its economic efficiency. As already indicated, on the benefits side, maintaining a minimum vital flow can sustain the environmental and ecological status of the surrounding area. This affects not only the natural beauty of the region which can result in benefits from recreational uses, but it is also very important in sustaining the stability of the socio-economic environment of the region. On the other hand, water reserved to maintain the minimum vital flow is no longer available for irrigation or any other water use. This represents an implicit (medium-run) cost to farmers and other users (domestic, tourism) that should be accounted for. It should be obvious from the above that the implementation of a policy on sustaining a minimum river flow will have run-long costs and benefits. Therefore the declining discounting approach is appropriate in order to place the right weights on the non-use long-run environmental benefits from the maintenance of a minimum vital flow, as well as the medium-run costs of each economic sector whose water supply will be further constrained.

## 6. An applied example.

In this section we illustrate the significance of declining discounting for project appraisal using the Cyprus case study. As described earlier the benefits from the aquifer recharge are will be enjoyed both by the general public and by the farmers in the area. These benefits include maintenance of current water quality, current water quantity, current environmental conditions and current employment in agriculture.

As indicators of the total values accruing to the characteristics mentioned above we use the valuations from two choice experiment applications in the region conducted during March and April 2008. Table 1 depicts the valuations of farmers and the general public used for the cost benefit analysis. Given the results of the choice experiments the aggregate benefit under the assumption that preferences will remain constant over the horizon is €60,717.45.

Table 1 here

For the cost benefit analysis we assume that the aquifer is going to be recharged with 1,000,000$m^3$ of tertiary treated wastewater each year at a cost of €0.06 per $m^3$. Since the wastewater treatment plant is already in operation we do not assume a cost for its construction. We also assume away expenditure for the construction of new treatment plants once the physical life of the existing one ends. Given our assumptions, the cost of recharge is €60,000 per year for the whole horizon.

We assume a long horizon of 200 years and calculate the NPV of the recharge project under two discounting schemes: a constant 5% discount rate and a discount rate decreasing over time. Given the absence of long-run time series data of market interest rates in Cyprus, the declining discount rate profile used in this chapter is generated using Gollier at al. (2008) as referred to in section 4 of the chapter. Figure 1 presents the path of the present value under the two discounting profiles.

Figure 1 here

We find that the NPV under declining discounting is €23,058.12 while under the constant discounting is €14,348.17. This result verifies that using constant discounting underestimates future benefits significantly when compared to declining discounting. Indicatively, a present expenditure of over €14,348.17 would suffice to reject the project's implementation under while the same expenditure under the declining discounting pattern would lead to the acceptance of the project.

## 7. Concluding Remarks

The choice of the discount rate is an important decision with substantial effects on the evaluation of policy proposals and on project appraisal. The choice of the discount rate can over or under value the present value of the project and be critical on its implementation or not.

In this chapter we illustrated the significance of the discount rate choice on project implementation based on the *AquaStress* case studies. The implications of the discount rate choice are significant for the implementation of the policy proposals examined in each case study. Specifically, for the aquifer recharge destined to be implemented in the Akrotiri aquifer in Cyprus, a constant discount rate would substantially underestimate the future benefits from maintaining current water quality, water quantity and environmental conditions. A decreasing discount rate on the other hand, raises the weight placed on future benefits. This is also the case for measures for industrial water and wastewater management in Poland and Bulgaria. While the implementation of water and wastewater management from industry in these case studies may be considered inefficient from the view of the private firms, social cost benefit analysis can determine the optimal solution from the society's perspective. The benefits of from installing new technology to industrial units is expected to generate a substantial stream of benefits I terms of improved water quality and general environmental conditions that will be enjoyed by future generations. Conducting the social cost benefit analysis using a declining discount rate will better take into account the welfare of future generations and give them more substantial weighting compared to the constant discounting case.

The modification of agricultural practices in terms of water management has substantial effects on both present and future welfare. Drawing from the results of case studies in Morocco, Tunisia and Portugal we can conclude that their implementation appears more intuitive and justified under declining discounting. Changed agricultural practices will prevent disastrous effects of extreme water stress like desertification and water quality degradation. In this way the changes if successful will guarantee the livelihood of not only the current farming population but also the continuation of agricultural activities for the distant future. Once the future costs and benefits are evaluated using declining discounting, the social benefits from agricultural activities are taken into account. Finally, as far as the Italian case study is concerned, the use of declining discount rates provides a policy tool towards a environmentally and ecologically sustainable water management.

Overall, declining discounting appears to be the discounting measure that can better account for long term projects. Based primarily on uncertainty and the notion of intergenerational equity, declining discounting is appropriate for water management projects. This is because such projects inherently involve significant uncertainty and their relevance extends beyond the short term horizon.3

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**Tables and Figures**

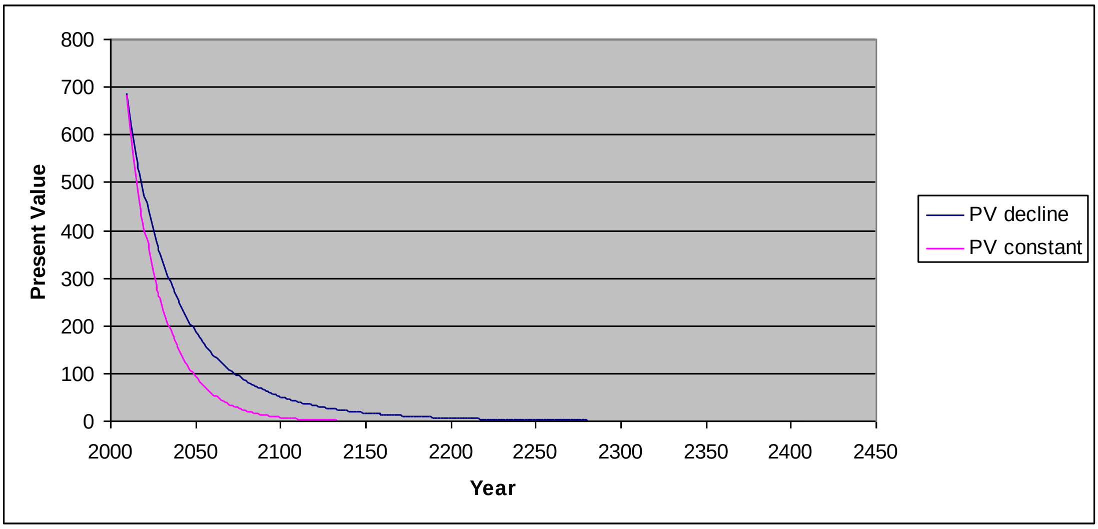
**Table 1: Valuations of recharge characteristics**

| Characteristic | Valuation (€/individual) | Total Benefit (€/year) |
|---|---|---|
| Farmers (1500 individuals) | | |
| Maintaining current water quality | 0.1309 | 196.35 |
| Maintaining current water quantity | 0.2034 | 305.1 |
| Maintaining one employment position at the agricultural sector | 0.0007 | 1575 (for maintaining full employment) |
| General Public (330000 individuals) | | |
| Maintaining current water quality | 0.1292 | 42636 |
| Maintaining current environmental conditions | 0.0478 | 15774 |
| Maintaining one employment position at the agricultural sector | 0.0007 | 231(for maintaining full employment) |
| Total benefits | | 60717.45 |

**Table 2: Net Present Value**

| Discounting Regime | Net Present Value |
|---|---|
| Declining | 23,058.12 |
| Constant 5% | 14,348.17 |

**Figure 1: Present Value Paths under constant 5% and declining discount rates**



800
700
600
500
400
300
200
100
0
Present Value
2000
2050
2100
2150
2200
2250
2300
2350
2400
2450
Year
PV decline
PV constant